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DIGITAL OPPORTUNITIES FOR SANITARY AND PHYTOSANITARY (SPS) SYSTEMS AND THE TRADE FACILITATION EFFECTS OF SPS ELECTRONIC CERTIFICATION

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Digital Opportunities for Sanitary and Phytosanitary (SPS) Systems and the Trade Facilitation Effects of SPS Electronic Certification

Countries are increasingly using digital technologies within their Sanitary and Phytosanitary (SPS) systems and the disruptions caused by the COVID-19 pandemic are accelerating this evolution. While countries are increasing their use of digital tools, digital technologies still have significant potential to create efficiencies in SPS systems and enhance agro-food trade. Quantitative analysis using structural gravity model estimates show that digital technologies such as SPS electronic certificates have positive effects on trade volumes, notably for plant-based, vegetables and processed food products. Despite these gains, significant challenges remain in expanding the use of digital technologies in agro-food trade, including mixed capacities to adopt these technologies. Successful expansion of the use of digital technologies requires careful planning and long-term investments, as well as sharing expertise and building trust in these tools. Targeted financial assistance and capacity building can provide support to countries currently lacking the capabilities to adopt these tools.

Key words: Agriculture and food standards, COVID-19, digitalisation, market access, gravity estimation

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What are the issues and why are they important?

- Countries are increasingly using digital technologies within their sanitary and phytosanitary (SPS) systems, including in risk assessment, the identification of risk management strategies, and the verification of SPS compliance in the movement of products.
- These technologies include the exchange of SPS electronic certificates (e-certification) for plant and animal products, conformity assessment platforms, traceability and supply chain integrity technologies, remote pest screening, and advanced consignment declarations and checks.
- Digital technologies have the potential to create efficiencies within SPS systems, facilitate trade, and lower administrative costs for countries and traders. They can reduce the risk of trade fraud, make trade systems more accessible for businesses (including businesses in developing countries), and help countries address food safety risks and risks to human health. But some of these technologies can be challenging to implement, and can give rise to new operational challenges, including the need for long-term investment.
- Empirical analysis on the effects of e-certification on trade flows remains limited. This paper aims to start filling this gap by analysing the specific trade-enhancing effects of e-certification.

What did we learn?

- Countries are using various forms of digital technologies in SPS systems. Notably, some countries have adopted digital technologies in compliance verification processes for imported and exported goods, whereas many still rely on paper-based systems. The majority of country activity in this area concerns the use of e-certification systems.
- While there is increasing adoption of e-certification in respect of phytosanitary (plant-based) products, the adoption of these systems in respect of sanitary (animal-based) products and livestock is less widespread. Sanitary certification is often administered separately, meaning adoption of e-certification systems progresses independently.
- The use of SPS e-certificates has positive effects on trade volumes, notably for plants, vegetables and processed food products. The quantitative analysis also points to greater responsiveness of quantity than prices to the implementation of e-certification. The effects of SPS e-certification on trade flows do not materialise immediately, as their implementation takes time and resources.
- In the context of disruptions caused by the COVID-19 pandemic, countries are adopting digital SPS systems more widely, notably the International Plant Protection Convention's ePhyto Hub. Country updates suggest those participating in these systems may have incurred fewer trade interruptions during this time.
- Digital tools require careful design to create efficiencies in SPS systems, and uptake must be supported with training and resources for countries and businesses. A scan of current initiatives demonstrates potential to expand the use of these technologies.
- To expand the use of digital technologies, countries must satisfy certain conditions: ensuring these technologies enhance existing food health and safety standards; accessing dependable sources of funding; establishing a clear and enabling regulatory framework; promoting the interoperability and equivalence of SPS systems using digital technologies; developing shared expertise in implementing and monitoring digital tools; and building trust in these tools.

Key recommendations

- Countries should consider expanding their use of digital technologies within SPS systems to create greater efficiencies, facilitate trade, and assist with the healthy and safe supply of food products. In particular, countries should examine the increased use of digital SPS technologies (notably e-certification) in the context of the COVID-19 pandemic response, with the aim of harnessing momentum for wider uptake.
- Countries should continue exchanging best-practice guidance regarding the use of digital technologies to develop a shared pool of expertise. Exchange of case studies illustrating the successful adoption of these technologies would provide insights into implementation and encourage wider adoption.
- The larger effects of e-certificates on trade in vegetable products, for which the use of a central e-certification platform has become increasingly prevalent, indicates that there seems to be room for countries to explore new multilateral certification systems for sanitary purposes, similar to the IPPC ePhyto Hub.

1. Introduction

The WTO Agreement on the Application of Sanitary and Phytosanitary Measures (WTO SPS Agreement) is a legally binding multilateral agreement combining the objectives of avoiding unnecessary obstacles to trade through the use of science and risk-based measures, and respecting the rights of countries to take appropriate measures for the protection of plant, animal, and human health.[1] Notwithstanding the WTO SPS Agreement's requirement for harmonisation[2] on the basis of standards developed by international organisations, SPS measures must be implemented in a country and product specific manner in order to be effective. Yet, multiple government departments can be involved in setting and enforcing SPS measures. This can render compliance challenging for importers and exporters, and can make it difficult for agencies to coordinate in upholding these measures (STDF, 2017[1]).

Despite efforts by the WTO SPS Committee to enhance Members' implementation of the WTO SPS Agreement obligations pertaining to harmonisation and equivalence, and despite a shared commitment for WTO Members to work towards simplifying and reducing formalities and documentation requirements (particularly under Article 10 of the WTO Trade Facilitation Agreement (WTO TFA)) SPS systems remain heterogenous (STDF, 2017[1]). In the context of this paper, 'SPS systems' are defined as each country's framework of SPS measures, including the specific institutions, processes, practices, and technologies

[1] For a short summary of the key provisions of the WTO SPS agreement, see (Grant and Arita, 2017[142]).

[2] The WTO SPS Agreement is based on five core principles:

(i) Harmonisation of SPS measures based on international standards, guidelines, or recommendations (Article 3);

(ii) Equivalence of SPS measures applied by countries if they achieve the appropriate level of protection (Article 4);

(iii) Risk assessment and determination of appropriate SPS protections based on scientific evidence (Article 5);

(iv) Regionalisation: SPS measures shall be adapted to the SPS characteristics of the area—whether all of a country, part of a country, or all or parts of several countries—from which a product originated and to which it is destined (Article 6); and

(v) Transparency: SPS measures shall be published promptly and enquiry points shall be established to provide information on SPS regulations, controls, inspection procedures, risk assessment procedures, and membership and participation in international and regional SPS bodies, arrangements, and agreements (Article 7 and Annex B).

used to assess the risks associated with the movement of plant or animal products and manage these risks through verifying compliance with SPS regulations.

These SPS systems depend on a range of conditions in both the importing country and the exporting country, including countries' pests and disease status. Countries also differ with regard to the acceptability of certain types of risk and their approach to science in law (Peel, 2004[2]). Furthermore, institutional structures, resources, methods, and practices all differ considerably, and are often largely path-dependent. Even with increased harmonisation around the methodologies supporting SPS systems, their application depends on conditions that vary across countries, and even from product to product (Spreij, 2007[3]) (Stone and Casalini, 2020[4]). As a consequence, exporters have to manage compliance with different sets of rules and regulations for each market. This lack of SPS system coordination at the multilateral level is costly, and can represent a barrier to trade (STDF, 2017[5]) (OECD, 2014[6]) (OECD, 2018[7]) (Blanc, 2018[8]). It must be noted, however, that Members have the right under the WTO SPS Agreement to set SPS measures necessary for the protection of human, animal, or plant life or health provided that SPS trade restrictions are non-discriminatory, transparent and scientifically justified.

Alongside these trends, SPS systems around the world are stretching to cope with rising trade volumes, placing a greater importance on effectiveness and efficiency (FAO, 2018[9]). In this context, countries must find new ways for SPS agencies to process increasing amounts of information. Digital technologies offer a solution to this challenge, particularly by enabling a more risk-based approach to regulatory delivery (Russell and Hodges, 2019[10]) (Mangalam and Vranic, 2020[11]).

In the context of this paper, digital technologies are defined as "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" (OECD, 2019[12]).

Digital technologies have the potential to create efficiencies at the three relevant stages of risk-based SPS regulation (WTO, 2014[13]) (OECD, 2014[6]):

- *risk assessment* based on scientific evidence and factors including, for example, the presence of plant pests or animal diseases in importing or exporting countries, and the characteristics and compliance record of economic operators involved;
- development of a *risk management strategy* reflecting this risk assessment; for example, setting screening requirements for imported products,[3] which should reflect the risk inherent in the product, the vulnerabilities of the importing country or region, and the characteristics of the country of origin, among other factors (OECD, 2010[14]); and
- development of processes governing the *movement of products and the verification of compliance* with standards and regulations, including control, inspection, and approval procedures such as product registration, certification, and testing, as well as trade facilitation measures.[4]

[3] In SPS systems, "risk" refers to the risk of the entrance of a pest or disease and the potential harm to human, animal, or plant life or health. While the terminology is similar, the concept of risk assessment and management as applied under the WTO SPS Agreement is different from the one under the WTO TFA. Article 7 of the WTO TFA states that "every Member shall base risk management on an assessment of risk through appropriate selectivity criteria". In this case, risk assessment refers to the risk of non-compliance. Risk management then refers to the system used by customs administrations to determine which persons, goods, and means of transport should be examined and to what extent (Standards 6.3 and 6.4 of the WCO Revised Kyoto Convention). According to the World Customs Organisation (WCO), 'risk management' is defined as "the systematic application of management procedures and practices which provide Customs with the necessary information to address movements or consignments which present a risk" (WCO, 2010[144]) (Moïsé and Sorescu, 2013[17]). Members are obligated to ensure that SPS measures are consistent with the obligations set out in both the WTO SPS Agreement and the WTO TFA.

[4] Common SPS measures include: Import controls for SPS reasons; tolerance limits for residues and use of substances; labelling, marking, and packaging requirements (when these relate directly to human, animal or plant life, or food safety); hygienic requirements (including hygienic practices during production); treatment for elimination of

Digital technologies can facilitate the rapid communication of information between stakeholders, enabling greater trust and coordination in SPS systems, particularly in regulatory inspections and official controls. These information flows can also support the scientific processes for risk assessment and management. SPS systems can benefit from the adoption of digital technologies not only by government authorities, but also by farmers, growers, and other agri-food chain actors (Jouanjean, 2019[15]). All of these impacts have a significant function in facilitating trade at both a regional and global level.

As noted by the UN Conference on Trade and Development (UNCTAD), mainstreaming the use of digital technologies in trade facilitation reform is not merely an obligation for most countries, but a necessity. This is especially the case as a greater number of countries shift towards paperless trade. However, recent results from UNCTAD's global survey on Digital and Sustainable Trade Facilitation show a significant lag in the adoption by governments of digital technologies for trade facilitation. The report also indicates potential for global improvements in paperless trade (UNCTAD, 2020[16]), and analysis suggests these and other trade facilitation measures have the potential to reduce overall trade costs by between 14% and 18% depending on the geographic region (Moïsé and Sorescu, 2013[17]).

This paper examines the ways in which digital technologies can create efficiencies in SPS systems from design through to implementation. These technologies offer new capacities to create, manage, and share information, and offer solutions or improvements to a range of existing issues, especially delays and uncertainties due to incomplete or unreliable information exchange, and the risk of fraudulent behaviour (OECD, 2019[12]). Digital technologies can reduce regulatory burden for governments and businesses and improve efficiency of expenditure for governments, while making it easier to meet SPS system objectives: the safe and dependable trade of food and agricultural products (including forestry and fisheries products).

The cross-border dimension of SPS systems does, however, present challenges for the uptake of digital technologies. Countries must consider the elements required for the smooth implementation of these technologies (including regulatory reforms and investment in both technology and human resources) and must coordinate amongst government agencies (including customs authorities), trading partners, and international organisations.

Notably, countries should follow the guidance set by the "three sisters" standard-setting organisations recognised in the WTO SPS Agreement. These 'three sisters' organisations are responsible for developing standards, guidelines, and recommendations, which support the SPS Agreement's harmonisation principle in relation to:

- animal health and zoonoses (diseases that are transmissible to humans) – the World Organisation for Animal Health (OIE);
- plant health – the International Plant Protection Convention (IPPC); and
- food safety – the Codex Alimentarius Commission (CAC).

Section 2 of this paper examines current trends in countries using digital tools to address existing constraints within the three stages of the SPS regulatory framework: risk assessment; risk management; and verification of compliance in the movement of products. Specifically, the paper examines trends in the exchange of SPS electronic certificates (e-certification)[5] and country responses to the COVID-19 pandemic

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pests and organisms (including cold / heat treatment, irradiation, and fumigation); production or post-production requirements (including plant-growth processes, animal-raising processes, food and feed processing, or storage and transport conditions); and control, inspection, and approval assessments relating to SPS (including product registration, resting, certification, inspection, traceability, quarantine, and the distribution and location of products after delivery) (UNCTAD, 2019[143]).

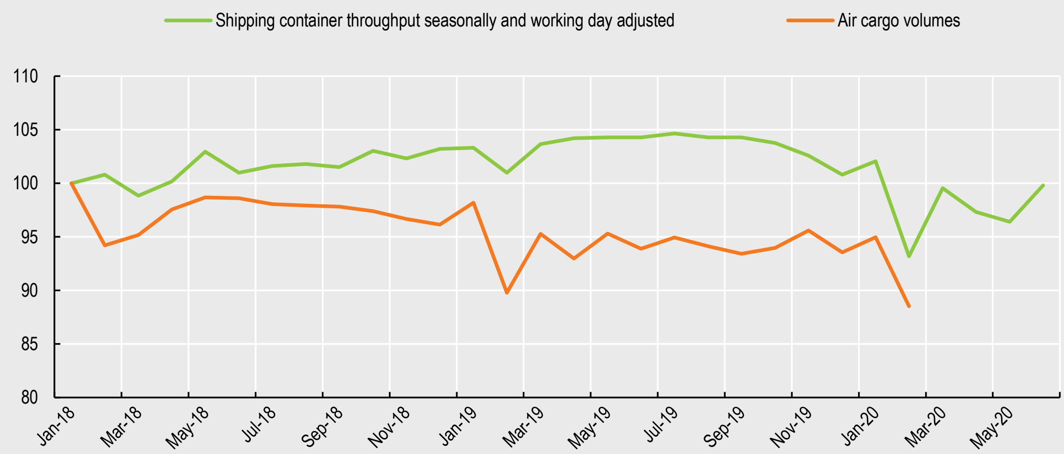
[5] This summary uses information from responses to questions sent by the Secretariat in July 2020. Requests for this information were sent to Argentina, Australia, Brazil, Canada, Chile, Costa Rica, the European Union, Japan, Korea, Mexico, the Netherlands, New Zealand, and the United States. Responses were received from Argentina, Australia, Brazil, Canada, Chile, Costa Rica, the European Union, Japan, Korea, Mexico, New Zealand, and the United States.

(Box 1). Section 3 examines the potential for digital technologies to create efficiencies in SPS systems. Drawing on the analysis in sections 2 and 3, section 4 assesses the trade facilitating impacts of electronic SPS certificates on agro-food trade using a gravity model. Section 5 identifies the challenges associated with the expanded use of these technologies, and identifies the conditions required to address these challenges.

Box 1. Use of digital SPS technologies in response to the COVID-19 pandemic

The COVID-19 pandemic has given rise to an unprecedented health crisis and caused significant disruption for international trade (OECD, 2020[18]). These effects are illustrated in the decline of cargo volumes during the first COVID-19 wave, between January and May 2020.

Figure 1. Sea and air cargo



Note: IATA statistics are available to March 2020 only.
Source: OECD, drawing on data from Innovative Solutions in Maritime Logistics (www.isl.org/en/containerindex) and International Air Transport Association (www.iata.org). (Accessed October 2020)

It should be noted that despite the disruptions associated with the COVID-19 pandemic, trade in agricultural products has been more resilient than overall trade, reflecting the essential nature of food and the resulting relative income-inelasticity of demand. For example, while overall merchandise trade fell sharply in the first half of 2020, agricultural and food exports increased by 2.5% during the first quarter compared to the same period in 2019, with an increase of 3.3% in March and an increase of 0.6% in April (WTO, 2020[19]).

The United Nations Food and Agriculture Organisation (FAO) has recommended countries adopt a proactive response to the pandemic by avoiding trade-restrictive policy measures, enhancing market transparency and coordination, and following international guidelines on safe travel and trade corridors (FAO, 2020[20]). Other multilateral organisations have noted the importance of leveraging technology, digital trade, and Single Window trade (streamlined government-mandated platforms allowing the submission of information to fulfil regulatory requirements electronically between supply chain actors and authorities) to allow businesses to continue operations (AEM, 2020[21]).

Indeed, in the context of this disruption, the use of digital technologies in SPS systems, most significantly e-certification systems, is helping countries to minimise the negative effects of social distancing measures introduced by many countries on the trade flow of both plant and animal products. While the COVID-19 pandemic has not represented a complete shift towards e-certification, it has provided a push in this direction (STDF, 2020[22]). The COVID-19 pandemic is presenting an opportunity to increase the uptake of e-certification systems, which reduce the need for personal contact and handling of paper certificates, including the costs of having to send these, in some cases using chartered flights. Countries have also instituted time-bound exceptions to compliance with SPS verification requirements: Argentina, Australia, Chile, Costa Rica, the European Union, Indonesia, Japan, Mexico, the Philippines, the Russian Federation, South Africa, Chinese Taipei, and the United States are accepting electronic copies of SPS certificates in lieu of original documentation due to travel restrictions (WTO, 2020[23]). New Zealand has extended its e-certification pilot with the People's Republic of China for all dairy exports due in part to the COVID-19 pandemic, and has also moved to partial e-certification for sanitary products with Samoa, New Caledonia, French Polynesia, Papua New Guinea, and Tonga.

Reports from the ePhyto Hub, the International Plant Protection Convention (IPPC) system for the centralised exchange of phytosanitary e-certificates, demonstrate a significant increase in countries exchange of e-certificates for plant products in early 2020. The total number of certificates exchanged increased from 7 992 in December 2019 to 23 343 in March 2020, 56 496 in June 2020, and 45 351 in August 2020 (IPPC, 2020[24]). This trend also reflects the linking of EU TRACES to the ePhyto Hub in May 2020, which has contributed to the exchange of approximately 20 000 additional e-certificates per month. This linking was already planned, and was not precipitated by the COVID-19 pandemic.

These responses to COVID-19 illustrate the advantages of using digital technologies, particularly e-certification, within SPS systems. Digital technologies add flexibility, resilience, and adaptability within SPS systems, and allow countries to minimise the disruptions to trade flows while maintaining protections for the healthy and safe trade of food products. The increased use of e-certification has helped staff in SPS agencies to become more familiar with the use of digital technologies. It is possible that these responses will lead to permanent changes to SPS systems.

2. Country use of digital technologies within SPS systems

Countries are using a range of digital technologies within each of the three stages of SPS regulatory framework: risk assessment, risk management, and the verification of SPS compliance in the movement of products. These technologies are most commonly used in compliance verification activities (third stage), which for many countries comprises the vast majority of SPS system activity. Each of these three stages also benefits from the WTO SPS transparency system, a digital notification platform providing access to centralised information about draft SPS measures around the world, and enabling an inclusive rulemaking process for SPS policies through stakeholder engagement. This transparency system is supported by the WTO "ePing" alert website which disseminates information on these SPS notifications, makes it easier for countries to comment on draft SPS measures, and facilitates private and public sector cooperation in resolving potential trade problems. The "ePing" website was launched in November 2016, and works by creating a searchable database of SPS requirements and allowing policy makers, exporters, importers, investors, and other parties to keep track of these requirements.[6] WTO SPS notifications are also available on the WTO Documents Online and SPS Information Management systems.[7]

[6] See https://www.epingalert.org/en.

[7] See https://docs.wto.org/ and http://spsims.wto.org/.

Although countries conduct risk assessment and risk management activities as discrete processes, there is a degree of overlap between these stages. Member countries often conceive of risk assessment as being a matter of scientific inquiry, and risk management as being a question of policy, based on the outcomes of this inquiry. However, these processes are in fact closely related (WTO, 2020[25]), and some digital technologies (including platforms for the collection, transmission, and sharing of data) are used in both of these stages.

2.1. Digital technologies within risk assessment

The WTO SPS Agreement tasks every country to take measures to protect human, animal, or plant health consistent with the disciplines set out in the Agreement. Central to this approach is the requirement that countries base their SPS measures on scientific risk analysis to ensure the restrictions, requirements and standards applicable to products imported are necessary and the least trade restrictive (Spreij, 2007[3]) (Jouanjean, 2019[15]).

The biggest challenges facing trade in agriculture and food – particularly in trading fresh products – is to manage trading billions of dollars' worth of products without accidentally spreading human, animal, or plant diseases and pests, or importing food considered to be harmful according to domestic regulation, and to do so in a way that minimises delays. Perfect access to information about product conditions before export would make it easy to decide whether a product is fit for import and whether any treatments should be applied before entry. However, such perfect information is costly to create, and complex to coordinate across the large number of stakeholders. Thus, SPS systems have evolved to cope with imperfect access to information, information gaps and asymmetries, and misalignments of incentives by taking a risk-based approach to the trade of agriculture and food products via risk assessment.[8]

Risk assessments take into account scientific evidence; relevant information about the production or processing methods used to develop the product in question; information from the inspection, testing, and sampling of products (both in the importing and exporting country); the prevalence of pests and diseases (in the importing and exporting country); and related factors. Assessing risks requires access to specialised information and expertise. These processes are complex, and can be long and costly (Spreij, 2007[3]).

Digital technologies have significant potential to make these assessments of risk more precise, informed and consistent. By making it easier to gather, analyse, and share information between countries (for example, on the existence and prevalence of pests in different countries), digital technologies offer significant efficiency gains for countries in the development and maintenance of SPS measures (OECD, 2019[12]). They also provide countries with the ability to conduct risk assessments with greater accuracy, making it less likely that countries will institute risk management policies that are either too stringent or insufficiently stringent based on incomplete or outdated information (Jouanjean, 2019[15]). For example, the OIE World Animal Health Information System (OIE-WAHIS) is an online database containing officially reported health status and veterinary service capacity information for country use when conducting import risk assessments.[9] Upgrades currently underway to OIE-WAHIS will allow for improved interoperability with digital systems for national and regional surveillance and outbreak management, beginning with a pilot to link the European Commission's Animal Disease Notification System to OIE-WAHIS to facilitate efficient reporting and information sharing (OIE, 2018[26]).

In particular, the capacity of countries to conduct risk assessments is being enhanced by the growth of Internet of Things technology. The WTO estimates suggest the number of internet-connected devices in the world will grow to approximately 75 billion by 2025, expanding the ability of countries to source,

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[8] It should be noted that while this paper focuses primarily on SPS systems for the trade of agricultural and food products, SPS measures also apply to trade in other goods (for example, furniture and other household goods).

[9] Further information is available at https://www.oie.int/en/animal-health-in-the-world/wahis-portal-animal-health-data/.

aggregate, and analyse food systems data accurately and efficiently (WTO, 2019[27]), and providing countries with the potential for more accurate assessments of risk within SPS systems. Alongside this technology, artificial intelligence and the analysis of big data can enable actors to better understand how agricultural products are produced, processed, transported, and stored, and share data securely along complex agricultural value chains (Tripoli, 2018[28]).

Additionally, significant advances in data acquisition, storage, communication, and processing technologies have enabled the rapid transfer of vast quantities of data, and have greatly increased the ability to process large datasets and automate analytical processes with machine learning (Jouanjean, 2019[15]) (Mangalam and Vranic, 2020[11]). Through facilitating the accurate and trusted dissemination of product information, digital technologies can provide a higher degree of knowledge and certainty regarding the risks presented by certain products, and the strategies and steps required to effectively manage these risks (OECD, 2019[12]). For example, countries can use digital platforms to collect, analyse, and share information regarding the toxicology risks involved with certain food products, informing their assessment of the risks associated with importing these products (Barlow et al., 2015[29]).

There is significant potential for SPS systems to be improved by digital technologies through the analysis of data within risk assessment activities. While revenue agencies (such as tax collection departments) have established practices in the use of data analysis techniques to identify risk indicators and their relative importance (Khwaja, Awasthi and Loeprick, 2011[30]), until recently this had been difficult to replicate for other areas of regulatory risk assessment. However, recent advancements in Machine Learning offer promising improvements in analysing data to understand and predict risk, and could allow for risk assessments within SPS systems to be considerably more effective (OECD, 2020[31]). These technologies are, however, still emerging.

2.2. Digital technologies within risk management

Based on risk assessments, countries then identify strategies for the management of risk, establishing the level of protection required to enable trade. For example, a country may use information regarding the presence of pests in other countries to categorise the goods, plants, or shipments it considers to be associated with a higher or lower risk of the accidental introduction or spread of these pests. It would then specify fumigation requirements for plant products from other countries to reflect this risk assessment. As with risk assessment activities, digital technologies have the potential to not only make risk management more efficient (for example, reducing the time and cost involved with inspecting goods consignments); they also enable countries to identify risk management strategies that are more informed, accurate, and effective. For example, digital sensor technology may make it possible to detect the presence of pests at a far more stringent threshold (Lima et al., 2020[32]), allowing a country to adjust their SPS requirements to reflect this added capability and provide greater protection against the potential entry of these pests.

Border inspections can involve a number of related processes, including: reviewing SPS certificates and other import documentation for relevance, accuracy and validity; and checking of the general condition of the entire shipment. For example, in the case of a frozen product, the inspector may check whether the container shows water stains that may indicate defrosting, leaking or water damage. Inspection can also entail the testing of the product, involving sensory evaluation or random sampling including laboratory analysis, or, for high-risk foods, a mandatory lot-by-lot inspection (FAO, 2016[33]).

In addition to border and customs agency risk management activities, countries also incorporate a range of in-country checks, data gathering, and data sharing controls and within their national SPS systems. These include systems for the detection of pests and diseases within national food and agriculture systems, and platforms allowing for any outbreaks of disease to be monitored and controlled. The presence of these in-country systems helps trading partners to classify countries of origin into different categories of risk regarding importing and exporting activities. As with border and customs agency activities, digital technologies have the potential to improve the efficiency and effectiveness of these in-country control systems through facilitating the easier gathering, analysis, storage, and transmission of SPS system data.

In the case of border and customs agencies, countries are already using algorithms and data analysis tools to increase the efficiency of cross-border controls, for example, Spain's automated customs management system allowing inspection officers to sort incoming goods on the basis of pre-assessed risk (OECD, 2016[34]). For large trading countries, the use of these technologies has allowed border agencies to continue fulfilling monitoring requirements despite increasing trade flows. However, according to the 2019 OECD Trade Facilitation Indicators, in only 48% of the 163 countries surveyed, are risk management systems applied and operating in an automated environment (OECD, 2020[35]).

Box 2. Regional pest detection and information-sharing framework

The partnership between the Standards and Trade Development Facility and Australia's Department of Agriculture and Water Resources to improve the accuracy and speed of pest detection in Thailand, Laos, Malaysia, Cambodia, Viet Nam, the Philippines, and Papua New Guinea offers a useful example of digital technologies being used to set strategies for SPS risk management.

Established in late 2016 and running to January 2021, this project uses digital surveillance, data exchange, and mobile communications technologies to allow trading partners to demonstrate their pest status to importing countries, facilitating access to valuable markets. National Plant Protection Organisations (NPPOs) in these countries are being trained to use handheld mobile devices on which a customised 'P-tracker' app is installed. This app is designed to collect and share surveillance data. This regionally harmonised pest information framework helps the participating countries to compile credible maps of pest status (STDF, 2018[36]).

This project demonstrates the value of digital technologies in improving a shared understanding of pest distribution, reducing chances of human error and assisting in the early detection of high-priority quarantine pests by sharing data and alerts in real time.

For instance, in the Philippines the project is enabling closer surveillance of coffee berry borer, coffee leaf rust, cocoa pod borer, and cocoa pod rot. The data collected and shared as a result of this surveillance have been critical in allowing the Philippines to demonstrate its pest status to trading partners and maintain access to regional and international markets. Though this project is time-limited, a number of participating NPPOs have indicated that they intend to continue using digital tools for pest surveillance (STDF, 2018[36]).

Digital technologies enable new solutions that change the way border services conduct these risk categorisation and inspection activities, allowing authorities to better distinguish between high and low-risk goods, and enabling the more effective allocation of limited inspection resources. This results in improved health protections, and also in reduced costs for businesses in complying with risk management measures.

These technologies go beyond the use of historical data for profiling of consignments to determine inspection decisions, for example, using weather data or other data about the pest status in the region of provenance to improve risk categorisation (Okasaki, 2017[37]). In addition to existing risk management methods based on historical data (for example, type of goods, country of origin, trading operator, and producer), decision-making or predictive intelligence tools using big data analytics can also assess vast amounts of trade information to notify border officers that they should perform an inspection on a given cargo (for example, based on travel time or weather conditions during travel). The use of surveillance drones also has significant potential for risk management procedures in the movement of goods, and is currently being implemented by a number of countries including the United States and within the European Union (Koslowski and Schulzke, 2018[38]). For example, Colombia has reported the use of drone technologies to identify illegal border crossings of livestock from its porous border with Venezuela, which is suspected to have been the cause of several outbreaks of foot-and-mouth disease since mid-2017 (Alsema, 2017[39]) (Arana, 2020[40]).

A number of governments are also implementing electronic pre-arrival processing as part of their risk management processes, including Canada's use of SPS e-certificates exchanged with Australia to assess consignment risk in advance,[10] and the Netherlands' development of a 'Virtual Inspector' to draw from the details included in e-certificates in analysing risk.[11] The use of these technologies facilitates the movement of agricultural and food products. The information contained in e-certificates can also improve or automate border management and risk categorisation for physical inspections, allowing countries to optimise the allocation of resources and speed up the decisions to release goods (UNCTAD, 2011[41]).

These remote (or "virtual") inspections can potentially save time and resources in conducting regulatory supervision, leading to increased efficiencies and an increased ability to reach remote locations or operate in difficult circumstances (for example, during lockdown situations such as those imposed by the COVID-19 pandemic). Virtual inspections can involve inspectors reviewing documentary evidence and discussions with importers and exporters, and also observing sites through video streams. This inspection technology is being considered in a number of jurisdictions and regulatory domains, and enables agencies to save transport and staff costs, reduce processing times, and ensure a lower risk of contamination. However, these virtual inspections also involve consideration of a number of potential disadvantages, as effectively assessing compliance with SPS regulations can involve being able to examine a physical location for hidden issues, interacting with different employees, and other observing activities that can be challenging to replicate remotely (OECD, 2020[31]).

Through informing these risk assessment and management activities, digital technologies also offer a new level of government accountability within SPS systems (WTO, 2019[27]). Combining and integrating these data at the level of SPS systems enables countries to model future patterns in imports and exports, helping countries to set tailored risk management strategies (IPPC, 2018[42]). These technologies contribute to harmonisation, recognition of equivalence, and the adoption of least restrictive trade policies and contribute to the effective implementation of the WTO SPS Agreement (Jouanjean, 2019[15]), and enable countries to take more risk-targeted and risk-proportional approaches with SPS regulatory systems (OECD, 2020[31]).

2.3. Digital technologies within product movement and compliance verification

While countries are applying digital technologies in the assessment and management of risk within SPS systems, the most significant area of current country activity is the verification of SPS control, inspection, and approval procedures in facilitating the movement of products, specifically the use of bilateral, plurilateral, and multilateral systems for the exchange of e-certificates (Box 3).

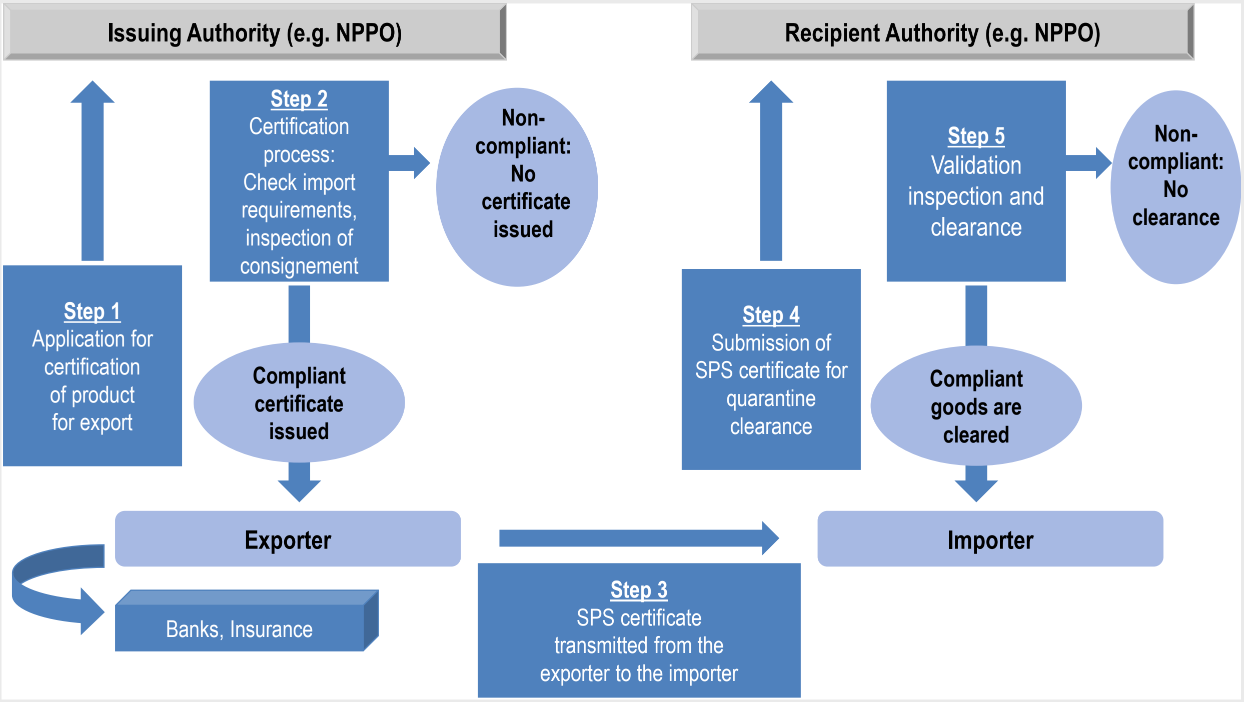
[10] Interview with Barbara Cooper, Meat Exports Branch, Australian Department of Agriculture Water and the Environment, July 2019.

[11] Interview with Alexander Moret, E-Cert Specialist, Netherlands Food and Consumer Product Safety Authority, June 2019.

Box 3. SPS certificates

For a plant, animal, or food product to enter an export market it must frequently be accompanied by an SPS certificate. SPS certificates are the proof that exported products comply with the SPS requirements of the importing country (established in accordance with a risk assessment and the resultant risk management measures). The transmission of SPS certificates (which are official documents) is a cross-border government-to-government exchange between the competent SPS authorities of importing and exporting countries (Lopez, 2015[43]). Figure 2 illustrates the transmission of a paper-based phytosanitary certificate.

Figure 2. Process for the transmission of a paper-based phytosanitary certificate



Source: Adapted from Lopez (2015[43]).

Within this process, exporters apply for a certificate with the competent authority in their respective country (for example, the NPPO for plants). The authority reviews the application and assigns an inspector to check that the import requirements of the importing country are met (this is also linked to in-country SPS controls such as regional pest or disease detection platforms). For animals and plants, physical inspections are often required, and performed either by public or private entities. According to the results of the inspection, the competent authority either issues a certificate or denies export authorisation. In some cases, risk mitigation measures are mandated for non-compliant consignments (for example, additional pest disinfestation procedures), before another inspection is performed. After payment and issuance of the certificate, the certificate can be sent to the importer.

2.3.1. How countries are advancing e-certification systems

Table 1 provides a summary of select countries' use of e-certification systems. It also notes the national e-certification systems administered by individual countries, and states where these systems are available only to specific trading partners with respect to specific products. This table represents a snapshot of country activity based on responses to a survey provided to the OECD in August 2020. Many countries around the world have initiated processes to develop the use of e-certificates, but it is difficult to establish the exact number of operational systems and the extent to which they are delivering expected outcomes. It should also be noted that this table is not an exhaustive list of activity; countries may be exchanging e-certificates more widely than reported. In the case of the ePhyto Hub, countries can freely exchange phytosanitary e-certificates ("ePhytos") with any of the 46 active members of the Hub, and are not limited in their exchange of ePhytos to the countries listed in Table 1. The ePhyto Hub is discussed in Section 2.3.3.

The establishment of in-country e-certification systems involves four phases of implementation: the exchange of e-certificates with exporting or importing countries; the development of e-certificate management systems; the integration of e-certificates into border clearance processes; and the development of in-country processes facilitating digital business transactions (UNECE, 2016[44]). Countries must consider the legal frameworks needed to support these systems, as well as providing certainty on the use of SPS data and the cooperation required between SPS and border agencies. These considerations are discussed in section five.

The 2019 United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) study of trade facilitation indicators showed that 46 out of the 128 countries surveyed had implemented systems for the electronic exchange of SPS certificates fully, partially, or on a pilot basis. Only 13 of these countries reported full implementation (UNESCAP, 2019[45]). It should be noted that even though countries may be exchanging e-certificates, completely paperless exchanges are not yet common. In the short-term, many countries may need to continue to maintain a paper-based system (in addition to implementing paperless systems) due to legislative or regulatory requirements.

The range of country activity described in Table 1 illustrates trends in the electronic exchange of SPS certificates. It should be noted that the use of the EU TRACES system to manage the import of goods subject to phytosanitary and sanitary certificates has been mandatory for all EU Member states since December 2019. For goods exported from the European Union, the situation is as follows:[12]

- Member States are using their own systems for the exchange of veterinary e-certificates, except in relation to harmonised certificates (of which there are approximately 40 models) where TRACES is used; and
- Member States can use TRACES for the exchange of phytosanitary e-certificates as of 2020.

It should be noted that the Netherlands – one of the earliest adopters of SPS e-certification for its exports of meat, dairy products, and cut flowers – also has its own e-certification platform (UNECE, 2016[44]), e-CertNL. This situation is unique, and a process is underway to converge these systems to the single TRACES platform receiving certificates from third countries.

[12] Interview with Philippe Loopuyt, Lead of the EU TRACES, Directorate SANTE.DDG2.G (Crisis management in food, animals and plants), European Commission, DG Health and Food Safety, August 2020.

Table 1. Summary of countries using e-certification

Country / Organisation	Sending phytosanitary?	Receiving phytosanitary?	Sending sanitary?	Receiving sanitary?	Using ePhyto Hub?	Governing agreement	E-certification platform[1]
Argentina	Chile (May 2020), United States (July 2020)	Chile (May 2020), United States (July 2020)	No	No	Yes	Bilateral and multilateral (ePhyto Hub)	Bilateral e-certification exchange system
Australia	New Zealand (since 2004, fully paperless from September 2020), Indonesia (2019), 15 other countries and European Union Member states	New Zealand (since 2004, fully paperless from September 2020), Indonesia (2019), 15 other countries and European Union Member states	Japan (since 1998), New Zealand (since 2004, fully paperless from September 2020), Indonesia (2019)	New Zealand (since 2004, fully paperless from September 2020), Indonesia (2019)	Yes	Bilateral (eCert platform) and multilateral (ePhyto Hub)	Bilateral eCert platform
Brazil	Yes	Yes	No	No	Yes	N/A	N/A
Canada	No	No	No	For meat products from Australia and New Zealand meat (2013)	Testing	Bilateral	Bilateral e-certification exchange system
Chile	China (2016), Russia (2016), Mexico (2019), Colombia (2020), Argentina (2020), Peru (2020), United States (2020), European Union (2020), The Netherlands (2020), Sri Lanka (2020)	Mexico (2019), Colombia (2020), Argentina (2020), Peru (2020), United States (2020), Sri Lanka (2020)	China (2016), Russia (2016)	No	Yes	Bilateral, multilateral, and plurilateral	Bilateral e-certification exchange system
Costa Rica	Argentina, Germany, Austria, Belgium, Bulgaria, Cyprus[2], Croatia, Denmark, Slovakia, Slovenia, Spain, Estonia, Finland, France, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Czech Republic, Romania, Sweden, Brazil, Chile, Fiji,	Mexico, Ecuador, France, New Zealand, Peru, Australia, Spain (all since March-April 2020)	No	For meat products from Mexico, Ecuador, France, New Zealand, United States, Peru, Australia, Spain, dairy products from Canada, and fish products from Philippines and Maldives (all since March-April 2020)	Yes	Multilateral (ePhyto Hub)	N/A

Country / Organisation	Sending phytosanitary?	Receiving phytosanitary?	Sending sanitary?	Receiving sanitary?	Using ePhyto Hub?	Governing agreement	E-certification platform[1]
	Ghana, Jamaica, Mexico, Morocco, New Zealand, Samoa, South Africa, Sri Lanka, United States (all since May 2020)						
European Union	Tunisia and five other remote European territories using TRACES to issue phytosanitary e-certificates	Via the ePhyto Hub: Argentina, United States, Chile, Costa Rica, Morocco, Uganda, Fiji	No	Uruguay, Morocco, Peru fully paperless; Australia, New Zealand, and United States (dairy) in data exchange migrating to paperless; 48 other countries using TRACES to encode their sanitary certificates	Yes	Multilateral (EU TRACES platform)	Multilateral EU TRACES platform
Japan	No	No	No	For meat products from Australia (since 1998)	No	Bilateral	Bilateral eCert platform
Korea	Yes	Yes	No	New Zealand (meat and dairy) (2017)	Yes	Bilateral and multilateral (ePhyto Hub)	Bilateral e-certification exchange system
Mexico	Colombia, Chile, Peru (August 2019)	Colombia, Chile, Peru (August 2019)	No	No	Yes	Bilateral and plurilateral (Pacific Alliance)	Bilateral e-certification exchange system
The Netherlands	Chile, China, Columbia, Indonesia, Kenya, Mexico, Peru, South Africa, and the United States	Yes	Australia, Belarus, Chile, China (dairy and meat paperless), Indonesia, Russia (trial paperless September 2020), and the United States	Yes	Yes	Bilateral, multilateral, and plurilateral	Bilateral E-CertNL platform
New Zealand	United States (2018), Australia (fully paperless September 2020), European Union (mid-	United States (2018), European Union (mid-2020), Australia (fully	Dairy products to China (2018), meat to United States (2010), meat and	Australia (fully paperless September 2020)	Yes	Bilateral and multilateral	Bilateral E-cert platform

Country / Organisation	Sending phytosanitary?	Receiving phytosanitary?	Sending sanitary?	Receiving sanitary?	Using ePhyto Hub?	Governing agreement	E-certification platform[1]
	2020), Korea (2017), Argentina (2018)	paperless September 2020), Indonesia (2018), Korea (2017), Argentina (2018)	seafood to European Union (2015), Australia (fully paperless September 2020), all animal products except fish to Indonesia (2017), Canada (2002), Korea (2017), sea freight to Jordan (2005), Singapore, Philippines, Russia, partial use with Samoa, New Caledonia, French Polynesia, Papua New Guinea, Tonga (2020)	Partial use with Samoa, New Caledonia, French Polynesia, Papua New Guinea, Tonga (2020)			
United States	Potential to send and receive with all 46 countries active in ePhyto Hub (since 2018)	Potential to send and receive with all 46 countries active in ePhyto Hub (since 2018)	Yes (COVID adjustment)	Yes (COVID adjustment)	Yes	Bilateral, multilateral, and plurilateral	Bilateral eCERT system

Notes:
1. These country-specific platforms can be accessed at: https://www.agriculture.gov.au/import/online-services/electronic-certification, https://webgate.ec.europa.eu/sanco/traces/, https://e-cert.nl/en/, https://www.mpi.govt.nz/exporting/export-certification/animal-products-ap-e-cert/, and https://www.cbp.gov/trade/quota/ecert.
2. Note by Turkey: The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the "Cyprus issue".
Note by all the European Union Member States of the OECD and the European Union: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

Source: Country responses provided to OECD, August 2020.*

* In addition to the information presented, countries offered the following updates: Australia's exchange of phyto e-certificates with New Zealand is occurring outside of the ePhyto Hub, with the intention to transition these to the hub from 30 September 2020. Brazil and Canada are currently working towards accessing the ePhyto Hub. Canada is also implementing an e-Certification and Digitisation project to automate export certification processes. The European Union expects to begin sending sanitary e-certificates in the 2nd-3rd quarter of 2021. Mexico is working towards the exchange of sanitary e-certificates with the other Pacific Alliance member countries (i.e. Chile, Colombia, and Peru), is reviewing the feasibility of connecting to EU TRACES and the ePhyto Hub, is working towards exchanging phyto e-certificates with the United States through a Single Window platform, and is accepting electronic certification for plant health from a range of countries during the COVID-19 pandemic. New Zealand is actively supporting Pacific Island countries to connect with its eCert platform via IPPC GeNS functionality, is committed to exchanging phyto e-certificates with China before looking at other commodities, has working commitments and basic trials with Viet Nam and Malaysia for electronic exchange of all SPS certification, plans to send phytosanitary certificates to Indonesia in late 2020, and is trailing halal e-certification with Indonesia. The United States still requires paper certification to accompany e-certificates, but is testing the ability to receive e-certificates exclusively. To facilitate trade during the COVID-19 pandemic the United States has temporarily waived requirements for physical copies of certificates.

A small number of trading partners have transitioned to fully paperless bilateral e-certification systems, for example New Zealand and Australia for both plant and animal products (Australian Department of Agriculture, Water, and the Environment, 2020[46]), and Argentina and Chile for plant products (IPPC, 2020[47]). Sri Lanka is also exchanging fully paperless e-certificates with Argentina and Chile.[13] This means e-certificates are considered equivalent to paper certificates, as these contain the same information and offer the same legal guarantees (STDF, 2017[5]). However, the wider implementation of paperless e-certification is occurring slowly. As noted in the UNESCAP 2019 *Global Survey on Digital and Sustainable Trade Facilitation*, the global average implementation of trade facilitation indicators relating to 'paperless trade' stands at 61%, whereas the implementation level for 'cross-border paperless trade' stands at only 36% (UNNExT, 2019[48]).[14]

While some countries have invested in the digitisation of SPS certification, these procedures are still mostly paper-based (IPPC, 2018[49]). Hardcopy documents must be filled in, signed, issued, printed, shipped directly along with the consignment, and distributed manually (Moïsé and Sorescu, 2013[17]). These paper certificates can be prone to errors and forgery, and can often be lost or damaged, causing delays and additional processing costs. Copies of these certificates are usually not accepted due to the risk of fraud. Shifting from paper-based systems to the exchange of digital documents enables greater efficiency, and creates a higher degree of system integrity (STDF, 2017[5]). However, this shift requires the comprehensive analysis of all related business processes (including the exchange of data between border and customs authorities) to ensure the acceptance of e-certificates is reflected in all associated systems.

Furthermore, paper versions of SPS certificates may still be required for different purposes. For instance, banks in importing countries may still request SPS certificates from exporters as a term of issuing letters of credit, which can limit the ability of businesses to give payment assurances (STDF, 2014[50]). Paper certificates may also be needed for other judicial procedures in an importing country. As seen during the COVID-19 pandemic, such practices can give rise to disruptions in trade (OECD, 2020[18]). In some cases, these practices have necessitated the use of charter flights by exporting businesses to deliver paper certificates. Country efforts to expand the use of e-certification must take these challenges and practices into account. It should also be noted that until paperless trade is implemented in full, countries may have to continue to maintain both paper and digital SPS certification systems in parallel. This may result in the requirement for additional resources for countries to manage the interface between these systems and ensure the provision of clear information and guidance for importers and exporters.

More broadly, the shift towards e-certification is part of a growing international trend towards the adoption of Single Window trade systems (OECD, 2018[51]). These systems are streamlined government-mandated platforms allowing for the electronic submission of all information to fulfil regulatory requirements (i.e. permits, licences and certificates for customs purposes) between supply chain actors and government authorities (UNECE, 2020[52]). As with e-certification systems, countries are adopting these systems at varying speeds. For example, Singapore began development of its Single Window 'TradeNet' system in 1986, and implemented this system in early 1989 (UNESCAP, 2018[53]). In addition, New Zealand has reported an increasing focus on connecting with trading partners' Single Window platforms when progressing e-certification goals, further illustrating the increasing relevance of these platforms.

[13] Interview with Craig Fedchock, Senior Advisor, IPPC Secretariat, August 2020.

[14] The indicators for "paperless trade" and "cross-border paperless trade" each consist of a series of specified measures, for example, the availability of an electronic or automated customs system, e-payment of customs duties or fees, the use of an electronic Single Window System. A full list of these indicators is available in the 2019 Global Report.

Box 4. Approaches to e-certification by the three sisters

The 'three sister' organisations recognised by the WTO SPS Agreement have to date taken different approaches to e-certification within SPS systems.

The IPPC issued guidelines for electronic phytosanitary certification in 2017, providing guidance on standardised language, harmonised message structure, and exchange protocols for National Plant Protection Organisations (NPPOs) (IPPC, 2017[54]). These efforts enabled the IPPC to establish the multilateral exchange of electronic phyto-certificates ('ePhytos') via the ePhyto Hub.

The OIE developed Article 5.2.4. of the Terrestrial Animal Health Code on "electronic certification" for animal health in 2014 (OIE, 2019[55]), and managed the STDF project 'Development of a Framework to Facilitate E-Veterinary Certification for International Trade on the Basis of a Single Window System' on behalf of applicant countries Cambodia, Eswatini, Nigeria, Paraguay, and Zimbabwe (OIE, 2020[56]). Recommendations from the report of this project are currently being considered by the OIE (STDF, 2020[22]).

The Codex Alimentarius Commission's (CAC) Committee on Food Import and Export Inspection and Certification Systems (CCFICS) established an electronic working group (EWG) in 2016 to prepare a discussion paper and a project document on the use of electronic certificates (paperless certification). In 2017, CAC approved the new work on paperless use of electronic certificates based on the project document submitted by CCFICS. The EWG[1] has developed a proposed draft guidance on the paperless use of e-certificates, including a generic model that could form the basis of official certificates (Codex, 2020[57]). The propose guidelines[2] will be discussed at the next meeting of the CCFICS scheduled for March 2021. Note that this ongoing work includes the revision to the existing Codex Guidelines for Design, Production, Issuance and Use of Generic Official Certificates (CXG38-2001) to include paperless exchange of electronic certificates.

While OIE and Codex offer guidance for countries to develop wider systems for e-certification of animal products and food products, respectively, unlike the IPPC these organisations are not directing the development of the systems or establishing the systems themselves (OIE, 2020[56]). Expert interviews suggest there is significant scope for cooperation among the three sisters in relation to SPS e-certification, especially in harmonising the exchange of e-certificates through the use of XML messages.[3] For example, the three organisations could examine the possibility of using existing multilateral instruments (notably the ePhyto Hub) to support the exchange of a wider set of e-certificates (for example, harmonised sanitary and veterinary certificates).

1. The current EWG comprises forty Codex member countries plus eight observer organisations, including the FAO, IPPC, OIE, UN Centre for Trade Facilitation and Electronic Business (UN/CEFACT) and World Customs Organisation (WCO).
2. Consideration is currently at step three of the eight-step Codex procedure / process, which begins with the Codex Commission's decision to develop a standard (approval) and terminating with the adoption of the standards or guidelines.
3. Interview with Erik Bosker, DVM and Senior Policy Advisor at the Ministry of Agriculture, Nature and Food Quality, The Netherlands, Chair of the CCFICS-EWG developing the proposed draft guidance on paperless use of electronic certificates and author of a recent report for the STDF e-veterinary certification project managed by OIE (OIE, 2020[56]), July 2020.

2.3.2. E-certification is advancing through bilateral and multilateral forums

Countries are advancing the exchange of SPS e-certificates through a range of channels, including multilateral work programmes (for example, the IPPC's ePhyto Hub), under plurilateral trade agreements (for example, the Pacific Alliance trade bloc formed in 2011 between Chile, Colombia, Mexico, and Peru) and as work streams forming part of bilateral trade agreements (for example, the 2014 Korea-New Zealand

Free Trade Agreement). A mixture of all three approaches is used by some countries to achieve their e-certification goals. For example, the United States is exchanging e-certificates through its national eCERT system,[15] and is also using the ePhyto Hub (described in Section 2.3.3). Many countries are also making incremental improvements by shifting some trading partners (or some categories of traded products) from paper certificates to e-certificates over time, indicating that e-certification does not have to be comprehensively adopted to have significant benefits for trading partners or international organisations.

As Table 1 shows, with the exception of phytosanitary certification (wherein 46 countries are exchanging e-certificates within an established business-as-usual framework), a number of e-certification platforms are being advanced through bilateral arrangements based on unique and separate agreements between trading partners outlining the terms of exchange (for example, through trade agreements with chapters outlining the specific SPS measures that will apply to the bilateral trade of plant or animal products). Establishing these bilateral arrangements can be costly for countries, as they require a number of interactions and investments to meet the unique characteristics of each individual bilateral exchange. IPPC studies have estimated the cost of establishing a bilateral system for the exchange of phytosanitary e-certificates to individual trading partners to exceed USD 50 000 per trading country, which can quickly become significant depending on the number of trading partners involved (Gain, B.; Sela, S., 2019[58]). This collaboration requires countries to agree upon provisions on the use and security of exchanged data, systems interoperability, and on the mechanism through which data is to be exchanged. Beyond being technically readable, e-certifications must include guarantees of mutual recognition of data elements, rules, and definitions (STDF, 2017[1]).

The growth of bilateral trade agreements specifying SPS system conditions reflects the increasing willingness of countries to address SPS matters within these agreements, and the growing capacity of developing countries to establish SPS systems where these systems may not have previously existed (WTO, 2020[59]). To encourage the broader standardisation of e-certification systems, the UN Centre for Trade Facilitation and Electronic Business (UN/CEFACT) published the global eCERT standard in 2008, including a message structure based in Extensible Markup Language (XML) and associated data components for developers (UNECE, 2016[44]).

The increasing number of individual trade negotiations has also resulted in a growing diffusion of regional trade agreements (RTAs). These trends have varied impacts on the efficiency and accessibility of SPS systems. Notably, RTAs frequently contain specific SPS chapters which can have a range of trade effects depending on the depth and nature of their provisions. These SPS chapters also establish SPS Committees which meet regularly and set work streams, including commitments to progress e-certification (Santeramo, 2020[60]). Of the 256 RTAs in force in 2015, 176 included SPS provisions (McDaniels, Molina and Wijkström, 2018[61]). Recent studies suggest a growing interest on behalf of countries in elevating the visibility and ambition of regulatory policy and regulatory cooperation, including cooperation in relation to SPS provisions (OECD, 2020[62]).

The variety of different bilateral e-certification agreements can create challenges in terms of system interoperability and harmonisation, and renders the goal of greater integration at the international level more difficult (Pavlovic, 2018[63]).

The widespread use of bilateral negotiations to progress e-certificate negotiations represents a barrier for some countries. For example, the IPPC has calculated that 80 different bilateral agreements for electronic data transmission would be needed for New Zealand to cover all of its trading partners within its SPS system (IPPC, 2014[64]). This focus on bilateral systems also risks creating a digital divide between the countries with the resources to undertake these negotiations and those lacking these resources. A multilateral or ‘single hub’ model (such as the IPPC ePhyto Hub) offers a solution to the proliferation of individual bilateral trade agreements.

[15] See https://www.cbp.gov/trade/quota/ecert.

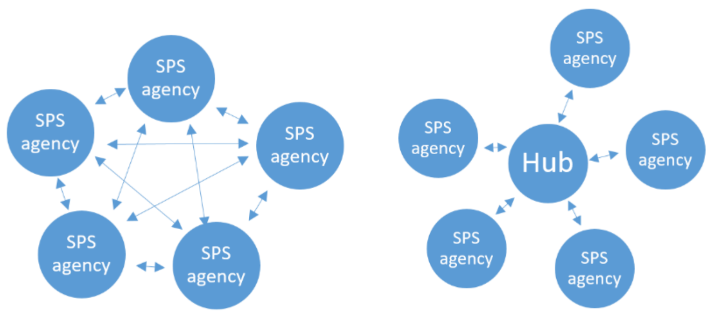
2.3.3. The IPPC ePhyto Hub - a multilateral approach

As Table 1 illustrates, the exchange of e-certificates for plant products ('ePhytos') is more widespread than it is for animal-based products. While countries are using bilateral and plurilateral channels for the exchange of ePhytos, as of late 2019 onwards countries are making increasing use of the IPPC ePhyto Hub.

The ePhyto Hub is a central exchange system for ePhytos that can be used by all countries linked to it, and offers a web-based Generic ePhyto National System (GeNS) for countries without their own e-certificate system infrastructure to participate in the exchange of ePhytos at no cost (IPPC, 2019[65]). The Hub was first established as a pilot in 2017 by the IPPC with financial support from the STDF[16] and donor countries, with the aim of improving the safe trade in plants and plant products by using a standardised certification format for the transmission and retrieval of ePhytos (IPPC, 2019[66]). This pilot involved ten countries (Argentina, Australia, Chile, The People's Republic of China – hereafter "China"–, Ecuador, Kenya, Korea, the Netherlands, New Zealand, and the United States), and closed on 31 March 2018, after which the Hub opened for wider country membership and exchange (IPPC, 2018[67]). Over the period of 2018 – 2020, use of the Hub has continued to expand, with over 200 000 transmissions of ePhytos through the hub in the January – August 2020 period, and 46 countries actively exchanging ePhytos. The UN International Computing Centre (UNICC) provides the technology for the operation of the Hub. At present, the current operating costs associated with the ePhyto Hub are estimated to be USD 700 000 per year.

The IPPC's ePhyto Hub offers a multilateral solution to the proliferation of individual bilateral trade agreements, facilitating the exchange of e-certificates between multiple SPS agencies without these agencies having to establish discrete connections.

Figure 3. Point-to-point and Single Hub model



The transmission of e-certificates within the IPPC ePhyto Hub increased considerably in May 2020 following its linking to the EU TRACES import certification platform, facilitating the participation of the EU member states into the system. Practically, this means ePhytos submitted to EU TRACES are then distributed to the relevant European Union countries for processing using a discrete channel. This is an approach which the IPPC is hoping to be able to adapt for use in connecting private blockchain companies to National Plant Protection Organisations using the ePhyto Hub.[17] The number of certificates exchanged during 2020 demonstrate a growing base of user countries actively exchanging ePhytos in XML format (IPPC, 2020[68]): approximately 45 000 – 55 000 ePhytos have been exchanged each month over the period of June - August 2020 via the Hub between 46 active member countries (IPPC, 2020[69]).[18] Over

[16] For further information, see: https://www.standardsfacility.org/PG-504

[17] Interview with Craig Fedchock, Senior Advisor, IPPC Secretariat, August 2020.

[18] As at August 2020 these 46 countries were: Argentina, Austria, Belgium, Brazil, Bulgaria, Chile, Costa Rica, Croatia, Cyprus, Czechia, Denmark, Dominica, Estonia, Fiji, Finland, France, Germany, Ghana, Greece, Guatemala, Hungary,

10 000 additional ePhyto certificates were received in the first three weeks of connection with EU TRACES, mostly from the United States, Argentina, and Morocco (IPPC, 2020[70]).

This expansion continues the trend of significant growth in country use of the ePhyto Hub, and illustrates the advantages of multilateral e-certification platforms in managing trade during market disruption. The ePhyto Hub has a capacity to receive approximately 100 000 certificates per day, though the Hub has received only 55 000 certificates per month at its busiest.[19]

It should be noted, however, that approximately 50 countries that are members of the ePhyto Hub are not yet actively exchanging ePhytos. As the IPPC notes, many of these members may lack the technical capacity to start exchanging certificates. Others may be uncomfortable working in the ePhyto environment with groups, companies, and organisations with which they are unfamiliar (IPPC, 2020[68]). Countries may also have reservations about the ease of integrating the Hub with their Single Window trade systems, due either to the need for specialist technical expertise, or to a lack of case studies showcasing how other successful integrations have worked in practice. The World Bank Group is currently working with the IPPC to implement ePhyto exchange capability in a number of developing countries, recognising that connectivity between traders, phytosanitary agencies, customs, food safety bodies, and other agencies is critical to advancing the benefits associated with e-certification (Gain, B.; Sela, S., 2019[58]).

A key lesson from the implementation of the ePhyto Hub so far is that digital technologies can provide solutions to simplify the implementation of complex SPS systems. However, the creation of multilateral digital tools requires significant collaboration and coordination between a large number of shareholders, and must be designed to support an easy transition from status quo systems (IPPC, 2018[71]).

The wider use of e-certification for plant products over animal products could also reflect country preferences to progress systems for trade in animal products as a matter for separate negotiation. Early adopters of e-certification regimes for animal products (such as New Zealand's 'E-cert' system[20] developed in 1999 or the Netherlands' 'e-CertNL' system[21] developed in 2001) have developed tailored bilateral arrangements in order to facilitate trade in animal products with key trading partners (such as the Russian Federation – hereafter "Russia" – and China). The agencies responsible for trade of animal products are often separate from those responsible for plant products, and do not always pursue identical policy agendas. This trend may also reflect the fact that there are fewer countries regularly exporting animal-based products in contrast with plant-based products (FAO, 2019[72]), and those countries with established systems for the exchange of sanitary e-certificates may wish to conserve these status quo systems.

Among SPS certificates, the phytosanitary certificate is one of a small number of standardised international models, and was developed by the IPPC as part of its harmonisation mandate (IPPC, 2017[54]).[22] All members of the IPPC can refer to this standard phytosanitary certificate, which facilitates the mutual recognition of country-specific SPS conformity assessments. Though integrated platforms such as EU TRACES do offer standardised animal and animal product e-certifications in the form of the Common

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Ireland, Italy, Jamaica, Korea, Latvia, Lithuania, Luxembourg, Malta, Mexico, Morocco, the Netherlands, New Zealand, Poland, Portugal, Romania, Samoa, Slovakia, Slovenia, South Africa, Spain, Sri Lanka, Sweden, Uganda, the United States, and Uzbekistan. A number of additional countries are registered to use the ePhyto Hub but were not actively exchanging ePhytos during the month of August 2020. The number of countries that are either registered to use the ePhyto Hub or actively exchanging ePhytos continues to grow.

[19] Interview with Craig Fedchock, Senior Advisor, IPPC Secretariat, August 2020.

[20] See https://www.mpi.govt.nz/exporting/export-certification/animal-products-ap-e-cert/

[21] See https://e-cert.nl/

[22] This standardised model includes three essential elements: first, the description of the consignment, certifying that the plants or plant products are free from pests; second, the Additional Declaration stating that the consignment complies with requirements such as fumigation treatments before shipping or origination from a disease-free area; and third, the description of the relevant disinfestation or disinfection treatments (IPPC, 2017[54]).

Health Entry Documents (CHED) (EC, 2020[73]), globally these certificates are varied in format and content (STDF, 2016[74]) (OIE, 2020[56]). These variations stem from the way individual countries have implemented Codex and OIE standards for their own export certification needs.[23]

The OIE Terrestrial Animal Health Code also sets out a model international health certificate for live animals, hatching eggs, and products of animal origins, using the UNCEFACT standard (OIE, 2019[55]). Compared with the standard IPPC phytosanitary certificate, the OIE model health certificate requires a greater depth of information, including details regarding the relevant Veterinary Authority and the temperature of products for transport and storage.[24]

Box 5. EU TRACES

EU TRACES is the European Commission's shared multilingual online platform processing the sanitary and phytosanitary certification required for the importation of animals, animal products, food and feed of non-animal origin, and plants into the European Union (as well as the EU export of certain animal products). The platform streamlines certification processes, links entry procedures, and offers a paperless workflow for import (EC, 2020[73]). It is used by more than 43 000 entities (35% of which are private sector entities) from approximately 91 countries (EC, 2020[75]).

The TRACES platform offers a number of benefits for users, including: greater accessibility for food chain actors; lower risk of loss or deterioration of certification and fraud; and automatic linkages with wider e-certification systems such as the ePhyto Hub and non-EU systems (including the national e-certification systems for Australia, the United States, and New Zealand) (EC, 2020[76]). The TRACES platform allows for the correction of information on e-certificates, allowing users to rectify certification problems at significantly lower cost than with paper certificates (EC, 2020[75]). The platform also bears the cost of exchanging e-certificates, which is a significant benefit for traders.

EU regulations outline the rules governing the exchange of e-certificates within the TRACES system, and set out requirements for the form, content, and secure exchange of these certificates (EC, 2019[77]). In 2019, the use of TRACES for issuing Common Health Entry Documents (CHEDs) by EU members was made mandatory. In response to the COVID-19 pandemic, the EU passed regulations making exceptions to regulatory requirements to present original paper certificates and official attestations, and authorised the temporary use of electronic clearance data as an alternative process to avoid health risks to staff (EU, 2020[78]). As a result, the volume of e-certificates being exchanged has increased, with some countries increasing the proportion of CHEDs exchanged electronically from 20% to 75%.[1] These adjustments have helped countries minimise disruptions to trade and provide for the dependable flow of goods.

EU TRACES supported the exchange of approximately 145 000 consignments in 2019, with the most significant users being Morocco (18 077 consignments), Viet Nam (17 338 consignments), New Zealand (11 468 consignments), and Ecuador (11 468 consignments). Figure 4 provides a breakdown of the more than 2.3 million certificates processed in TRACES in 2019.[2]

[23] Interview with Erik Bosker, DVM and Senior Policy Advisor at the Ministry of Agriculture, Nature and Food Quality, The Netherlands, Chair of the CCFICS-EWG developing the proposed draft guidance on paperless use of electronic certificates and author of a recent report for the STDF e-veterinary certification project managed by OIE (OIE, 2020[56]), July 2020.

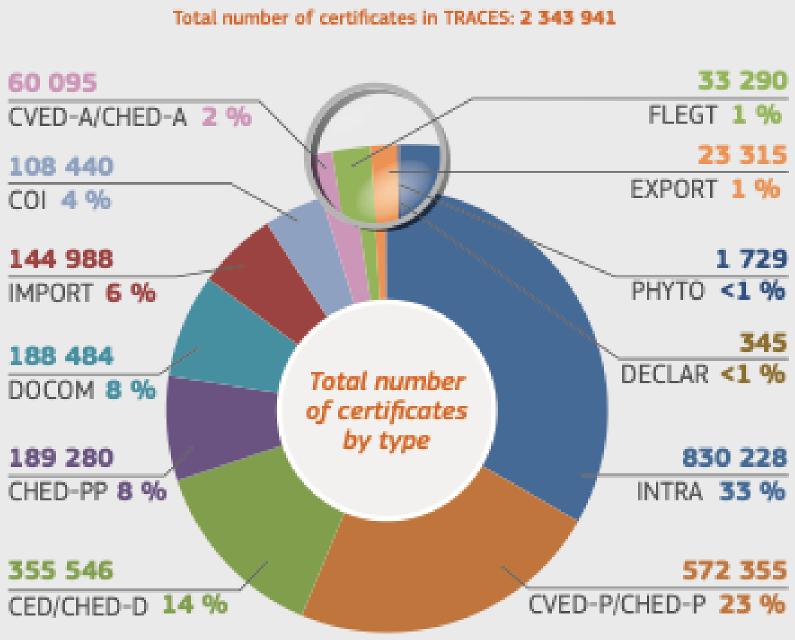
[24] See https://www.oie.int/index.php?id=169&L=0&htmfile=chapitre_certif_live_animals.htm;

Since the ePhyto Hub was linked to EU TRACES in May 2020, the platform has received an additional 40 000 ePhyto certificates in the June – July 2020 period (approximately 20 000 per month). Five countries (Argentina, Chile, Costa Rica, Morocco, and the United States) are now submitting ePhytos to EU TRACES as a result.[3] Linking these two platforms involved working through a number of challenges: notably, the ePhyto Hub supports country-to-country e-certification, but linking to EU TRACES required linking individual countries to a network of 27 countries.

As a platform, EU TRACES is built to receive and process certification of all products, both phyto and sanitary. The EU TRACES system also exchanges data with the EU Customs Single Window Certificates Exchange (CERTEX) system (STDF, 2020[22]). As shown in Table 1, one EU country (the Netherlands) has its own dedicated platform for the exchange of e-certificates. However, this system has to be closely integrated with the TRACES system to comply with the provisions of EU law. The Netherlands' e-certificate transmission channel will have to be fully integrated (by EU law) in the TRACES system in October 2020 for phytosanitary certification using the ePhyto Hub.[4]

The EU TRACES system was originally established to provide a backup for the flow of paper SPS certificates, not to replace these certificates. However, as attitudes have shifted, e-certification is now becoming a primary focus for businesses and governments.[5] Through EU TRACES, countries have been using harmonised animal health certificates for the last fifteen years (since 2005), achieving a widespread degree of consistency in these documents. While EU TRACES is designed primarily to receive documents, Tunisia and five other remote EU territories are using the platform to issue phytosanitary certificates.

Figure 4. Certificates in EU TRACES



Note: Codes for the following types SPS certificates for consignments are: CHED-A live animals (accounting for 2% of certificates in TRACES in 2019); CHED-P products of animal origin, germinal products, animal by-products and derived products, composite products, and hay and straw (accounting for 23% (mainly for fish product imports)); CHED-PP plants, plant products and other objects (8%); CHED-D food and feed of non-animal origin (14%); COI Certificate of inspection for imported organic products.
Source: (EC, 2020[75]).

The EU TRACES system allows EU countries to split administrative compliance verification into multiple stages for more efficient processing. For example, because the platform is shared, the EU can require documentation checks to occur in Spain, while physical consignment checks occur in France. This allows greater administrative flexibility, especially during periods of trade disruption. EU TRACES administrators have approved the use of electronic signatures for Uruguay and Morocco, and intend to transition an additional 57 countries to electronic signatures to replace paper systems, with the 20 countries with the greatest volumes transitioning by the end of 2020.

In addition to the efficiencies offered to businesses and governments engaging with EU TRACES, the scale of the platform also provides oversight in e-certification trends, the extraction of EU import and export data, and intra-EU trade.

1. Interview with Philippe Loopuyt, Lead of the EU TRACES, Directorate SANTE.DDG2.G (Crisis management in food, animals and plants), European Commission, DG Health and Food Safety, August 2020.
2. A full list and explanation of certificate categories is available at the EU's TRACES website: https://ec.europa.eu/food/animals/traces/certif-docs-features_en.
3. Interview with Philippe Loopuyt, Lead of the EU TRACES, Directorate SANTE.DDG2.G (Crisis management in food, animals and plants), European Commission, DG Health and Food Safety, August 2020.
4. Ibid.
5. Ibid.

2.4. Beyond e-certification: Blockchain, remote pest assessment, and other tools

While e-certification is the most significant area of activity for countries incorporating digital technology within SPS systems, countries and supply chain actors are also making use of other technologies, including distributed ledger technologies (DLTs), as well as digital platforms enabling remote pest assessment, advanced consignment screening, and processing at ports.

DLT systems such as blockchain have significant potential to enhance the transparency of trade transactions and the traceability of goods. These technologies offer new ways to accurately identify animals and products, collect more data, integrate communication flows, and share data quickly and securely between supply chain actors (FAO, 2020[79]). By spreading responsibility for data collection and processing to a number of different actors, these systems also enable the rapid identification of issues such as the use of fraudulent labels or SPS certifications within the supply chain (OECD, 2020[80]). In these systems, no one entity is entrusted with recordkeeping: data provenance is always easily identifiable, and records cannot be changed or deleted once they have been created (OECD, 2018[81]). However, while blockchain is a tool for securely and efficiently sharing information between stakeholders, it does not in itself verify that information written and communicated to the blockchain is accurate. Blockchain and other DLT systems require a network of trusted stakeholders and an institutional framework of harmonised rules that ensures the input of high-quality data into the ledger.

A number of private agri-food chain actors are actively using DLTs to facilitate the faster and more dependable exchange of consignments, including through making it easier to comply with SPS system requirements. For example, the global shipping and logistics firm Maersk has partnered with IBM on its 'TradeLens' project, a blockchain-enabled digital shipping platform that allows trading participants to connect and share information, including consignment and SPS certification details. The TradeLens project currently involves over a hundred organisations globally, including carriers, ports, terminal operators, freight forwarders, and shippers (Maersk, 2019[82]). TradeLens is also investigating the potential to include SPS certificates (including phytosanitary, veterinary, and fumigation certification) within their platform, and is looking for ways to align with international standards for data exchange, particularly the UN/CEFACT XML data model (TradeLens, 2019[83]).

Another notable example of DLTs being used to facilitate SPS compliance is the April 2020 Cargill-Agrocorp partnership using the open-source blockchain technology Hyperledger Fabric. These companies completed the sale of a wheat consignment worth USD 12 million using this technology, and reduced processing time from several weeks to a matter of hours. These efficiencies were created through using blockchain technology to facilitate the exchange of information between the many parties involved in the sale, including financial service providers, ship owners, and shipping agents. The technology allowed for the efficient and trusted exchange of data and trade documentation, including letters of credit, waybills, bills of lading, and other contracts (Ellis, 2020[84]).

The use of these traceability technologies within SPS systems has just as much potential positive impact for farmers and food chain actors. They offer a simple way for producers to share consignment details, comply with SPS conformity assessment requirements, and offer assurances of product authenticity (Tripoli, 2018[28]). Since their earliest use in 2016 by Barclays Africa to facilitate the shipment of dairy products from Ireland to the Seychelles, these technologies have demonstrated a promising number of potential applications in international trade (Tripoli, 2020[85]).

The use of DLTs such as blockchain also distributes responsibility for documentation to a degree that it essentially neutralises the possibility of fraud in the trade of goods. Each transaction processed on a DLT carries process details and specific, unique product attributes (for example, agriculture and livestock production or husbandry practices, transportation information, environmental sustainability details, and export certification) which can be verified by supply chain actors or by sensors (for example, internet-connected digital scales, or remote sensors detecting pests or confirming fumigation levels) (Tripoli, 2019[86]). The USDA is examining applications for DLTs such as blockchain within food supply chains, particularly in the supply of organic foods (USDA, 2020[87]), and is working with IBM to design a proof-of-concept based on blockchain technology to modernise the Food Safety and Inspection Service's food certification processes (USDA, 2020[88]).

The Argentinian National Service of Agri-Food Health and Quality (SENASA) has developed a system incorporating blockchain technology into its traceability system for citrus products, an industry with a high risk of food fraud due to the fragmented and siloed nature of production. This system applies blockchain to timecode interactions between encoded information from producers and processors, providing traceability through the use of immutable and distributed data collection (Otieno, 2019[89]). SENASA has indicated a willingness to expand this system to other industries. This project reflects the fact that e-certification systems are not sufficient on their own to completely guarantee protections against fraud; instead, they can be combined with other forms of digital technology.

The Antwerp Port Authority in Belgium has also partnered with blockchain company T-Mining to develop a safer and more efficient system of trade document flows. Established in June 2018, this system allows for certificates (such as certificates of origin or phytosanitary certificates) to be transferred via an automated chain of "smart contracts". During this pilot, phytosanitary certificates for a shipment of fruit from New Zealand destined for the European market were provided to the importer and freight forwarding companies, then to Belgian authorities, to facilitate the release of the shipment. The Port of Antwerp is now considering options for expanding this pilot (Port of Antwerp, 2018[90]).

In July 2020, the USDA released its *New Era of Smarter Food Safety* report, outlining a new approach to food safety, leveraging new technology to create a safer and more digital, traceable food system. This report notes the use of a wide range of digital technologies within SPS systems and the agri-food supply chain more generally, including: exploring the potential of artificial intelligence to mine non-traditional sources of information to detect outbreaks of food-borne disease; using predictive analytical systems to mitigate potential food contamination events; and encouraging the use of traceability platforms to monitor product risk factors (USDA, 2020[91]). This demonstrates a commitment to a broad range of digital technologies within SPS systems and the wider agri-food supply chain.

Countries are also using digital technologies to facilitate compliance with SPS regulations for specified exports. For example, the Syngenta Foundation for Sustainable Development worked in partnership with USAID to procure *Farmforce*, an electronic product traceability system tracking pesticide and fertiliser use to the farm level. This data collection system supports farmer training by identifying which farms may be improperly applying pesticides or fertilisers. The *Farmforce* product has been active since its launch in Kenya and India in early 2013, and is used in 35 countries by over 520 000 individual farmers (Farmforce, 2020[92]).

Digital technologies offer the possibility of consignment information being transmitted to border authorities in advance of arrival, paving the way for advance decisions on inspections for compliance with SPS requirements (OECD, 2017[93]). For example, pilots in blockchain technology have allowed containers of roses and avocados from Kenya to enter the EU more smoothly, and were linked with the bilateral e-certification system between Kenya and the Netherlands to offer customs authorities advanced notice of container arrival. This pilot demonstrates the potential of digital technologies to avoid unnecessary checks on arrival, increasing the shelf-life and marketability of perishable fresh products. Using this method avoided the costs and delays associated with paper-based SPS compliance systems (WTO, 2018[94]).

Blockchain technologies can, however, involve significant expense and technical complexity for participating countries and multilateral organisations. Alternatively, EU TRACES representatives have confirmed that, instead, the platform is using electronic signature technology for e-certificates (PAdES for pdf documents and XAdES for XML), which guarantees authenticity and non-repudiation, while avoiding complex and expensive blockchain solutions.[25]

These digital technologies are not always necessary to enable countries to incorporate a helpful element of risk assessment and risk proportionality within their SPS systems. For example, blockchain technologies can increase levels of trust within supply chains and make trade exchanges more efficient, but risk management methods shaping the application of SPS controls (for example, border checks) to fit the risk profile of particular consignments (for example, country or region of origin information) can also achieve similar efficiencies.

3. Potential for digital technologies to create efficiencies in SPS systems

By making it easier for countries and food chain actors to exchange information and comply with the SPS requirements of other countries, and by enabling countries to more effectively assess and manage risk, digital technologies offer significant possibilities to create efficiencies in SPS systems.

For example, the e-certification systems being progressed through bilateral, multilateral, and plurilateral country negotiation have the potential to enhance transparency, harmonisation, and recognition of equivalence of SPS measures and advance the effective implementation of the WTO SPS Agreement. They can also create significant efficiencies for food chain actors, as well as importing and exporting countries. Despite these benefits, the majority of countries have been slow to adopt these e-certification systems (UNESCAP, 2019[95]).

3.1. Increasing security and reducing processing time

Adopting digital technologies in SPS systems, particularly e-certification, can lead to improved security, easier flows of information, and faster clearance times for consignments of exported goods (USAID, 2019[96]). Estimates suggest the switch to paperless trade systems could save annual export gains worth up to USD 257 billion, reducing export time by up to 44%, and lowering export costs by up to 33% (STDF, 2017[5]). In the context of growing international agricultural trade, e-certification can also reduce the trade-

[25] Interview with Philippe Loopuyt, Lead of the EU TRACES, Directorate SANTE.DDG2.G (Crisis management in food, animals and plants), European Commission, DG Health and Food Safety, August 2020.

inhibiting impacts of some SPS requirements (USAID, 2019[96]). It can also improve a country's reputation as a trading partner, enhancing the marketability of its products (UNECE, 2016[44]).

E-certification systems also allow for enhanced security and integrity, with each step in the creation, exchange, and validation of certificates being timestamped to offer a clear overview of document lifecycle (EC, 2018[97]). This makes it easier for oversight bodies to audit the exchanges of e-certificates in trade, making SPS processes more robust (UNECE, 2016[44]).

The variable nature of SPS systems can make it a challenge to accurately estimate the cost of status quo paper systems to governments and businesses, and the potential savings resulting from a switch to e-certification. However, several studies have been conducted which suggest a potential for significant benefits resulting from the adoption of these systems. Section 4 estimates how the use of digital technologies within SPS systems, particular e-certification systems, impacts the cost of trade.

As an indication of the possible benefits of implementing SPS e-certification, an Asia Pacific Economic Cooperation (APEC) study analysed the benefits of an Electronic Certificate of Origin (e-CO) exchanged between exporters in Korea and customs authorities in Chinese Taipei to substantiate the product's eligibility to for entry. This study estimated that on average, exporters experienced a two-day reduction in processing time and total savings of USD 274 per container, while importers experienced a reduction of three days in processing time and total savings of USD 397 per container. This study indicated cost savings of around 22% for exports and 34% for imports (APEC, 2011[98]). These figures suggest e-certification may be a particularly promising tool for trade in perishable goods, ensuring the efficient, fast, and safe clearance of products. For example, the development of an e-certification system in Malaysia reduced the issuance time for SPS certificates (including application, inspection, and payment) from four to eight days down to less than two days (UNESCAP, 2017[99]). In Kenya, e-certifications have had a positive effect on export volumes and government revenue, and have helped to decrease informal trade and create trust in the value chain due to enhanced data integrity and authenticity assurances (STDF, 2017[5]).

IPPC representatives estimate that switching from paper certificates to e-certification can save exporting companies approximately USD 180 000 to 200 000 per year, and pointed to an instance in which a business based in the United States saved approximately USD 36 000 by being able to amend a mistake on a phytosanitary e-certificate for a shipment to Chile, rather than having to travel to have it corrected.[26]

Beyond cost savings and increased efficiencies, the use of DLTs (such as blockchain) in SPS systems also increases security and reduces the risk of fraud in the movement of products, improving the integrity of compliance assessments and generating greater levels of trust (Tripoli, 2019[86]).

3.2. Enabling the fast and trusted flow of data within SPS systems

Many of the challenges facing trade and supply chains are related to how data are collected, analysed, and shared. Unfortunately, international trade transactions are still characterised by inefficiencies, including the quantity of paper documents (often duplicates) and the reliance on human labour to check and clear goods. These complex, expensive, and time-consuming processes often result in long payment terms for businesses, and give rise to insufficient levels of transparency and traceability in food chains to prevent and mitigate food safety risks and the risk of food fraud, or to enforce compliance with sustainability practices (OECD, 2020[100]).

By adopting e-certification processes, countries can enable the swift flow of SPS data. This helps to build trust, reduce transaction costs, and support the better management of the movement of goods and stock. As with other digital technologies within SPS systems, e-certification provides new solutions for least-trade restrictive measures at the border, and can streamline the role of government intervention in the administration of certification and border inspections. E-certification can also increase transparency and

[26] Interview with Craig Fedchock, Senior Advisor, IPPC Secretariat, August 2020.

better identify responsibilities through the value chain, and contribute to the overall sustainability and resilience of the agri-food and trade system (Jouanjean, 2019[15]).

In addition to promoting efficiencies within SPS systems, the use of digital technologies gives countries, international organisations, and multilateral bodies additional capacity to gather and analyse data relating the movement of products within global trade systems. For example, by monitoring country exchanges through the ePhyto Hub, the IPPC could prompt countries to make use of the infrastructure. Linking these data with country-specific information regarding the export and import of goods could unlock even wider data analysis capacity, providing this is consistent with IPPC assurances to observe the integrity and sensitivity of country-specific information (IPPC, 2020[101]). The IPPC's *2020-2030 Strategic Framework* recognises the right of member countries to determine how electronic phytosanitary certificate information interfaces with integrated trade systems (IPPC, 2019[102]), and reflects the IPPC's undertaking to use country-specific data only for the purposes of administering the ePhyto Hub and advocating its wider use.

The use of these technologies also offers countries and international bodies the ability to use data as an asset to support better service design and delivery within SPS systems, consistent with wider goals in relation to the responsible and proactive collection, analysis, and use of data. In turn, this has the potential to promote a higher degree of openness, engagement, and transparency within SPS systems, and can reinforce trust in governments (OECD, 2019[103]).

3.3. Creating a more equitable, inclusive and accessible international trade system

SPS certification procedures can be subject to duplicative, costly, and inefficient processes due to the need for product inspection, and, when required, sampling and laboratory tests. This can present barriers for countries lacking capacities and institutions needed to demonstrate compliance, and can lead to inequities for smaller businesses in these countries (Jouanjean, 2019[15]). It is important to note that e-certification cannot address SPS measures that are not based on scientific evidence, and which may in fact constitute unnecessary barriers to trade (WTO, 1998[104]). E-certification can, however, make these systems significantly easier to navigate.

The implementation of digital technologies such as e-certification within SPS systems has the potential to significantly help developing countries to participate in systems of international trade (Spreij, 2017[105]). By assisting the harmonisation of guidance for countries to comply with SPS systems, digital technologies can enable a broader participation in trade systems, and also simplify administrative processes (STDF, 2020[106]). This is particularly important for small businesses. In a 2017 survey 43% of exporters from developing countries identified the issuing and acceptance of SPS certificates as a constraint for micro, small, and medium-sized enterprises (STDF, 2017[5]). E-certification systems can make it easier for these enterprises to export goods to other countries, for example, by making SPS certification processes simpler, more accessible, and less technically demanding for enterprises to complete in relation to traded goods. Given that women entrepreneurs tend to operate smaller businesses, these effects may also contribute to increased gender inclusivity and representation in trade (OECD, 2017[107]).

4. Estimating the trade facilitating effects of electronic SPS certificates

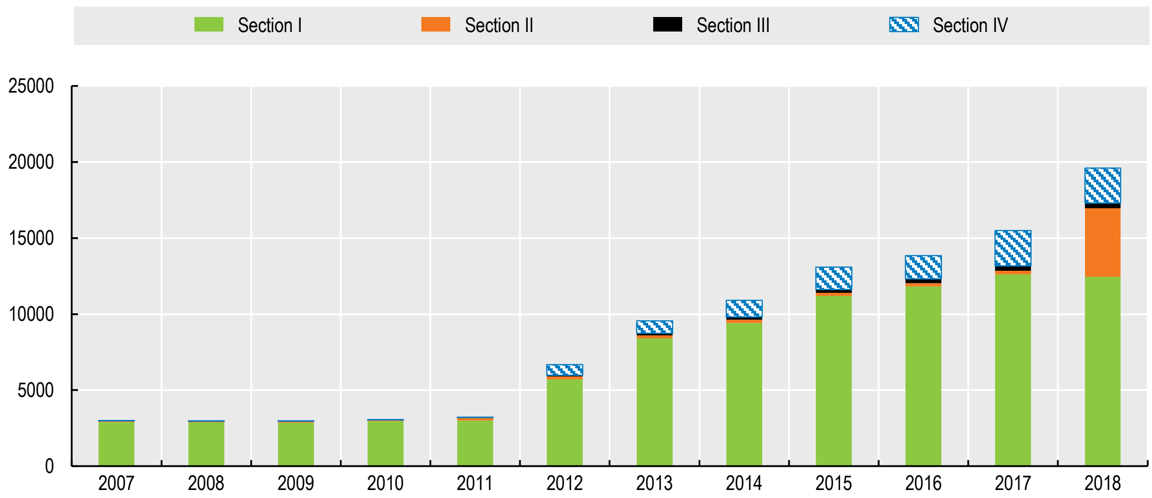
The potential for digital technologies to reduce costs and enhance efficiencies has been documented in the literature, potentially counterbalancing the reduction in trade volumes stemming from the implementation of non-tariff measures (Cadot, Gourdon and van Tongeren, 2018[108]). Using digital tools can also decrease trade costs (Moïsé and Sorescu, 2013[17]) and streamline border processes, strengthen security and fraud detection, improve supply chain sustainability (Jouanjean, 2019[15]), and speed border clearance of perishable products, resulting in less waste and greater consumer satisfaction. However, as the adoption of e-certification is relatively new and still evolving (as shown in Table 1), more analysis is needed to fully grasp the effects on trade volumes and value.

4.1. Combining the information on bilateral SPS e-certificates with trade data

The number of bilateral trade flows at the Harmonised System 6-digits (HS6) level covered by e-certification grew more than fivefold from about 4 000 in 2010 to more than 20 000 in 2018 (Figure 5). The use of e-certificates has increased rapidly since 2010, mainly because of the greater number of countries using the EU TRACES platform over the years and the creation of new agreements among countries on the exchange of e-certificates. As trade statistics only report the total trade flow in a given period, and not individual transactions, the actual number of e-certificates issued is much larger. The creation of the ePhyto Hub pilot led to rapid increase in the use of e-certificates between 2017 and 2018 as described in Section 2.3.3. Vegetable products now account for one quarter of all e-certificates (Figure 6).

Across all years, electronic certificates are mainly issued for products from HS Section I (live animals, animal products)[27]. This is explained by the intra-European Union trade and imports certificates received through EU TRACES from non-EU member countries. According to the EU TRACES annual reports, 80% of import certificates are used in the creation of Common Veterinary Entry Documents for animals and products of animal origin (CVEDA and CVEDP) (EC, 2020[75]).[28]

Figure 5. Annual number of bilateral trade flows covered by electronic certificates, by HS Section



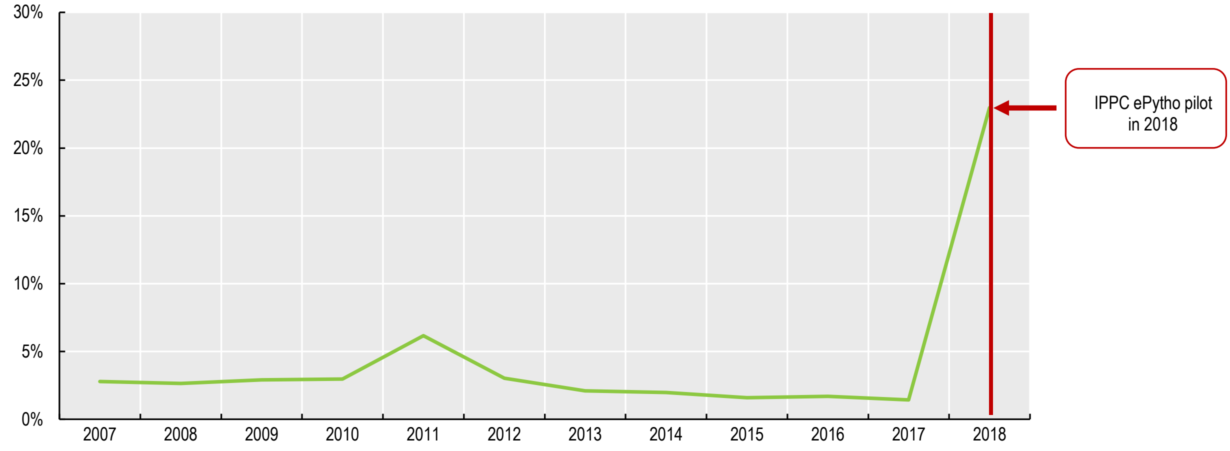
Note: This figure shows the count of the number of bilateral trade flows, measured at HS 6 level and by section, that is covered by e-certification. It is not to be confused with the number of issued e-certificates at individual transactions level, which is much larger. Section I covers live animals, animal products (HS chapters 1-5), Section II vegetable products (HS chapters 6-14), Section III animal or vegetable fats and oils (HS chapter 15) and Section IV prepared foodstuffs, beverages, spirits and vinegar, and tobacco (HS chapters 16-24).
Source: OECD calculations based on trade flows data from CEPII and e-certificates information in Table 1.

[27] Four sections are considered, regrouping agro-food products covered by the Harmonised System (HS) of classification: Section I (animal products including HS 2-digit sectors HS chapters 1-5), Section II (plant-based products, HS chapters 6-14), Section III (animal or vegetable fats and oils, HS chapter 15) and Section IV (processed food, HS chapters 16 to 24). The full list of sectors is provided in Annex A.

[28] These documents are now referred to as Common Health Entry Documents Animals (CHED-A) and Common Health Entry Documents Products (CHED-P).

Figure 6. Proportion of bilateral trade flows covered by phytosanitary electronic certificates per year

Products from Section II only (vegetable products)



Note: Section II vegetable products (HS chapters 6-14) (see Annex B for more detail on the product coverage). The chart shows the count of the number of bilateral trade flows, measured at HS 6 level, that is covered by e-certification, as a share of the total number of trade flows at HS 6 level. It is not to be confused with the number of issued e-certificates at individual transactions level, which is much larger.
Source: OECD calculations based on trade flows data from CEPII and e-certificates information in Table 1.

Detailed data coverage of e-certification implementation and use by individual firms is still scant, but statistics at the bilateral trade flows level reveal some insights on the developments over time and across products (Table 2). The bulk of e-certificates in the early years of SPS systems digitilisation was applied to HS Section I products (live animals, animals products), mainly on the trade of animals and products of animal origin to the European Union on the TRACES platform and on intra-EU trade.

As digital tools became more widespread in SPS systems, so did e-certification and more bilateral trade flows now have e-certificates requirements, not only for Section I but also Section II (vegetable products) and Section IV (prepared foodstuffs, beverages, spirits and vinegar, and tobacco). With more countries using the IPPC ePhyto Hub, the share of bilateral trade flows of Section II products covered by e-certificates increased from 3% of all trade flows to 24% between 2007 and 2018. The COVID-19 pandemic has accelerated countries' digitilisation efforts. As of 2020, an increasing number of countries are now accepting or using e-certificates instead of paper certificates (Box 1), but this recent information cannot be used in the econometric analysis as published trade statistics are not yet available.

Finally, the use of e-certification varies widely across countries: while some importing countries in the dataset did not accept e-certification over the time period of the dataset (2007-18), other countries may have had up to 1 477 bilateral trade flows covered by e-certificates. The use of e-certificates seems to expand differently for bilateral compared to multilateral agreements. On the one hand, using platforms such as the ePhyto Hub or EU TRACES to issue e-certificates helped more countries to increasingly issue e-certificates. On the other hand, countries receiving e-certificates in bilateral agreements initially do so only for specific products (for example, dairy or meat products only). But some arrangements gradually expand both the number of exporters and products covered over time, either by entering into new bilateral agreements or by connecting to existing multliateral platforms.

Table 2. Summary statistics on e-certification coverage

	2007	2018
Share of bilateral trade flows covered by e-certificates		
Section I	3%	8%
Section II	0.05%	2%
Section III	0%	1%
Section IV	0.01%	1%
Bilateral trade flow e-certificates coverage by receiving country		
Maximum	201	1 477
Minimum	0	0
Median	15	20
Average	52	300
Bilateral trade flow e-certification coverage by country pair		
Maximum	111	227
Minimum	0	0
Median	0	0
Average	2	6

Source: OECD estimations.

The empirical analysis in this report combines detailed trade data at product level with information on bilateral SPS e-certificates exchanges – based on Table 1[29] – to estimate their trade facilitating impacts. These two sets of information are introduced in a structural gravity model (details in Annex B) to assess the effects of e-certification on trade (export) volumes, unit values (export prices) and value of exports (Box 6).

The regression technique used in this report estimates the change in trade at both the intensive margin and the extensive margin. The intensive margin is the change in trade (volume or value) for two countries that were already trading the product, while the extensive margin is the creation of new trade links, or new product – market combinations. This estimation thus carries information about the potential for market-creation from using e-certification (Cadot, Gourdon and van Tongeren, 2018[108]).

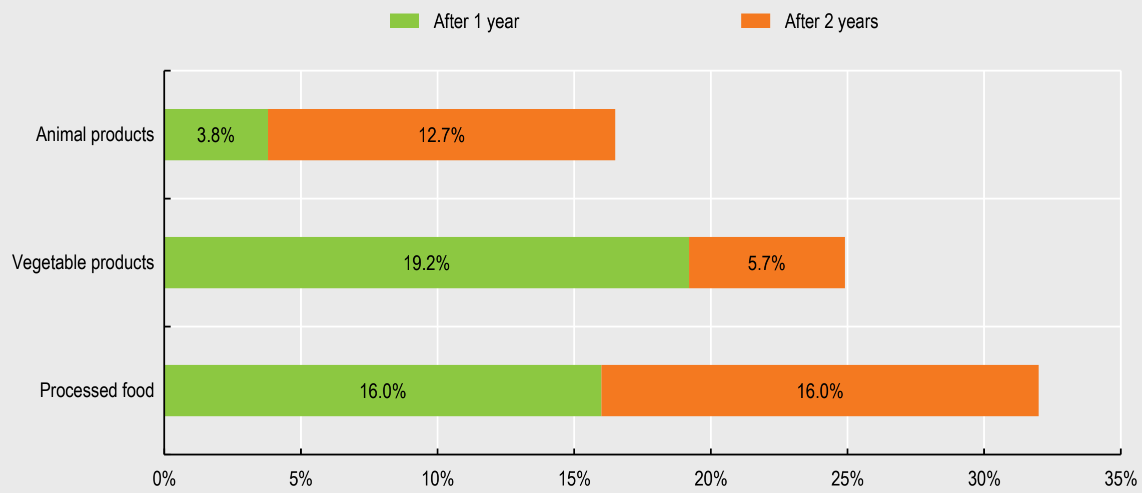
Box 6. Capturing effects of SPS e-certificates exchanges in a gravity model

The implementation of digital technologies in SPS systems is captured with an e-certification dummy variable signalling the emission and reception of an e-certificate by the exporter and importer country in a given year. The dummy variable introduced in the gravity model is equal to one if an e-certificate is issued for the product by the exporting country involved in the year of the observed exchange flow, and zero otherwise. As a result, not all products in the dataset are covered by e-certificates. In addition, some products might be covered by e-certificates in one bilateral trade flow due to importing country requirements and their ability to receive e-certificates, but might not be covered by e-certificates in other bilateral trade flows if the respective importing countries do not have the same requirements or the ability to receive e-certificates.

[29] Table 1 includes mechanisms representing both bilateral and multilateral agreements.

E-certification agreements are also phased-in progressively and there can be several years between the creation of an e-certification pilot programme and its full implementation. Consequently, the potential trade-facilitating effects are expected to be relatively limited during the first year of their creation, but increase over time. The phasing-in of the trade effects is tested by including the one-year and two-year lags of the e-certification dummy variable in the estimations, instead of the contemporaneous variable. The total value of exports for selected agro-food product groups (except for animal or vegetable fats and oils) increases over time by between 17% and 32% (Figure 7).

Figure 7. Increase in export values from implementing SPS e-certificates (%)



Source: OECD estimates.

These first results on the trade effects of e-certification are encouraging, but they also point to more avenues that need to be explored to develop more targeted policy recommendations. The first aspect to address would be to repeat the econometric analysis with more recent trade data. The currently available trade data cannot reflect the recent increase of e-certification in the context of the COVID-19 pandemic. Second, the question of trade enhancement at the extensive margin (new firms and new trade links) merits attention, especially in view of efforts to enhance the trade participation of SMEs as well as of developing economies. Understanding the balance between increasing revenues from larger trade flows against the initial fixed costs of setting up e-certification infrastructure will be key to assessing the costs and benefits of adopting digital technologies for SPS systems, in particular e-certification.

4.2. Impacts on trade volumes

The signs of estimated coefficients on quantities traded are broadly in line with expectations. Tariffs decrease and e-certification increases trade volumes.

Tariffs tend to show a stronger impact for the products in Sections I (animal products) and II (vegetable products) of the HS classification. The estimated coefficient of tariffs for Sections III (fats and oils) and IV (prepared food stuffs) is not statistically different from zero. Because the estimations control for the effects of bilateral tariffs, the additional trade effect of being part of a regional trade agreement (RTA) appears to vanish (the estimated coefficients are not statistically significant, see Annex Table D.1). The statistical insignificance of the RTA dummy does not imply that RTAs do not impact trade. Since RTAs entail the application of reduced tariffs, much of their trade effects will be absorbed in the bilateral tariff variable in the estimated model.

E-certification has clearly positive effects on trade volumes, except for oils and fats (Section III), which have a less widespread use of e-certification than the other product groups. The smaller markets of Section III products could make it less attractive for exporters to incur the investments and adapt to e-certification infrastructure relative to the potential cost savings. In addition, recent estimates of non-tariff measures impacts (Gourdon, Stone and van Tongeren, 2020[109]) show that for traders of oils and fats the costs in complying with TBT requirements of the destination market are more important than the costs associated with SPS requirements.

Both animal products and vegetable products show a strong impact of e-certification on trade volumes. E-certificates implemented one year ago have strong market-creation effects as the coefficient for products in Section I of 1.426 is significant; e-certificates imposed two years ago have a smaller effect of 0.147. The total effect of e-certification is thus positive and significant after two years. Also, this means that most of market-creation effects generated by e-certificates will be realised relatively shortly after implementation.

For vegetable products in Section II, the effect of e-certificates on volume traded is 2.101 after one year and the cumulative effect of e-certificates is still positive after two years. The negative coefficient on the two-year lagged dummy variable can perhaps be explained by a catch-up effect: after the creation of the ePhyto Hub, trade of plants and vegetable products grew much more strongly than in the previous year, so that the lagged dummy captures the opportunity cost of not having had in place before a single platform for countries able to send and receive e-certifications. There was a strong increase in phytosanitary e-certificates in the last two years of the dataset (2017-18) when the ePhyto Hub pilot was implemented. The two-year lag variable is thus only relevant for certificates applied to products exchanged mainly through bilateral agreements, and not through the ePhyto Hub. This negative sign thus reflects the smaller relative impact of e-certificates for these products, compared to products exchanged in the ePhyto Hub in later years.

Restricting the time period to 2012-16 and 2012-18 in the robustness tests (Annex E) allows estimating the effects of e-certification on bilateral trade flows of vegetable and plant products before the creation of the IPPC ePhyto Hub and renders this negative coefficient on the two-year lagged e-certification dummy non-significant. This could indicate that the opportunity cost of not having a multilateral platform only became apparent once the IPPC ePhyto Hub was put in place.

The stronger market-creating effects of phytosanitary certificates compared to sanitary certificates can partly be explained by the generalised use of the ePhyto Hub. This enables countries to send certificates via a single platform to the 46 active countries[30] using the ePhyto Hub system, instead of relying on several bilateral agreements that are more common for e-certification arrangements for Section I (animal products). The positive market-creation effects of digital certificates are similar for products in Section IV (foodstuffs, beverages, spirits and vinegar and tobacco) as the coefficient on e-certificates is significant and equal to 2.309 after one year.

4.3. Impacts on unit values and trade flows value

The coefficients obtained from the estimations with unit values can be transformed and expressed in percentages of the value of bilateral trade flows (ad-valorem equivalents, AVE[31]). For example, effects on trade volumes are statistically significant for Section I (animal products) and their unit value decreases by 6% one year after the creation of an e-certificate and by another 1.8% after two years (Annex Table D.2).

[30] For a list of participating countries, see https://www.ippc.int/en/ephyto/.

[31] These results are obtained by computing the exponential of the coefficients minus one and multiplying by 100. For the 1-year lagged coefficient of products in Section I (Annex Table D.2) this yields (exp(-0.0641) -1) x 100 = 6%.

Since these are the first AVE estimations from e-certification, results are difficult to compare with the literature but previous research on SPS non-tariff measures have found AVE estimates on Section I products' unit value between 3% (Cadot, Gourdon and van Tongeren, 2018[108]), and 15% across regions or even 23% for the European Union (Cadot et al., 2015[110]). Given that most of the e-certificates in Section I are import certificates sent on the EU TRACES platform, these estimates can be considered moderate. Similarly, the total value of bilateral trade flows increases by 3.8% after one year and by another 12.7% after two years, pointing to a strong long-term positive impact (Annex Table D.3). These estimates can also be interpreted as the loss in trade value when e-certificates are not being used.

The effects of e-certification on the total value of bilateral trade are positive and increase two years after implementation, while the effects on quantity are smaller after two years. This reflects the relative change in quantity traded compared to the change in unit value: the increase in quantity is not large enough to completely compensate the strong decline in unit value, resulting in a small change after one year. Still, the increase in total value despite the lower unit values signals that quantity traded reacts more strongly than price. This in turn implies a strong supply-enhancing effect associated with e-certification.[32]

Similar findings hold for products in Section II (vegetable products), where unit values decline by 13.5% one year after the implementation of e-certification and by 2.4% in the second year (but not statistically significant). Again, while it is difficult to compare these results with the literature, these estimates seem moderate as AVE estimates of SPS non-tariff measures on Section II products for example have been found to be between 4.1% (Cadot, Gourdon and van Tongeren, 2018[108]), and 19.7% on average across regions (Cadot et al., 2015[110]). Concerning bilateral trade flows and similar to Section I (animal products), the total value for Section II products (vegetable products) reacts more strongly in the first than in the second year after the implementation of the phytosanitary e-certification (19.2% compared to 5.7%).

Concerning Section III (animal or vegetable fats and oils), while effects on quantity traded are not significant, the estimates suggest a decrease of unit value by 11.9% in the first year, and by 7.9% after two years. However, the change in total value is almost null over time as it decreases by 6.9% in the first year, but increases by 10.4% after two years. Market-creation impacts of e-certificates seem relatively small for Section III products firstly because there are only few trade flows in these products, and second because most of the e-certificates are applied to products either with smoothly functioning trade (such as margarine imports into the European Union) or with more niche markets (such as beeswax). Nevertheless, further research could explore whether firms that are already trading these products significantly expand their activity once e-certification is implemented.

The unit value of products in Section IV (prepared foodstuff) appears not to show a lasting impact from e-certification: while the results show price–rising effects initially (+3.9%), a decline is observed after two years (-5.1%), resulting in almost no change in unit value over time. This, combined with the strong increase in volumes observed (Annex Table D.1), helps explain the increase in the value of bilateral trade flows of approximately 16% in both years (Annex Table D.3).

Overall, a preliminary conclusion from this analysis is that the more generalised use of multilateral e-certification platforms such as the ePhyto Hub seems to enhance the supply-enhancing effects of e-certification, resulting in stronger impacts on phytosanitary measures for trade in plant-based products than for measures applying to trade in animal-based products.

[32] The calculation of *ad valorem* equivalents relies on the assumption of a horizontal (perfectly elastic) supply curve: producers do not change their prices, even when the quantity supplied increases. This implies that the estimated ad valorem equivalents are lower bounds, and gains from e-certification could even be greater if price- as well as volume adjustments are accounted for. The simplifying assumption of a horizontal supply curve also implies that the gains from reducing SPS trade costs through e-certification would entirely accrue to purchasers and consumers in the importing country. Additional research could help determine the proportion of these trade facilitation gains going to exporting and importing countries.

5. Challenges and conditions associated with digital technologies in SPS systems

The introduction of digital technologies within SPS systems can give rise to new challenges for governments, supply chain actors, and international bodies such as the 'three sister' organisations. These challenges stem from: the planning and analysis required to successfully implement digital technologies; the mixed capacities of countries and supply chain actors in adopting these technologies; and trust concerns regarding the treatment and use of data within SPS systems.

This part of the paper examines these challenges and specifies the conditions required for digital technologies to have a positive impact in the operation of SPS systems.

5.1. Digital technologies require careful planning, analysis, and investment

The adoption of digital technologies within SPS systems can be a complex and technically challenging process involving significant investments for countries (Spreij, 2017[105]). These systems feature a multiplicity of stakeholders, and can have major potential impacts on trade flows. Even where systems need to be updated and modernised, introducing digital solutions requires careful planning, analysis, and investment in order to be successful (UNECE, 2016[44]). The challenge for countries is to ensure the continuous operation of existing systems during the implementation process, to ensure all parties have access to dependable sources of information, and to ensure the introduction of digital technologies contributes to the achievement of country policies for the safe and healthy movement of products. Countries should begin by considering the desired functionalities within their SPS systems (for example, verifying the compliance of imported goods with SPS regulations more efficiently), and assessing how digital technologies may be able to contribute to these goals.[33]

In the context of e-certification, the introduction of digital technologies in SPS systems typically begins with the establishment of a memorandum of understanding between trading parties, followed by working groups addressing technical requirements. An exception is the IPPC ePhyto Solution, through which IPPC member countries have collectively agreed to the harmonised format of the electronic phytosanitary certificate (in the same manner as they had collectively agreed to the format of the phytosanitary certificate in paper form), thereby eliminating the need to establish any individual bilateral agreements.[34] Consistent with good practice in public investment, the establishment of e-certification systems requires a thorough analysis of business processes, including: a cost-benefit analysis to establish a case for change; a thorough mapping of existing production chain processes; integrating information between customs and other government agencies; and enabling the electronic transmission of data (USAID, 2019[96]). For many countries (particularly developing countries), the capacity to undertake this analysis may be limited.

As noted in discussions with e-certification experts and experienced SPS trade negotiators, the initial process of establishing shared platforms for the exchange of e-certificates can be lengthy and complicated. For example, the co-operation between the Netherlands and China on the paperless exchange of e-certificates for dairy and veterinary products occurred over a five-year period from 2010 to 2015, and involved a number of individual administrative steps, such as linking export databases and providing for online verification of certifications (Moret, 2018[111]). This means that the efficiencies generated through the use of e-certification can take time to embed. However, once these systems were established in one country, its bilateral e-certification agreements with other exporters were finalised more quickly due to the

[33] Interview with Erik Bosker, DVM and Senior Policy Advisor at the Ministry of Agriculture, Nature and Food Quality, The Netherlands, Chair of the CCFICS-EWG developing the proposed draft guidance on paperless use of electronic certificates and author of a recent report for the STDF e-veterinary certification project managed by OIE (OIE, 2020[56]), July 2020.

[34] Interview with Craig Fedchock, Senior Advisor, IPPC Secretariat, August 2020.

existence of platforms and the accumulation of experience and expertise. For example, the exchange of e-certificates between the Netherlands and the Russian Federation took only three months to establish because both countries already had the systems required to issue, send, and receive these e-certificates. In this case, the two countries simply needed to create standardised XML messages and formalise access to systems, such as the Netherlands' Certificate Mastering System.[35]

Establishing bilateral e-certification agreements on an ad hoc country-by-country basis nevertheless still involves additional time and expense for countries, in contrast with the use of a multilateral exchange agreement such as the IPPC ePhyto Solution. These expenses can be a deterring factor for many countries, notably developing countries.[36]

A set of conditions should be considered in relation to the use of digital technologies within SPS systems, including e-certificate systems. Prior to automating certification systems, countries must conduct a comprehensive analysis of their export and import business processes. Any decision to invest in an e-certification system should only be made after due consideration of the costs and benefits (STDF, 2017[1]), the education and information needs for exporters and importers, and the need to deliberately build government capability to adopt digital tools (UNDP, 2019[112]).

Additionally, countries must have an optimal paper certificate in place to start with, including a sound knowledge of the rights and obligations of the WTO SPS Agreement. Other pre-requisites for e-certification include political will, a mature trade sector, and adequate IT infrastructure and capabilities within the SPS authorities (STDF, 2017[1]). E-certification requires that electronic certificates represent perfect equivalents to paper certificates, containing the exact same information and having the same legal value (UNECE, 2016[44]).

Collaboration on e-certification, for example, also requires countries to include provisions on the use and security of exchanged data, and on the mechanism for exchange. Countries willing to exchange e-certificates must create mechanisms for correspondence and interoperability, including harmonising their data exchange systems and ensuring cybersecurity based on international standards. This means countries may also need to coordinate across multiple authorities participating in the domestic SPS system around those same standards. As with other technical requirements, the IPPC ePhyto Solution provides a standardised multilateral framework for countries to use.

The transmission of e-certificates between governments is enabled by the use of Electronic Data Interchange (EDI) systems. EDI is an umbrella term for various methods of automated electronic transfer from one computer system to another via standardised message formatting, without the need for human intervention. However, these systems also have to be codified to enable connectivity and interoperability. For example, a unique code has to be attributed to all the different words that can be used to describe traded goods. The UN/CEFACT develops and maintains the only international standard for EDI (EDIFACT) (UNECE, 2020[113]),[37] however, different countries use different technical solutions and standards for EDI, and do not all refer to the same international standards.

When considering the use of digital technologies within SPS systems, countries must pay attention to guidance from international organisations on addressing regulatory uncertainty. For example, although countries are increasingly using e-certificates in SPS systems, there is often an absence of clear and unambiguous rules for the legal recognition of e-certificates or e-identities. This creates uncertainty for

[35] Interview with Erik Bosker, DVM and Senior Policy Advisor at the Ministry of Agriculture, Nature and Food Quality, The Netherlands, Chair of the CCFICS-EWG developing the proposed draft guidance on paperless use of electronic certificates and author of a recent report for the STDF e-veterinary certification project managed by OIE (OIE, 2020[56]), July 2020.

[36] Interview with Craig Fedchock, Senior Advisor, IPPC Secretariat, August 2020.

[37] In 2009, the UN/CEFACT created a standard for the implementation and the security of data exchange for electronic SPS certificates, to support their uptake and promote interoperability (UNECE, 2016[44]).

countries and businesses, and can present challenges for the wider uptake of these technologies. Standardising regulations governing the acceptance of e-certification is one way of overcoming this: for example, the recognition within (or in data exchange with) EU TRACES of e-certificates as original electronic documents replacing paper certification (EC, 2018[97]). Another example is the adoption of the standardised form for the ePhyto, an appendix to the International Standard for Phytosanitary Measures (ISPM) 12, which was adopted as an international standard by the 184 member country IPPC Commission on Phytosanitary Measures (IPPC, 2017[54]).

Additionally, countries need to ensure they are promoting the interoperability between legacy systems and new technologies in terms of the capture and flow of data (Tripoli, 2018[28]). This interoperability is key to the successful implementation of digital technologies, as it ensures that there are no gaps or inconsistencies in the capture, treatment and dissemination of data.

Consideration of regulatory frameworks also extends beyond core SPS regulations, and can involve decisions made by private actors within trade systems. Similarly to banks requiring physical copies of SPS certificates, where countries are relying on DLT technologies such as blockchain to facilitate the movements of goods, banks and other financing institutions may still require hardcopy documentation to issue letters of credit (Ellis, 2020[84]) or paper certificates can be needed for judicial procedures. In this case, countries must consider the wider regulatory implications of introducing digital technologies to avoid any unexpected impediments to uptake. Interviews with experts suggest that banks or other financial institutions in China are no longer requiring hardcopy documentation of official certificates for the issuance of letters of credit.[38]

Countries must also consider the long-term investment requirements for e-certification systems, as these can be a significant barrier. For example, New Zealand, the first country to implement a system for e-certification, spent approximately NZD 13 to 14 million from 1999 to 2002 on implementing the country's internal system, including traceability requirements. About NZD 3.5 million of that amount was required for the export module, securing web access and direct certificate exchange. Following initial investments, New Zealand allocates NZD 1 million annually on maintenance and improvements of the whole system (UNECE, 2016[44]). The STDF project examining a potential framework to facilitate e-veterinary certification also noted the cost of establishing and maintaining e-certification systems as a common factor limiting the willingness of both developed and developing countries to implement such systems (OIE, 2020[56]).

According to the UNECE consultation, the cost of implementing an electronic SPS IT system alone is between USD 600 000 and USD 800 000 (UNECE, 2016[44]). This does not include the cost of advocating adoption by importers or exporters, or the cost of securing bilateral agreements with trading partners. Multilateral solutions such as the IPPC's GeNS can offer an alternative to many of these implementation costs. The GeNS is free for use, and centrally-managed and maintained by the UNICC.

In addition to the specific examples described in this paper, it should also be noted that many platforms enabling SPS systems to be more risk-based and risk-proportional are less complex, and do not require significant investments or regulatory changes for countries (OECD, 2020[31]). These technologies include existing 'traffic light' models which allow agencies to apply a low/medium/high-risk range of proportional SPS screening requirements based on consignment information (including the presence or absence of quarantine pests or transboundary animal diseases in the country of origin and other factors) (Black, 2019[114]).

[38] Interview with Erik Bosker, DVM and Senior Policy Advisor at the Ministry of Agriculture, Nature and Food Quality, The Netherlands, Chair of the CCFICS-EWG developing the proposed draft guidance on paperless use of electronic certificates and author of a recent report for the STDF e-veterinary certification project managed by OIE (OIE, 2020[56]), July 2020.

5.2. Digital technologies require a clear and enabling legal framework

Countries must consider the legal implications of digital SPS systems, such as the requirements for e-certification to have the same legal value as traditional paper certificates. Both analogue and digital SPS systems require a certain level of security to ensure the authenticity of documentation and to guarantee that no information is lost or modified. In a paper-based system, SPS agencies usually proof integrity and authentication by issuing certificates on security paper, with wet signatures and stamps (UNECE, 2018[115]). For electronic data exchange, different tools are needed to ensure data security.

For example, in the case of SPS e-certificates, e-signatures and digital signatures can be required to provide security for electronic messages, transactions or documents. Both terms refer to a variety of technologies that allow for signatures to have the same value as wet (handwritten) signatures. Globally, there are a number of different approaches to determining the legal status of e-signatures. Electronic signatures for electronic SPS certificates are not required in many jurisdictions, and the global ePhyto Hub does not require any either. But other systems, such as the EU certification system Integrated Management System for Official Controls, Trace Control and Expert System (IMSOC-TRACES), have mandatorily required them since 2018 (EC, 2018[116]); ePhyto has accommodated that requirement.[39] As for other bilateral initiatives, both trading parties must recognise e-signatures mutually, for example by referring to a standard model such as the XML signature.

The use of e-signatures is nevertheless constrained by the absence of clear rules for the legal recognition of e-certificates or e-identities. This gap can be a barrier to introducing electronic documentation that is e-signed. While this issue has been addressed in many countries in the world, there is still a gap between OECD countries and other regions in the world. In addition, without the proper regulatory requirements, some countries are not yet able to use electronic certificates and still need paper documents on which wet (handwritten) signatures are required (STDF, 2017[1]).

5.3. Capacity to adopt digital technologies within SPS systems is mixed

The pace of change in the use of digital technologies within SPS systems can pose a capacity challenge for many countries (Spreij, 2017[105]). Developing and incorporating technologies such as e-certification regimes takes a significant level of expertise and familiarity with specific tools, and the swift evolution in digital tools can result in some countries being excluded from their use (Jouanjean, 2019[15]).

In particular, the implementation of digital tools within SPS systems can present challenges for developing and least developed countries. The adoption of tools such as DLTs and Internet of Things sensors involves an additional burden for these countries, in terms of the level of investment in these systems, and the expertise required. In considering the wider uptake of these tools, countries must be mindful of the digital divide between countries with the capacity and capability to adopt these tools, and those which require additional support and assistance to participate (OECD, 2020[117]). Without this support and assistance, developing and least developed countries may face significant disadvantages in their ability to trade with countries already using these systems.

The ePhyto Hub GeNS (the generic web-based system allowing countries without dedicated e-certification systems to exchange ePhytos) offers a useful example of the challenges of adopting digital technologies within SPS systems. Despite the support, training, and expert guidance offered to countries to adopt the GeNS (including free training offered by the IPPC in English, French, and Spanish), many countries are still not actively using it to exchange ePhyto certificates (FAO, 2019[118]). However, the number of countries actively exchanging these certificates via the ePhyto Hub is growing (IPPC, 2020[24]).

[39] Interview with Craig Fedchock, Senior Advisor, IPPC Secretariat, August 2020.

Similar trends have been observed regarding the EU TRACES system, whereby many of the EU's trading partners are not actively using the system, despite the support and guidance offered by the European Union (EC, 2020[76]). Again, some trading partners lack the technical capacity and infrastructure to engage with these systems, and require assistance from specialised experts; this technical assistance can be provided as part of capacity building and bilateral cooperation.

As noted by the IPPC in relation to the ePhyto Hub, a comprehensive and varied set of training resources must be offered to countries at all stages of technological capacity to encourage the use of shared digital SPS technologies. These resources should be accompanied by regular communications to countries to boost awareness of the availability of these multilateral systems, and to highlight examples of successful system implementation (IPPC, 2020[68]).

Countries should continue to build capacity through sharing case studies and technical expertise on the use of digital technologies within SPS systems. Where suitable, countries should consider investments in guidance and support for developing countries to transition to shared digital technologies. A recent example of this is funding by the German Agency for International Cooperation (GIZ) of an ePhyto pilot in Morocco – see Box 7.

There are a number of international organisations involved in promoting the adoption of digital technologies in SPS systems, including by funding technical cooperation programmes. To encourage coordination between international bodies, in October 2019 the STDF established a SPS electronic certification Advisory Committee (ECAC).[40] (STDF, 2016[119]) (STDF, 2019[120]).

Box 7. Morocco ePhyto project

The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) is currently supporting a project to develop additional ePhyto capability in Morocco. This project, a partnership between GIZ and the Global Alliance for Trade Facilitation, has successfully enabled Morocco to exchange ePhytos via the ePhyto Hub from March 2020 (GTD, 2017[121]), making it one of the first African countries to fully integrate the use of ePhytos in its national trade system (Global Alliance for Trade Facilitation, 2020[122]). Morocco has also recently developed a new online portal which companies can use to apply for phytosanitary certificates. Prior to this integration, export processes for Moroccan plant products were paper-based, and as with all paper-based systems the use of these certificates was prone to error, loss, theft, and counterfeiting. Significant processing times at the border also created a higher risk of goods spoiling. The transition to ePhytos, combined with other digitalisation initiatives, such as the Port of Casablanca's switch to electronic delivery notes, has created efficiencies and reduced processing time (International Transport Journal, 2020[123]). It has also reduced the risk of fraud or loss for Moroccan exporters, allowing them to match the physical flow of goods with digital records.

The project is also building a detailed baseline of the costs faced by Moroccan businesses in complying with paper-based phytosanitary certification (including delays, spoiled goods, demurrage fees, breakage, theft, and other costs), and comparing this against costs following the introduction of ePhyto. This measurement has involved surveying companies regarding the frequency of export delays; the cause(s) of these delays; the costs sustained as a result; and the possible impacts on customers, clients, and other stakeholders. The results of this baseline measurement will be available to project partners in early 2021 and will offer a clear and detailed sense of how the transition to e-certification for phytosanitary products has benefitted Moroccan exporters and government agencies.

[40] Members of the group include the STDF Secretariat WTO, the Codex Secretariat, IPPC, OIE, the World Bank, FAO, UNECE/ UNCEFACT, UNICC.

The STDF also encourages the use of the Prioritising SPS Investments for Market Access (P-IMA) tool in a range of developing countries (including Ethiopia, Madagascar, Malawi, Tajikistan, and Belize) to help countries make more efficient decisions about investing in SPS systems. This tool offers an evidence-based framework to inform and approve SPS planning and decision-making processes (STDF, 2019[120]).

Elsewhere, countries are using digital technologies to boost the capacity of small and medium-scale agricultural producers to conduct food safety inspections through the supply chain. For example, in 2015 the Inter-American Institute for Cooperation on Agriculture (IICA) launched a virtual food inspection training platform implemented in Belize, Costa Rica, the Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua, and Panama. The aim of this project was to train food safety inspectors in harmonised controls for the safe production and storage of food products, helping to bring greater consistency to food inspection, modernise and improve food safety standards, and minimise obstacles to regional and international trade. This training was delivered using remote learning platforms, and was financed by the STDF (IICA, 2015[124]).

As discussions with subject matter experts have suggested, given existing digital SPS platforms (notably, e-certification systems) are designed to exchange electronic documentation in XML format, there is a common framework available for linking these systems. Generating momentum in governments is the most significant challenge in promoting the use of these platforms.[41]

Part of the reluctance from countries with established capacity in the use of digital technologies may be due to the fact that changes will require reforms to existing administrative systems, many of which may be spread across a number of government agencies involved in administering SPS systems, adding an additional layer of complexity (for example, customs agencies, agricultural and environmental agencies, food safety standards bodies, and trade organisations). Furthermore, there are likely to be path dependencies (a reliance on established practices due to convention) in the way SPS systems are governed (STDF, 2017[125]; STDF, 2018[126]). (Cerna, 2013[127]). Reforms to introduce these technologies will require sustained effort, investment, cooperation and integration between parties.

Another factor contributing to the complexity of existing SPS systems is the often agency-specific nature of existing methods for risk-based management. In order to automate cross-border processes (such as product identification and compliance assessment), countries first need to coordinate the risk-management systems of all authorities in charge of monitoring imported goods. An important first step can be the coordination of product classification between SPS agencies and customs; for example, the consistent use of Harmonised System (HS) codes.[42] One example of successful coordination is the European Union's adoption of the Rapid Alert System for Food and Feed in 1979, a system of notification and information exchange on emergency sanitary measures taken at the border by EU Member states. This system enables member states to share information on rejected consignments to avoid the possibility of entry via another EU border post (EC, 2020[128]). This system is now integrated with TRACES in the Integrated Management System for Official Control (IMSOC) approach covered by the new Official Control Regulation for the European Union.

Cultural barriers may prevent the wider uptake of digital technologies such as e-certification. Interviews with e-certification experts suggest numerous government bodies involved in SPS certification have a

[41] Interviews with Craig Fedchock, Senior Advisor, IPPC Secretariat; Philippe Loopuyt, Lead of the EU TRACES, Directorate SANTE.DDG2.G (Crisis management in food, animals and plants), European Commission, DG Health and Food Safety; and Erik Bosker, DVM and Senior Policy Advisor at the Ministry of Agriculture, Nature and Food Quality, The Netherlands, Chair of the CCFICS-EWG developing the proposed draft guidance on paperless use of electronic certificates and author of a recent report for the STDF e-veterinary certification project managed by OIE (OIE, 2020[56]), July-August 2020.

[42] Wider OECD work on cross-organisational service communities offers a relevant example of this coordination – see *Digital Government in Chile – Improving Public Service Design and Delivery* (OECD, 2020[145]).

preference for status quo paper-based systems.[43] Sharing country experience and expertise can help to address this reticence. Furthermore, the experience gained from the time-bound use of e-certification during COVID-19 will increase the familiarity with digital methods for officials involved in administrating and implementing the measures.

5.4. Digital technologies can give rise to trust concerns regarding data

The use of digital technologies within SPS systems offers significant advances in transmitting, gathering, and analysing data regarding the flow of traded goods, and can also assist governments in using this data to shape SPS policy. However, these advances also involve new considerations in relation to trust, privacy, and data security. The goal of countries should be to create and maintain trust in SPS systems (OIE, 2020[56]). Countries should consider the implications of the use of digital technologies within SPS systems in the context of cross-border data flows, in particular the regulatory approach needed to protect sensitive data and regulate the flow, processing, and storage of data. These approaches can range from ex-post accountability for the misuse of data through to permitting the transfer of data only to specified countries and allowing data to be transferred on a case-by-case basis subject to review and discretionary approval. Increasingly, countries are making explicit provisions addressing data flows and storage requirements within trade agreements (Casalini and González, 2019[129]).

Applying technologies such as e-certification systems, DLTs, and other shared and secure digital platforms for the exchange of information can improve the integrity and accuracy of data shared regarding traded products (Australian Department of Agriculture, Water, and the Environment, 2020[46]). For example, e-certificates are transferred securely and instantaneously between governments, allowing information to be cross-checked and reconciled with other databases, and reducing the potential for fraud (Tripoli, 2020[85]).

In existing SPS systems, human assessors are relied upon to make decisions about matters of compliance. This involves a level of discretion and variability on behalf of individual actors, but it also gives reassurance to food supply chain actors about the responsiveness of SPS systems. Transitioning away from human assessors and towards the use of digital technologies such as algorithms and automatic sensors can potentially result in an erosion of trust in these systems, even though SPS regulations may be applied in a more consistent and predictable manner (Weiss, 2019[130]).

The wider use of tools such as digital platforms for the collection, analysis, and dissemination of SPS information creates new considerations and roles for government in this data infrastructure, either as a coordinating body, a regulator setting standards for interoperability, or in developing this infrastructure itself. In performing these roles, governments must bear in mind their duties to: encourage better data management practices; provide a model of good practice for the responsible and transparent use of data in public analysis and decision-making; and provide clear and reliable information to affected parties concerning the use and treatment of these data (OECD, 2019[131]). This is an area that would benefit considerably from the exchange of best practice guidance and case studies, especially from early adopters of e-certification regimes such as New Zealand, Australia, and the Netherlands.

Data ownership and use is of concern to all parties participating in digital SPS systems (Gain, B.; Sela, S., 2019[58]). Countries must actively monitor the collection and use of SPS systems data and ensure that the use of digital technologies is in accordance with international privacy principles such as those of the UNDP 2019 Digital Strategy, the OECD Recommendation of the Council on Digital Government Strategies, and the legal frameworks established by national governments. The use of these tools is an opportunity to build

[43] Interviews with Craig Fedchock, Senior Advisor, IPPC Secretariat; Philippe Loopuyt, Lead of the EU TRACES, Directorate SANTE.DDG2.G (Crisis management in food, animals and plants), European Commission, DG Health and Food Safety; and Erik Bosker, DVM and Senior Policy Advisor at the Ministry of Agriculture, Nature and Food Quality, The Netherlands, Chair of the CCFICS-EWG developing the proposed draft guidance on paperless use of electronic certificates and author of a recent report for the STDF e-veterinary certification project managed by OIE (OIE, 2020[56]), July-August 2020.

trust in the handling and treatment of SPS systems data (OECD, 2019[103]). Many countries and regional bodies are considering new regulatory measures governing the responsible and trusted collection, storage, and use of data within agricultural and trade systems, for example, Australia's recent *Future of Agricultural Technologies* paper (Lockie et al., 2020[132]), and the European Union's *Customs Union Action Plan* (EC, 2020[133]).

As noted in the OECD report *Digital Opportunities for Better Agricultural Policies: Insights from Agri-Environmental Policies*, the capacity to create additional value in food systems, including through the use of digital technologies in SPS systems, depends not only on connectivity infrastructure (hard infrastructure) but also on the regulatory environment and institutional arrangements (soft infrastructure) which work together to govern the use of digital technologies in the food and agriculture sector (OECD, 2019[131]).

6. Conclusion

Country use of digital tools and technologies within SPS systems is expanding significantly, particularly in the context of the disruptions and travel limitations (both international and domestic) caused by the COVID-19 pandemic. In particular, countries are expanding systems for the transmission and receipt of e-certificates to satisfy SPS requirements, either through joining or increasing engagement with established multilateral platforms such as the ePhyto Hub, or through making time-limited exemptions to requirements for physical certification. This expanded activity has the potential to shift cultural attitudes of SPS agencies towards the use of digital technologies within SPS systems within border and customs agencies, and could contribute to long-term shifts in SPS systems around the world. In particular, the emergence of fully paperless bilateral trade (for example, between Australia and New Zealand or Argentina and Chile) has the potential to demonstrate the benefits of these trends.

Countries should consider expanding their use of digital technologies within SPS systems to create greater efficiencies, facilitate trade, and assist with the healthy and safe supply of food products. In particular, these digital technologies have the potential to enable countries to adopt more risk-targeted and risk-proportional approaches within SPS systems, allowing resources to be allocated where they are most needed. Although country efforts are still mostly focused on the exchange of e-certificates, there are growing instances of countries using technologies for applications such as:

- conformity assessment platforms (for example, the Netherlands' development of a 'Virtual Inspector' to draw from e-certificates in analysing risk);
- the integration of risk assessment, risk management, and e-certification in a single concept for all of the EU countries (IMSOC approach merging TRACES, the Rapid Alert System for Food and Feed, and the EU Notification System for Plant Health Interceptions in an integrated platform covered by a new single Official Control Regulation);
- traceability and supply chain integrity systems (including the use of DLTs such as blockchain) (for example, Argentina's use of blockchain technology in its citrus product traceability system);
- platforms to support regional pest information exchange (for example, the partnership between the STDF and Australian Department of Agriculture and Water Resources promoting a digital pest detection platform in Thailand, Laos, Malaysia, Cambodia, Viet Nam, the Philippines, and Papua New Guinea); and
- advanced border screening (for example, Canada's use of e-certificates to assess consignment risk in advance of product arrival).

The use of these digital technologies offers significant benefits for countries, businesses, and international organisations. They enable information to be exchanged quickly and accurately between SPS and border agencies, and support more efficient decision-making processes and reduced processing times. They also offer enhanced security in the exchange of products, and greater integrity through product traceability. In particular, these technologies provide a valuable source of data to inform countries' SPS risk management processes, including through the transfer of real-time data on risk factors such as pest prevalence and the presence of in-country SPS controls. Finally, they can help to facilitate regional and international trade by making SPS systems easier to navigate, particularly for small to medium-sized businesses.

The 'three sister' organisations are each taking steps to set guiding frameworks for country activity in the use of these technologies. In particular, the IPPC is actively advocating increased country use of its ePhyto Hub platform, which has hosted an increasing number of exchanges in 2020 in the context of the COVID-19 pandemic. The OIE has managed an STDF project on the establishment of a framework for the exchange of veterinary e-certificates in a Single Window environment (although the next steps following this project are still under consideration). Codex Alimentarius is developing guidance for the paperless use of electronic food certificates (Codex, 2020[57]).

There is a time-limited opportunity in the context of the COVID-19 pandemic to advocate for greater country use of digital technologies within SPS systems, particularly e-certification platforms. The disruptions caused by the pandemic have served to highlight the importance of flexibility and adaptation in SPS systems, and the need to reduce country reliance on analogue, paper-based processes supporting the movement of goods.

Meeting this opportunity involves addressing a number of challenges and constraints in relation to the use of digital technologies within SPS systems. These technologies must be designed to address clearly defined inefficiencies and inconsistencies in status quo systems, and must build on existing systems in ways which provide certainty and dependability for businesses and other SPS systems actors (UNECE, 2016[44]). Certain technical matters require resolution, including determining the legal acceptability of e-signatures, ensuring digital technologies contribute to the implementation of the obligations of the WTO SPS Agreement, and promoting the interoperability and equivalence of SPS systems using digital technologies. These systems must be supported by dependable sources of long-term funding, including funding for multilateral platforms such as the IPPC's ePhyto Hub.

The modelling approach used in this report confirms the market-creation potential of e-certificates and that due to the necessary time and resources for their implementation, the full impact of e-certificates on trade does not materialise immediately. The total value of exports increases significantly over time for all agro-food product groups (except for animal or vegetable fats and oils), suggesting that supply-enhancing effects could drive increase in revenue for exporters. The estimates for trade in plant-based products signal the information and cost reduction potential of centralised platforms used to create and generate electronic certificates, such as ePhyto Hub.

At present, countries are advancing the shared use and recognition of digital technologies within SPS systems primarily through bilateral forums, such as trading agreements. Alongside these bilateral forums, it is crucial for countries to continue participating in multilateral forums to consider and resolve technical issues relating to the use of these technologies. It is similarly important for countries to share best-practice guidance in the use of these technologies (including case studies) to develop further expertise in the implementation, monitoring, and oversight of these technologies.

In light of the trends and opportunities described in this report, it is recommended that countries:

- identify their automation needs within SPS systems and consider the appropriate expansion of their use of digital technologies within SPS systems to create greater efficiencies, facilitate trade, and assist with the healthy and safe supply of food products (including live animals, products of animal origin, and plant products);
- consider the elements needed to support the successful expansion of these digital technologies within SPS systems, including: careful planning and analysis; a clear and enabling regulatory environment; building capacity in the use of these technologies; accessing dependable long-term

sources of funding; providing assurances regarding data storage, transmission, and use; and promoting the interoperability and equivalence of SPS systems using digital technologies;

- consider the implications of the expanded use of these digital technologies for developing and least developed countries, and remain mindful of the digital divide in capacity and capability to adopt these technologies and the support and assistance these countries may require;
- examine the increased use of digital SPS technologies (notably e-certification) in the context of the COVID-19 response, with the aim of harnessing momentum for wider uptake;
- continue to exchange best-practice guidance regarding the use of digital technologies to develop a shared pool of expertise, in particular, case studies illustrating the successful adoption of these technologies; and
- examine the potential for greater harmonisation between countries and relevant international organisations in the use of digital technologies within SPS systems, notably the exchange of e-certificates (including harmonised sanitary and veterinary SPS certificates).

References

AEM (2020), *Strengthening ASEAN's Economic Resilience in Response to the Outbreak of the Coronavirus Disease (COVID-19)*, https://asean.org/storage/2020/03/AEMR-26-Statement-on-COVID-19-FINAL-10.03.2020.docx.pdf (accessed on October 2020). [21]

Alsema, A. (2017), *How Colombia Plans to Confront Foot and Mouth Disease*, https://colombiareports.com/colombia-plans-confront-foot-mouth-disease/ (accessed on September 2020). [39]

Anderson, J., M. Larch and Y. Yotov (2018), *Growth and Trade with Frictions: A Structural Estimation Framework*, https://www.wto.org/english/res_e/reser_e/gtdw_e/wkshop18_e/larch_e.pdf. [140]

APEC (2011), *Facilitating Electronic Commerce in APEC: A Case Study of Electronic Certificate of Origin*, https://www.apec.org/Publications/2011/11/Facilitating-Electronic-Commerce-in-APEC-A-Case-Study-of-Electronic-Certificate-of-Origin. [98]

Arana, F. (2020), *The Geostrategic Use of Drones in South America*, https://wgi.world/the-geostrategic-use-of-drones-in-south-america/ (accessed on September 2020). [40]

Australian Department of Agriculture, Water, and the Environment (2020), *Electronic Certification (eCert) for Imports*, https://www.agriculture.gov.au/import/online-services/electronic-certification (accessed on October 2020). [46]

Barlow, S. et al. (2015), "The Role of Hazard and Risk-Based Approaches in Ensuring Food Safety", *Trends in Food Science and Technology*, Vol. 45/2015, pp. 176-188. [29]

Black, R. (2019), *Integrating Risk Assessment into ICT-Enabled Border Management*, https://www.carecprogram.org/uploads/11-Integrating-Risk-Assessment-ICT-Enabled-Border-Management.pdf (accessed on September 2020). [114]

Blanc, F. (2018), *From Chasing Violations to Managing Risks*, E. Elgar, Cheltenham. [8]

Cadot, O. et al. (2015), *Deep Regional Integration and Non-tariff Measures: A Methodology for Data Analysis, UNCTAD Policy Issues in International Trade and Commodities Research Study Series, (69)*, https://unctad.org/en/PublicationsLibrary/itcdtab71_en.pdf. [110]

Cadot, O., J. Gourdon and F. van Tongeren (2018), "Estimating Ad Valorem Equivalents of Non-Tariff Measures: Combining Price-Based and Quantity-Based Approaches", *OECD Trade Policy Papers*, No. 215, OECD Publishing, Paris, https://dx.doi.org/10.1787/f3cd5bdc-en. [108]

Casalini, F. and J. González (2019), *Trade and Cross-Border Data Flows*, OECD Publishing, Paris, https://doi.org/10.1787/18166873. [129]

Cerna, L. (2013), *The Nature of Policy Change and Implementation: A Review of Different Theoretical Approaches*, OECD Publishing, Paris, https://www.oecd.org/education/ceri/The%20Nature%20of%20Policy%20Change%20and%20Implementation.pdf (accessed on October 2020). [127]

Codex (2020), *Proposed Draft Guidance on Paperless Use of Electronic Certificates*, http://www.fao.org/fao-who-codexalimentarius/sh-proxy/en/?lnk=1&url=https%253A%252F%252Fworkspace.fao.org%252Fsites%252Fcodex%252FMeetings%252FCX-733-25%252FWorking%2BDocuments%252Ffc25_05e.pdf (accessed on October 2020). [57]

Eaton, J. and S. Kortum (2002), "Technology, Geography, and Trade", *Econometrica*, Vol. 70/5, pp. 1741–1779, https://www.jstor.org/stable/3082019. [137]

EC (2020), *RASFF - Food and Feed Safety Alerts*, https://ec.europa.eu/food/safety/rasff_en (accessed on September 2020). [128]

EC (2020), *Taking the Customs Union to the Next Level: A Plan for Action*, European Commission, Brussels, https://ec.europa.eu/taxation_customs/sites/taxation/files/customs-action-plan-2020_en.pdf. [133]

EC (2020), *TRACES Annual Report 2019*, https://ec.europa.eu/food/animals/traces/information-material/traces-annual-report-2019_en (accessed on October 2020). [75]

EC (2020), *TRACES Overview*, https://www.standardsfacility.org/sites/default/files/ECAC_TRACES_Presentation_Jun-20.pdf (accessed on June 2020). [76]

EC (2020), *What is TRACES?*, https://ec.europa.eu/food/animals/traces_en (accessed on August 2020). [73]

EC (2019), *Commission Implementing Regulation 2019/1715*, https://eur-lex.europa.eu/eli/reg_impl/2019/1715/oj (accessed on October 2020). [77]

EC (2018), *E-Certification: The European Union Approach and Experience*, EC, Geneva, https://www.wto.org/english/tratop_e/sps_e/session_4_2c_eu_ecertification_philippe_loopuyt.pdf. [97]

EC (2018), *Integrated Management System for Official Controls*, https://ec.europa.eu/food/sites/food/files/safety/docs/official-controls_expert-group_20180227_pres03.pdf (accessed on October 2020). [116]

Ellis, J. (2020), *Cargill and Agrocorp Complete Groundbreaking $12m Intercontinental Wheat Trade on Blockchain*, https://agfundernews.com/cargill-and-agrocorp-complete-groundbreaking-12m-intercontinental-wheat-trade-using-hyperledger-fabric.html (accessed on August 2020). [84]

EU (2020), *Commission Implementing Regulation 2020/466*, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32020R0466 (accessed on October 2020). [78]

FAO (2020), *Agri-Food Markets and Trade Policy in the Time of COVID-19*, http://www.fao.org/3/ca8446en/CA8446EN.pdf (accessed on October 2020). [20]

FAO (2020), *The Role of Digital Technologies in Livestock Traceability and Trade*, http://www.fao.org/3/ca9939en/CA9939EN.pdf (accessed on December 2020). [79]

FAO (2019), *Overview of Global Meat Market Developments*, http://www.fao.org/publications/card/en/c/CA8819EN/ (accessed on October 2020). [72]

FAO (2019), *The Generic ePhyto National System (GeNS)*, http://www.fao.org/3/ca2695en/CA2695EN.pdf (accessed on October 2020). [118]

FAO (2018), *Climate Change, Sanitary and Phytosanitary Measures, and Agricultural Trade*, http://www.fao.org/3/CA2351EN/ca2351en.pdf (accessed on October 2020). [9]

FAO (2016), *Risk-Based Imported Food Control Manual*, http://www.fao.org/3/a-i5381e.pdf (accessed on October 2020). [33]

Farmforce (2020), *The Digital Solution to Secure Sustainable Sourcing*, https://farmforce.com/ (accessed on August 2020). [92]

Feenstra, R., J. Markusen and R. K. (2001), "Using the gravity equation to differentiate among alternative theories of trade", *Canadian Journal of Economics*, Vol. 34/2, pp. 430-447, https://www.jstor.org/stable/3131862. [138]

Gain, B.; Sela, S. (2019), *EPhyto: Promoting Safe and Efficient Trade*, https://blogs.worldbank.org/trade/ephyto-promoting-safe-and-efficient-trade (accessed on October 2020). [58]

Global Alliance for Trade Facilitation (2020), *Morocco Leads the Way in Africa as Digital Phytosanitary Certificates Go Live*, https://www.tradefacilitation.org/article/morocco-leads-the-way-in-africa-as-digital-phytosanitary-certificates-go-live/ (accessed on September 2020). [122]

Gourdon, J., S. Stone and F. van Tongeren (2020), "Non-tariff measures in agriculture", *OECD Food, Agriculture and Fisheries Papers*, No. 147, OECD Publishing, Paris, https://dx.doi.org/10.1787/81933f03-en. [109]

Grant, J. and S. Arita (2017), *Sanitary and Phyto-Sanitary Measures: Assessment, Measurement, and Impact, IATRC Commissioned Paper 21*, https://iatrc.umn.edu/sanitary-and-phyto-sanitary-measures-assessment-measurement-and-impact/ (accessed on October 2020). [142]

GTD (2017), *PortNet Project Led by GTD*, https://www.gtd.eu/fr/news-and-events/portnet-project-led-gtd (accessed on September 2020). [121]

IICA (2015), *IICA Launches Virtual Food Inspection School in Central America and the Dominican Republic*, https://www.iica.int/en/press/news/iica-launches-virtual-food-inspection-school-central-america-and-dominican-republic (accessed on September 2020). [124]

International Transport Journal (2020), *Port of Casablanca Shows Resilience*, https://www.transportjournal.com/fr/home/news/artikeldetail/port-of-casablanca-shows-resilience.html (accessed on September 2020). [123]

IPPC (2020), *Argentina and Chile Set a Milestone with the Application of the IPPC ePhyto Solution*, https://www.ippc.int/en/news/argentina-and-chile-set-a-milestone-with-the-application-of-the-ippc-ephyto-solution/ (accessed on August 2020). [47]

IPPC (2020), *EPhyto Hub Service Report August 2020*, IPPC, Rome. [24]

IPPC (2020), *EPhyto Industry Advisory Group (IAG) and EPhyto Steering Group (ESG) Meeting with Industry Representatives*, [70] https://www.ippc.int/static/media/files/publication/en/2020/07/Report_ESG_IAG_Industry_2020_June_2020-07-27.pdf (accessed on October 2020).

IPPC (2020), *EPhyto Newsletter*, https://www.ippc.int/static/media/files/publication/en/2020/07/ePhytoNewsletter10_final_IPPC.pdf (accessed on October 2020). [68]

IPPC (2020), *IPPC Procedure Manual for Implementation and Capacity Development*, https://www.ippc.int/en/publications/86954/ (accessed on October 2020). [101]

IPPC (2020), *The Republic of Korea and Costa Rica Go into Live IPPC ePhyto Production*, https://www.ippc.int/en/news/the-republic-of-korea-and-costa-rica-go-into-live-ippc-ephyto-production/ (accessed on August 2020). [69]

IPPC (2019), *Strategic Framework for the International Plant Protection Convention 2020-2030*, https://www.ippc.int/en/publications/85576/ (accessed on October 2020). [102]

IPPC (2019), *The Generic ePhyto National System (GeNS)*, http://www.fao.org/documents/card/en/c/ca2695en/ (accessed on October 2020). [65]

IPPC (2019), *The Global ePhyto Hub: ePhyto Factsheet #2*, https://www.ippc.int/en/publications/86944/ (accessed on October 2020). [66]

IPPC (2018), *A Beginner’s Guide to the IPPC ePhyto Solution*, https://www.ippc.int/static/media/files/publication/en/2018/07/2018-02-20_ePhyto_for_beginners_finalized.pdf (accessed on September 2020). [71]

IPPC (2018), *Report of the IPPC ePhyto Hub Pilot*, https://www.ippc.int/static/media/files/publication/en/2018/05/IPPC_ePhyto_hub_pilot_report_FINAL.pdf (accessed on October 2020). [67]

IPPC (2018), *The IPPC ePhyto Solution and Business Model Considerations*, https://www.unece.org/fileadmin/DAM/cefact/cf_forums/2018_Geneva/PPTs/SingleWindow_PPTs/07_-_TButterly_The_Phyto_Solution.pdf (accessed on August 2020). [49]

IPPC (2018), *Third IPPC Global Symposium on ePhyto*, https://www.ippc.int/en/ephyto/ephyto-symposia/3rd-global-symposium-on-ephyto-kuala-lampur-malaysia-22-26-january-2018/ (accessed on October 2020). [42]

IPPC (2017), *ISPM 12: Phytosanitary Certificates*, https://www.ippc.int/en/publications/609/ (accessed on October 2020). [54]

IPPC (2014), *A Global ePhyto Feasibility Study*, https://www.ippc.int/static/media/files/publication/en/2016/03/A_Global_ePhyto_Feasibility_Study.pdf?__cf_chl_jschl_tk__=e717276322c1f6a56ab9eb3b1ddf2257e17054fe-1608476475-0-ASAdK5RJyAtyGVsOXpLOVVlHl8uqJXPIStb1cJCG44tIAsb9JRvDa1MAeYSgid7i68wPhmKAa6Qr8rtE (accessed on October 2020). [64]

Jouanjean, M. (2019), “Digital Opportunities for Trade in the Agriculture and Food Sectors”, *OECD Food, Agriculture and Fisheries Papers*, No. 122, OECD Publishing, Paris, https://dx.doi.org/10.1787/91c40e07-en. [15]

Khwaja, M., R. Awasthi and J. Loeprick (2011), *Risk-Based Tax Audits: Approaches and Country Experiences*, https://openknowledge.worldbank.org/handle/10986/2314. [30]

Koslowski, R. and M. Schulzke (2018), *Drones Along Borders: Border Security UAVs in the United States and the European Union*, https://www.albany.edu/~rk289758/documents/Koslowski&Schulzke_Drones_along_Borders_ISA.pdf (accessed on October 2020). [38]

Lima, M. et al. (2020), "Automatic Detection and Monitoring of Insect Pests - A Review", *Journal of Agriculture*, Vol. 1/10, p. 161. [32]

Lockie, S. et al. (2020), *The Future of Agricultural Technologies*, Australian Council of Learned Academies, https://acola.org/hs6-future-agricultural-technologies/ (accessed on October 2020). [132]

Lopez, F. (2015), *Prospects in Implementing Automated Systems for Cross-Border Agri-Food Trade*, https://www.unescap.org/sites/default/files/2.1%20Prospects%20and%20challenges%20implementing%20automated%20systems%20and%20e-SPS%20systems%20for%20cross-border%20agrifood%20trade_F.%20Lopez.pdf. [43]

Maersk (2019), *TradeLens Blockchain-Enabled Digital Shipping Platform Continues Expansion with Addition of Major Ocean Carriers Hapag-Lloyd and Ocean Network Express*, https://www.maersk.com/news/articles/2019/07/02/hapag-lloyd-and-ocean-network-express-join-tradelens (accessed on August 2020). [82]

Mangalam, S. and G. Vranic (2020), *Use of New Technologies in Regulatory Delivery*, https://www.enterprise-development.org/wp-content/uploads/DCED-BEWG-Use-of-New-Technologies-in-Regulatory-Delivery.pdf (accessed on October 2020). [11]

McDaniels, D., A. Molina and A. Wijkström (2018), "A Closer Look at WTO's Third Pillar: How WTO Committees Influence Regional Trade Agreements", *Journal of International Economic Law*, Vol. 21/4, pp. 815-843. [61]

Moïsé, E. and S. Sorescu (2013), "Trade Facilitation Indicators: The Potential Impact of Trade Facilitation on Developing Countries' Trade", *OECD Trade Policy Papers*, No. 144, OECD Publishing, Paris, https://dx.doi.org/10.1787/5k4bw6kg6ws2-en. [17]

Moret, A. (2018), *The 'Why' of Electronic Certification*, https://unece.org/fileadmin/DAM/trade/agr/meetings/ge.11/2016/MeatSeminar_PPTs/3_AlexanderMoret.pdf (accessed on October 2020). [111]

OECD (2020), *COVID-19 and International Trade: Issues and Actions*, http://www.oecd.org/coronavirus/policy-responses/covid-19-and-international-trade-issues-and-actions-494da2fa/ (accessed on August 2020). [18]

OECD (2020), *Digital Government in Chile - Improving Public Service Design and Delivery*, OECD Publishing, http://dx.doi.org/10.1787/b94582e8-en. [145]

OECD (2020), *Digitising Regulatory Delivery Using Emerging Technologies - A Review of Current Practices (Forthcoming)*, OECD Publishing, Paris. [31]

OECD (2020), *GRPs and IRC Approaches in Trade Agreements (forthcoming)*, OECD Publishing, Paris. [62]

OECD (2020), *Leveraging Digital Trade to Fight the Consequences of COVID-19*, https://www.oecd.org/coronavirus/policy-responses/leveraging-digital-trade-to-fight-the-consequences-of-covid-19-f712f404/ (accessed on December 2020). [117]

OECD (2020), *Market Consultation: Feasibility Study on the Digitalisation of OECD Seed Schemes Labelling and Certification Processes*, OECD Publishing, https://www.oecd.org/callsfortenders/OECD%20MC_Seed%20Schemes%20Digitalisation%20Project.pdf (accessed on August 2020). [80]

OECD (2020), *OECD-FAO Agricultural Outlook 2020-2029*, OECD Publishing, Paris, http://www.fao.org/publications/oecd-fao-agricultural-outlook/2020-2029/en/ (accessed on October 2020). [100]

OECD (2020), *Trade Faciliation Indicators*, OECD, Paris, https://www1.compareyourcountry.org/trade-facilitation. [35]

OECD (2019), *Digital Opportunities for Better Agricultural Policies*, OECD Publishing, Paris, https://dx.doi.org/10.1787/571a0812-en. [12]

OECD (2019), *Digital Opportunities for Better Agricultural Policies: Insights from Agri-Environmental Policies*, OECD Publishing, https://doi.org/10.1787/571a0812-en. [131]

OECD (2019), *The Path to Becoming a Data-Driven Public Sector*, OECD Publishing, Paris, http://dx.doi.org/10.1787/059814a7-en. [103]

OECD (2018), *Blockchain Technology and Corporate Governance*, OECD Publishing, https://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=DAF/CA/CG/RD(2018)1/REV1&docLanguage=En (accessed on October 2020). [81]

OECD (2018), *OECD Regulatory Enforcement and Inspections Toolkit*, OECD Publishing, Paris, https://dx.doi.org/10.1787/9789264303959-en. [7]

OECD (2018), *Trade Facilitation and the Global Economy*, OECD Publishing, Paris, https://doi.org/10.1787/9789264277571-en. [51]

OECD (2017), *Digital Connectivity and Trade Logistics: Getting Goods Shipped, Across the Border, and Delivered*, OECD Publishing, Paris, https://doi.org/10.1787/aid_glance-2017-en. [93]

OECD (2017), *Policy Brief on Women's Entrepreneurship*, OECD Publishing, Paris, https://www.oecd.org/cfe/smes/Policy-Brief-on-Women-s-Entrepreneurship.pdf (accessed on October 2020). [107]

OECD (2016), *Integrity in Customs: Taking Stock of Good Practices*, OECD Publishing, Paris, https://www.oecd.org/gov/ethics/G20-integrity-in-customs-taking-stock-of-good-practices.pdf (accessed on October 2020). [34]

OECD (2014), *Regulatory Enforcement and Inspections*, OECD Publishing, Paris, https://dx.doi.org/10.1787/9789264208117-en (accessed on October 2020). [6]

OECD (2010), *Risk and Regulatory Policy: Improving the Governance of Risk*, OECD Reviews of Regulatory Reform, OECD Publishing, Paris, https://dx.doi.org/10.1787/9789264082939-en. [14]

OIE (2020), *Development of a Framework to Facilitate E-Veterinary Certification for International Trade on the Basis of a Single Window System*, [56] https://www.oie.int/fileadmin/Home/eng/Internationa_Standard_Setting/docs/pdf/e-vet/A-Veterinary_certification.pdf (accessed on October 2020).

OIE (2019), *OIE Terrestrial Animal Health Code*, https://www.oie.int/standard-setting/terrestrial-code/ (accessed on October 2020). [55]

OIE (2018), *The OIE-WAHIS Project*, https://www.oie.int/animal-health-in-the-world/the-oie-wahis-project/ (accessed on September 2020). [26]

Okasaki, Y. (2017), *Implications of Big Data for Customs - How it Can Support Risk Management Capabilities*, http://www.wcoomd.org/-/media/wco/public/global/pdf/topics/research/research-paper-series/39_okazaki_big-data.pdf (accessed on October 2020). [37]

Otieno, N. (2019), *Argentina Adopts Blockchain Technology for Traceability in the Citrus Industry*, https://blockchain.news/news/argentina-adopted-blockchain-technology-to-secure-traceability-in-the-citrus-industry#:~:text=Argentina%20Adopts%20Blockchain%20Technology%20for%20Traceability%20in%20the%20Citrus%20Industry,-Nicholas%20Otieno%20Oct&text=The%2 (accessed on October 2020). [89]

Pavlovic, D. (2018), *E-Certification: Paperless Export Certification,*, https://static1.squarespace.com/static/59a47d89cd39c377e521fda2/t/5bb804df8165f5299ea62de7/1538786528686/7_APEC_eCert_Paperless_Export_Certification_New_Zealand_Drasko_Pavlovich.pdf (accessed on October 2020). [63]

Peel, J. (2004), *Risk Regulation Under the WTO SPS Agreement: Science as an International Normative Yardstick?*, NYU School of Law, https://www.peacepalacelibrary.nl/ebooks/files/JMWP_PEEL_Risk-Regulation.pdf (accessed on October 2020). [2]

Port of Antwerp (2018), *Antwerp Blockchain Pilot Pioneers with Secure and Efficient Document Workflow*, https://www.portofantwerp.com/en/news/antwerp-blockchain-pilot-pioneers-secure-and-efficient-document-workflow (accessed on September 2020). [90]

Russell, G. and C. Hodges (2019), *Regulatory Delivery*, Hart/Beck Publishing. [10]

Santeramo, F. (2020), *Trade Effects of SPS Measures in Regional Trade Agreements*, http://dx.doi.org/10.13140/RG.2.2.35856.02566. [60]

Shepherd, B., H. Doytchinova and A. Kravchenko (2019), *The gravity model of international trade: a user guide [R version]*, , https://www.unescap.org/resources/gravity-model-international-trade-user-guide-r-version. [141]

Spreij, M. (2017), *Electronic Sanitary and Phytosanitary Certification for Faster and Safer Trade*, https://www.oecd.org/aidfortrade/casestories/casestories-2017/CS-84-STDF-Electronic-Sanitary-and-Phytosanitary-certification-for-faster-and-safer-trade.pdf (accessed on October 2020). [105]

Spreij, M. (2007), *The SPS Agreement and Biosafety*, FAO Legal Papers, http://www.fao.org/3/a-bb098e.pdf (accessed on October 2020). [3]

STDF (2020), *SPS Electronic Certification Advisory Committee (ECAC) Summary Report of the First Virtual Meeting 18 March 2020*, STDF, [106] https://www.standardsfacility.org/sites/default/files/Minutes_ECAC_1st_Virtual_Meeting_Final.pdf.

STDF (2020), *SPS Electronic Certification Advisory Committee (ECAC) Summary Report of the Second Virtual Meeting 24 June 2020*, STDF, https://www.standardsfacility.org/sites/default/files/Minutes_ECAC_2nd_Virtual_Meeting_Final_0.pdf. [22]

STDF (2019), *STDF Annual Report 2019*, https://standardsfacility.org/sites/default/files/Annual_Report_2019.pdf (accessed on October 2020). [120]

STDF (2018), *Improving Sanitary Capacity to Facilitate Livestock and Meat Exports*, https://www.standardsfacility.org/sites/default/files/STDF_PG_477_Application%20_Form.pdf (accessed on August 2020). [126]

STDF (2018), *STDF Annual Report 2018*, https://www.standardsfacility.org/sites/default/files/STDF-AnnualReport2018.pdf (accessed on October 2020). [36]

STDF (2017), *Electronic Sanitary and Phytosanitary (SPS) Certificates in the Context of Paperless Trade*, https://www.standardsfacility.org/sites/default/files/SPS_Ecert_Backgroundpaper.pdf (accessed on October 2020). [1]

STDF (2017), *Electronic SPS Certification: Key Takeaways from STDF's Work*, http://mddb.apec.org/Documents/2017/SCSC/FSCF-PTIN-WKSP/17_scsc_fscf_ptin_wksp_011.pdf (accessed on August 2020). [125]

STDF (2017), *Facilitating Safe Trade: Going Paperless with SPS E-Certification*, WTO, https://www.standardsfacility.org/sites/default/files/e_Cert_Briefing_note_EN.pdf. [5]

STDF (2016), *Electronic Sanitary and Phytosanitary (SPS) Certification*, https://www.unece.org/fileadmin/DAM/trade/agr/meetings/ge.11/2016/MeatSeminar_PPTs/2_STDF_Presentation_KLM_Final.pdf (accessed on August 2020). [74]

STDF (2016), *STDF Seminar on Electronic Certification*, https://www.standardsfacility.org/SPS-eCert_Seminar (accessed on August 2020). [119]

STDF (2014), *Implementing SPS Measures to Facilitate Safe Trade in Cambodia*, STDF, https://www.standardsfacility.org/sites/default/files/Implementing_SPS_Measures_to_Facilitate_Safe_Trade_Cambodia_Jul-2014.pdf (accessed on August 2020). [50]

Stone, S. and F. Casalini (2020), *Chapter 13: Sanitary and Phytosanitary Measures*, World Bank Group, https://doi.org/10.1596/978-1-4648-1539-3_ch13. [4]

Tinbergen, E. (ed.) (1962), *An Analysis of World Trade Flows, in Shaping the World Economy*, New York, NY: Twentieth Century Fund. [136]

TradeLens (2019), *Why Interoperability Matters*, https://www.tradelens.com/post/why-interoperability-matters (accessed on September 2020). [83]

Tripoli, M. (2020), *A Window of Opportunity for Africa: Agricultural Innovation, Integration, and Entrepreneurial Ecosystems*, https://trade4devnews.enhancedif.org/en/op-ed/window- [85]

opportunity-africa-agricultural-innovation-integration-and-entrepreneurial-ecosystems (accessed on August 2020).

Tripoli, M. (2019), *How Can Blockchain's Architecture Enhance Trade Facilitation in Agricultural Supply Chains?*, http://www.fao.org/policy-support/tools-and-publications/resources-details/en/c/1319968/ (accessed on October 2020). [86]

Tripoli, M. (2018), *Emerging Opportunities for the Application of Blockchain in the Agri-Food Industry*, UN, https://www.researchgate.net/publication/327287235_Emerging_Opportunities_for_the_Application_of_Blockchain_in_the_Agri-food_Industry (accessed on October 2020). [28]

UNCTAD (2020), *Advancing the Digitalisation of Trade with Partnerships: National Trade Facilitations Committees as a Platform for Policy Modernisation*, https://unctad.org/en/pages/newsdetails.aspx?OriginalVersionID=2402 (accessed on September 2020). [16]

UNCTAD (2019), *International Classification of Non-Tariff Measures*, https://unctad.org/webflyer/international-classification-non-tariff-measures-2019-version (accessed on October 2020). [143]

UNCTAD (2011), *Pre-Arrival Customs Processing*, https://unctad.org/en/Docs/TN15_PreArrivalClearance.pdf. [41]

UNDP (2019), *UNDP Digital Strategy 2019*, https://digitalstrategy.undp.org/assets/UNDP-digital-strategy-2019.pdf (accessed on October 2020). [112]

UNECE (2020), *Introducing UN/EDIFACT*, https://www.unece.org/cefact/edifact/welcome.html (accessed on September 2020). [113]

UNECE (2020), *The Characteristics of a Single Window*, http://tfig.unece.org/contents/single-window-concept.htm (accessed on August 2020). [52]

UNECE (2018), *White Paper on Paperless Trade*, http://www.unece.org/fileadmin/DAM/cefact/GuidanceMaterials/WhitePapers/WP-PaperlessTrade_Eng.pdf (accessed on October 2020). [115]

UNECE (2016), *Implementing UN/CEFACT e-Business Standards in Agricultural Trade*, https://unece.org/trade/ECE-TRADE-428 (accessed on October 2020). [44]

UNESCAP (2019), *Asia-Pacific Trade Facilitation Report 2019: Bridging Trade Finance Gaps through Technology*, https://www.unescap.org/resources/asia-pacific-trade-facilitation-report-2019-bridging-trade-finance-gaps-through-technology (accessed on October 2020). [95]

UNESCAP (2019), *UN Global Survey on Digital and Sustainable Trade Facilitation 2019*, UN, https://untfsurvey.org/ (accessed on October 2020). [45]

UNESCAP (2018), *Single Window for Trade Facilitation: Regional Best Practices and Future Development*, https://www.unescap.org/resources/single-window-trade-facilitation-regional-best-practices-and-future-development (accessed on October 2020). [53]

UNESCAP (2017), *Towards Electronic Phytosanitary Certification and E-Cert Issuance*, https://www.unescap.org/sites/default/files/UNNExTBrief19.pdf (accessed on October 2020). [99]

UNNExT (2019), *UN Global Survey on Digital and Sustainable Trade Facilitation 2019*, UN, https://unnext.unescap.org/content/un-global-survey-digital-and-sustainable-trade-facilitation-2019. [48]

USAID (2019), *Assessing the Benefits of the Trade Facilitation Agreement for Agricultural Trade*, https://pdf.usaid.gov/pdf_docs/PA00TNBS.pdf (accessed on October 2020). [96]

USDA (2020), *Food Safety and Inspection Service Annual Plan 2020*, https://www.fsis.usda.gov/wps/wcm/connect/222f19ff-a1f5-42ed-8704-bfa23f00bcb2/annual-plan-fy2020.pdf?MOD=AJPERES (accessed on October 2020). [88]

USDA (2020), *National Organic Program: Strengthening Organic Enforcement*, https://www.federalregister.gov/documents/2020/08/05/2020-14581/national-organic-program-strengthening-organic-enforcement. [87]

USDA (2020), *New Era of Smarter Food Safety: FDA's Blueprint for the Future*, https://www.fda.gov/media/139868/download (accessed on October 2020). [91]

WCO (2017), *HS Nomenclature 2017 edition*, http://www.wcoomd.org/en/topics/nomenclature/instrument-and-tools/hs-nomenclature-2017-edition/hs-nomenclature-2017-edition.aspx. [134]

WCO (2010), *Revised Kyoto Convention Guidelines on the Revised Kyoto Convention General Annex*, http://www.wcoomd.org/en/Topics/Facilitation/Instrument%20and%20Tools/Conventions/pf_revised_kyoto_conv/Kyoto_New (accessed on October 2020). [144]

Weiss, M. (2019), "Remote Sensing for Agricultural Applications: A Meta Review", *Remote Sensing of Environment*, Vol. 236/5, p. 34, https://doi.org/10.1016/j.rse.2019.111402. [130]

WTO (2020), *COVID-19 and Agriculture: A Story of Resilience*, http://wto.tj/en/press-centr/news/631/ (accessed on October 2020). [19]

WTO (2020), *Regional Trade Agreements*, https://www.wto.org/english/tratop_e/region_e/region_e.htm (accessed on August 2020). [59]

WTO (2020), *Standards, Regulations, and COVID-19: What Actions Taken by WTO Members?*, https://www.wto.org/english/tratop_e/covid19_e/standards_report_e.pdf (accessed on October 2020). [23]

WTO (2020), *WTO Analytical Index - SPS Agreement Article 5 Jurisprudence*, https://www.wto.org/english/res_e/publications_e/ai17_e/sps_anna_jur.pdf (accessed on October 2020). [25]

WTO (2019), *Digitisation, Food Safety, and Trade*, https://www.who.int/docs/default-source/resources/digitalization-food-safety-and-trade-en.pdf?sfvrsn=a11a03b8_2 (accessed on October 2020). [27]

WTO (2018), *Can Blockchain Revolutionise International Trade?*, WTO, https://www.wto.org/english/res_e/publications_e/blockchainrev18_e.htm. [94]

WTO (2014), *Risk Analysis in the SPS Agreement and Lessons Learned from Dispute Settlement*, [13] https://www.wto.org/english/tratop_e/sps_e/wkshop_oct14_e/Session1_PPT_SPS_Secretariat.pdf.

WTO (2012), *A Practical Guide to Trade Policy Analysis*, https://www.wto.org/english/res_e/publications_e/wto_unctad12_e.pdf. [139]

WTO (1998), *Understanding the WTO Agreement on Sanitary and Phytosanitary Measures*, https://www.wto.org/english/tratop_e/sps_e/spsund_e.htm (accessed on September 2020). [104]

Yotov, Y. et al. (2016), *An Advanced Guide to Trade Policy Analysis: The Structural Gravity Model*, https://www.wto.org/english/res_e/booksp_e/advancedwtounctad2016_e.pdf. [135]

Annex A. List of sectors selected for the analysis

Table A A.1. Harmonised Commodity Description and Coding Systems (HS): List of products at the HS 2-digit level selected for the analysis

HS 2-digit code and **HS Section**
SECTION I: LIVE ANIMALS; ANIMAL PRODUCTS
01 Live animals.
02 Meat and edible meat offal.
03 Fish and crustaceans, molluscs and other aquatic invertebrates.
04 Dairy produce; birds' eggs; natural honey; edible products of animal origin, not elsewhere specified or included.
05 Products of animal origin, not elsewhere specified or included.
SECTION II: VEGETABLE PRODUCTS
06 Live trees and other plants; bulbs, roots and the like; cut flowers and ornamental foliage.
07 Edible vegetables and certain roots and tubers.
08 Edible fruit and nuts; peel of citrus fruit or melons.
09 Coffee, tea, mate and spices.
10 Cereals.
11 Products of the milling industry; malt; starches; inulin; wheat gluten.
12 Oil seeds and oleaginous fruits; miscellaneous grains, seeds and fruit; industrial or medicinal plants; straw and fodder.
13 Lac; gums, resins and other vegetable saps and extracts.
14 Vegetable plaiting materials; vegetable products not elsewhere specified or included.
SECTION III: ANIMAL OR VEGETABLE FATS AND OILS
15 Animal or vegetable fats and oils and their cleavage products; prepared edible fats; animal or vegetable waxes.
SECTION IV: PREPARED FOODSTUFFS; BEVERAGES, SPIRITS AND VINEGAR; TOBACCO
16 Preparations of meat, of fish or of crustaceans, molluscs or other aquatic invertebrates.
17 Sugars and sugar confectionery.
18 Cocoa and cocoa preparations.
19 Preparations of cereals, flour, starch or milk; pastry cooks' products.
20 Preparations of vegetables, fruit, nuts or other parts of plants.
21 Miscellaneous edible preparations.
22 Beverages, spirits and vinegar.
23 Residues and waste from the food industries; prepared animal fodder.
24 Tobacco and manufactured tobacco substitutes.

Source: WCO (2017[134]).

Annex B. Econometric model

This report employs a standard structural gravity trade model estimated on a panel data set (Yotov et al., 2016[135]). Gravity models have become a workhorse of applied trade analysis, and both the theoretical underpinnings and the econometric methods have seen a significant development since their conception by (Tinbergen, 1962[136]). If no time series of observations are available, this model uses the variation in geographical and cultural bilateral variables such as the distance between two countries to explain the variation in trade flows (Eaton and Kortum, 2002[137]) (Feenstra, Markusen and K., 2001[138]). Alternatively, if observations over time and by country are available (a panel dataset), as is the case in this report, exporting-importing countries pair fixed effects are used instead of the set of typical gravity variables. This approach helps reduce the systematic difference between the estimated effect of e-certification and the true value that would be created by large differences across countries (WTO, 2012[139]).

Importer and exporter fixed effects mainly control for any country-specific characteristics. They also represent the inward and outward multilateral resistances that capture the effects of trade with other partners on any given bilateral trade relationship. Inward resistance is the relative propensity of the destination country to import a product from the origin country given the trade cost between both countries and compared to the trade costs between the destination country and all other potential origin countries (Yotov et al., 2016[135]) (Anderson, Larch and Yotov, 2018[140]). Similarly, outward resistance is the relative propensity of the origin country to export a product to the destination country given the trade cost between both countries and compared to the trade costs between the origin country and all other potential destination countries. The panel structure of the dataset allows including the time dimension in the importer and exporter fixed effects. This feature controls for changes over time in country-specific characteristics and the aforementioned inward and outward multilateral resistance terms. The large dimension of the dataset and the number of different products also permits the inclusion of product fixed effects and year trends as explanatory variables in the model.

The basic model estimated separately for each HS Section I to IV is:

$$Q_{ijkt} = \exp\left[\beta_1 T_{jkt} + \beta_2 RTA_{ijt} + \beta_3 ecert_{ijkt-1} + \beta_4 ecert_{ijkt-2} + \delta_{it} + \delta_{jt} + \delta_k + \delta_t + \delta_{ij}\right] u_{ijkt} \quad (1)$$

where:

- Q_{ijkt} is the quantity of HS6 product k traded between exporter country i and importer country j in year t.
- T_{jkt} is the tariff imposed by importer j on product k in year t. The logarithm of this variable + 1 is considered in the estimation.
- RTA_{ijt} is a dummy variable equal to 1 if countries i and j belong to the same regional trade agreement.
- $ecert_{ijkt}$ is a dummy variable equal to 1 if a digital certificate is sent by exporter i to importer j when trading product k in year t. To take implementation delays into account the one- and two-year lags of this variable are included in the estimations. The coefficient on the one-year lag, β_3, gives the effect on current trade flows of an e-certificate implemented one year ago, while the coefficient on the two-year lag, β_4, gives the effect on currenttrade flows of an e-certificate implemented two year ago. The total effect of e-certification after two years is given by β_3+β_4.
- δ_it, δ_jt, δ_k, δ_t, δ_ij represent the importer and exporter time trends, product fixed effects, yearly fixed effects, and exporter-importer pair fixed effects. Inclusion of the year fixed effects and country time trends allows controlling for potential endogeneity bias between bilateral trade flows and digitalisation of SPS systems. It could also be that larger trade flows mandate additional e-

certifications efforts, implying reversed causality in the model. However, the fixed effects mentioned above would capture such simultaneous variations. The inclusion of lagged e-certification variables, instead of contemporaneous ones also mitigates endogeneity concerns, because current levels of trade flows cannot influence past use of e-certificates. As explained in Section 2.3 of the paper, the acceptance of e-certificates take time to fully negotiate and implement.

Standard errors are clustered at the exporter-importer pair level to correct for potential correlation of errors across country-pairs, as recommended in the literature (WTO, 2012[139]) (Shepherd, Doytchinova and Kravchenko, 2019[141]). Clustering means that the standard errors of estimated coefficients are allowed to have different distributions based on the importing and exporting country pairs. This mitigates possible skewness of results that arises from not including unobserved variables that differ systematically by importing and exporting countries pairs.

Equation (1) is estimated using a Poisson-Pseudo Maximum Likelihood (PPML) estimation method. The PPML estimation technique presents several advantages over linear estimation methods: first, a common challenge with very disaggregated trade flows, like the one used for this report, is the prevalence of zero flows when two countries do not exchange a product. For the majority of bilateral trade flows in the database, the quantity exchanged will be zero implying a sparse estimation matrix. Simple linear estimation methods will drop flows where the quantity traded is null. However, the zero flows still carry some valuable information as two countries might not exchange goods due to high trade costs, preferences over product characteristics, or destination and origin country characteristics. The PPML method on the other hand allows estimating cases where two countries might start trading a product following the implementation of e-certification. Consequently, keeping the zero trade flows for the estimation allows controlling for selection biases and minimises heteroscedasticity issues.

Regressions using export unit values and total values as dependent variables are estimated in a similar way as equation (1).

Annex Tables D present estimates of the impact of electronic certificates on trade volumes, prices and values. For each of the four HS sections, two regressions are estimated, which differ only in their e-certificate dummy. The first regression only considers the one-year lag which represents the effects of e-certification one year after implementation, while the second includes both the one-year and the two-year lag which represents the effects of e-certification one and two years after implementation.

Annex C. Data sources used in the gravity model

International trade flow data come from the *Base pour l'Analyse du Commerce International* (BACI) dataset maintained by the Centre for Prospective Studies and International Information (CEPII)[44]. This dataset contains information on international bilateral trade flows (including intra-European Union trade) such as quantity traded and total value of exports between 2007 and 2018, collected and harmonised at the HS6 level.

For the purposes of this report, only HS sections to which SPS e-certification is usually applied are retained. As a result, Sections V to XXII of the HS code classification are excluded from the analysis. The dataset used for the analysis includes 722 products for the period 2007-18 from Sections I to IV of the HS code classification. These sections include the following products (for more details on the list of products covered, see Annex A):

- Section I: Live animals, animal products (HS chapters 1-5),
- Section II: Vegetable products (HS chapters 6-14),
- Section III: Animal or vegetable fats and oils (HS chapter 15),
- Section IV: Prepared foodstuffs, beverages, spirits and vinegar and tobacco (HS chapters 16-24)

Information on e-certificates use is based on Table 1. This information varies greatly in precision on the level of product coverage, with most jurisdictions providing information at the Harmonised System[45] two-digit (HS2) or four-digit (HS4) level, and only a few jurisdictions providing information at the more detailed six-digit (HS6) level. Due to these discrepancies in coverage, some assumptions had to be made to map the coverage of e-certification to trade statistics. Specifically, the *Base pour l'Analyse du Commerce International* (BACI) database used in this analysis provides information on bilateral trade flows at the HS6 level. When a country reported e-certification use at the HS2 or HS4 level, it was assumed that all products at the lower HS6 level pertaining to these HS2 and HS4 sections were covered by e-certificates. Future research could focus on more precisely mapping e-certificates use at the HS6 level if countries were to provide such disaggregated information.

[44] The CEPII applies original procedures to harmonise the UN COMTRADE data (evaluation of the quality of country declarations to average mirror flows, evaluation of cost, insurance and freight rates to reconcile import and export declarations, etc.). The latest available year is 2018.

[45] Harmonised System international nomenclature for the classification of products codes.

Annex D. Trade effects of SPS e-certificates

Table A D.1. Volume effects of electronic certificates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Section I	Section I	Section II	Section II	Section III	Section III	Section IV	Section IV
ln(tariff)	-0.188***	-0.188***	-0.103*	-0.103*	-0.0737	-0.0737	0.449	0.449
	(0.0497)	(0.0497)	(0.0625)	(0.0625)	(0.196)	(0.196)	(0.277)	(0.277)
L1.e-certification	1.426***	1.305***	1.730***	2.101***	-0.182	-0.377	2.221***	2.309***
	(0.128)	(0.102)	(0.466)	(0.465)	(0.427)	(0.475)	(0.657)	(0.654)
L2.e-certification		0.147***		-0.432**		0.278		-0.119
		(0.0535)		(0.171)		(0.233)		(0.181)
RTA	0.0650	0.0663	0.120	0.124	0.192	0.192	0.00208	0.00215
	(0.0667)	(0.0668)	(0.143)	(0.143)	(0.162)	(0.162)	(0.0687)	(0.0687)
Constant	7.803***	7.802***	9.906***	9.903***	10.14***	10.14***	14.80***	14.80***
	(0.0911)	(0.0912)	(0.130)	(0.130)	(0.420)	(0.421)	(0.175)	(0.175)
Observations	20 564 691	20 564 691	30 633 036	30 633 036	3 155 320	3 155 320	27 202 937	27 202 937

Note: Clustered standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.
Source: OECD estimations.

Table A D.2. Unit value effects of electronic certificates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Section I	Section I	Section II	Section II	Section III	Section III	Section IV	Section IV
ln(tariff)	0.00734***	0.00731***	-0.0258***	-0.0258***	0.00157	0.00157	-0.00339**	-0.00339**
	(0.00192)	(0.00192)	(0.00183)	(0.00183)	(0.00464)	(0.00464)	(0.00148)	(0.00148)
L1.e-certification	-0.0641***	-0.0509***	-0.165***	-0.145***	-0.175***	-0.127***	0.00575	0.0379***
	(0.00563)	(0.00541)	(0.0421)	(0.0228)	(0.0365)	(0.0372)	(0.0122)	(0.0119)
L2.e-certification		-0.0179***		-0.0241		-0.0823*		-0.0522***
		(0.00479)		(0.0315)		(0.0486)		(0.0135)
RTA	0.00528	0.00520	-0.00354	-0.00353	-0.00703	-0.00700	0.0124**	0.0124**
	(0.00567)	(0.00567)	(0.00549)	(0.00549)	(0.0106)	(0.0106)	(0.00496)	(0.00496)
Constant	0.822***	0.822***	0.669***	0.669***	0.502***	0.502***	0.541***	0.541***
	(0.00433)	(0.00433)	(0.00399)	(0.00399)	(0.0101)	(0.0101)	(0.00421)	(0.00421)
Observations	1 179 440	1 179 440	2 066 199	2 066 199	309 149	309 149	2 424 639	2 424 639

Note: Clustered standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.
Source: OECD estimations.

Table A D.3. Total value effects of electronic certificates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Section I	Section I	Section II	Section II	Section III	Section III	Section IV	Section IV
ln(tariff)	-0.0346***	-0.0345***	-0.00331	-0.00331	-0.0176***	-0.0176***	-0.0110***	-0.0110***
	(0.00299)	(0.00299)	(0.00289)	(0.00289)	(0.00621)	(0.00621)	(0.00213)	(0.00213)
L1.e-certification	0.127***	0.0370***	0.222***	0.176***	-0.0106	-0.0712**	0.244***	0.149***
	(0.00832)	(0.00688)	(0.0203)	(0.0206)	(0.0356)	(0.0332)	(0.0159)	(0.0149)
L2.e-certification		0.120***		0.0554***		0.0986***		0.145***
		(0.00606)		(0.0186)		(0.0345)		(0.0127)
RTA	0.0102*	0.0108*	-0.000508	-0.000541	-0.0146	-0.0146	0.00461	0.00442
	(0.00602)	(0.00604)	(0.00492)	(0.00492)	(0.00948)	(0.00947)	(0.00419)	(0.00419)
Constant	1.547***	1.547***	1.411***	1.411***	1.527***	1.527***	1.497***	1.497***
	(0.00615)	(0.00617)	(0.00536)	(0.00536)	(0.0129)	(0.0129)	(0.00521)	(0.00521)
Observations	1,179,440	1,179,440	2,066,199	2,066,199	309,142	309,142	2,424,639	2,424,639

Note: Clustered standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.
Source: OECD calculations.

Annex E. Robustness tests: Estimations with shorter time periods

I. 2012-2018 time period

Table A E.1. Volume effects of electronic certificates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Section I	Section I	Section II	Section II	Section III	Section III	Section IV	Section IV
ln(tariff)	-0.179***	-0.178***	-0.104	-0.104	-0.0809	-0.0809	0.372	0.372
	(0.0497)	(0.0496)	(0.0653)	(0.0653)	(0.207)	(0.207)	(0.227)	(0.227)
L1.e-certification	1.704***	1.506***	2.528***	2.663***	-0.341	-0.444	2.081***	2.128***
	(0.148)	(0.110)	(0.921)	(0.687)	(0.443)	(0.486)	(0.577)	(0.505)
L2.e-certification		0.230*		-0.163		0.145		-0.0645
		(0.126)		(0.357)		(0.222)		(0.215)
RTA	0.0464	0.0508	-0.105	-0.105	0.341**	0.341**	0.0570	0.0572
	(0.0727)	(0.0717)	(0.171)	(0.171)	(0.143)	(0.143)	(0.0740)	(0.0739)
Constant	7.832***	7.829***	10.23***	10.23***	10.22***	10.22***	14.78***	14.78***
	(0.0919)	(0.0924)	(0.141)	(0.141)	(0.451)	(0.451)	(0.151)	(0.151)
Observations	11 296 806	11 296 806	17 055 800	17 055 800	1 744 747	1 744 747	15 069 928	15 069 928

Note: Clustered standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.
Source: OECD estimations.

Table A E.2. Unit value effects of electronic certificates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Section I	Section I	Section II	Section II	Section III	Section III	Section IV	Section IV
ln(tariff)	0.00938***	0.00936***	-0.0294***	-0.0294***	0.00534	0.00534	-0.00342**	-0.00342**
	(0.00202)	(0.00202)	(0.00198)	(0.00198)	(0.00508)	(0.00508)	(0.00158)	(0.00158)
L1.e-certification	-0.0724***	-0.0660***	-0.207***	-0.189***	-0.150***	-0.0997***	0.00179	0.0274**
	(0.00644)	(0.00666)	(0.0342)	(0.0205)	(0.0364)	(0.0375)	(0.0128)	(0.0125)
L2.e-certification		-0.00842		-0.0205		-0.0890*		-0.0421***
		(0.00603)		(0.0339)		(0.0490)		(0.0136)
RTA	-0.00267	-0.00269	-0.00728	-0.00729	-0.0139	-0.0138	-0.00337	-0.00327
	(0.00699)	(0.00699)	(0.00606)	(0.00606)	(0.0135)	(0.0135)	(0.00554)	(0.00554)
Constant	0.833***	0.833***	0.693***	0.693***	0.518***	0.518***	0.560***	0.560***
	(0.00509)	(0.00509)	(0.00445)	(0.00445)	(0.0118)	(0.0118)	(0.00460)	(0.00460)
Observations	732 451	732 451	1 302 056	1 302 056	195 419	195 419	1 521 718	1 521 718

Note: Clustered standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.
Source: OECD estimations.

Table A E.3. Total value effects of electronic certificates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Section I	Section I	Section II	Section II	Section III	Section III	Section IV	Section IV
ln(tariff)	-0.0337***	-0.0335***	-0.00486*	-0.00486*	-0.0181***	-0.0182***	-0.0129***	-0.0129***
	(0.00294)	(0.00294)	(0.00293)	(0.00293)	(0.00635)	(0.00635)	(0.00214)	(0.00214)
L1.e-certification	0.144***	0.0321***	0.293***	0.212***	-0.0236	-0.0784**	0.255***	0.155***
	(0.00956)	(0.00825)	(0.0399)	(0.0497)	(0.0358)	(0.0340)	(0.0175)	(0.0160)
L2.e-certification		0.144***		0.0932***		0.0898***		0.153***
		(0.00726)		(0.0198)		(0.0346)		(0.0129)
RTA	0.0135	0.0137	0.000556	0.000633	-0.0190	-0.0191	-0.00161	-0.00203
	(0.00844)	(0.00847)	(0.00589)	(0.00590)	(0.0132)	(0.0132)	(0.00554)	(0.00554)
Constant	1.540***	1.539***	1.412***	1.412***	1.528***	1.528***	1.507***	1.508***
	(0.00696)	(0.00698)	(0.00567)	(0.00567)	(0.0146)	(0.0146)	(0.00568)	(0.00568)
Observations	732 451	732 451	1 302 056	1 302 056	195 414	195 414	1 521 716	1 521 716

Note: Clustered standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.
Source: OECD estimations.

II. 2012-2016 time period

Table A E.1. Volume effects of electronic certificates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Section I	Section I	Section II	Section II	Section III	Section III	Section IV	Section IV
ln(tariff)	-0.179***	-0.179***	-0.102	-0.102	-0.0780	-0.0780	0.431*	0.431*
	(0.0501)	(0.0501)	(0.0641)	(0.0641)	(0.201)	(0.201)	(0.257)	(0.257)
L1.e-certification	1.711***	1.564***	2.083**	2.271*	-0.210	-0.523	1.864***	2.223***
	(0.166)	(0.122)	(0.954)	(1.258)	(0.467)	(0.525)	(0.691)	(0.562)
L2.e-certification		0.179		-0.194		0.659**		-0.641**
		(0.147)		(0.445)		(0.261)		(0.297)
RTA	-0.0390	-0.0327	-0.199	-0.199	0.309*	0.309*	0.1000	0.103
	(0.0705)	(0.0678)	(0.239)	(0.239)	(0.169)	(0.169)	(0.0811)	(0.0808)
Constant	7.878***	7.874***	10.30***	10.30***	10.24***	10.24***	15.13***	15.13***
	(0.0901)	(0.0906)	(0.176)	(0.176)	(0.439)	(0.439)	(0.154)	(0.156)
Observations	7 661 459	7 661 459	11 479 191	11 479 191	1 139 023	1 139 023	10 146 793	10 146 793

Note: Clustered standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.
Source: OECD estimations.

Table A E.2. Unit value effects of electronic certificates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Section I	Section I	Section II	Section II	Section III	Section III	Section IV	Section IV
ln(tariff)	0.0107***	0.0107***	-0.0289***	-0.0289***	0.00302	0.00303	-0.00238	-0.00238
	(0.00214)	(0.00214)	(0.00206)	(0.00206)	(0.00551)	(0.00551)	(0.00165)	(0.00165)
L1.e-certification	-0.0686***	-0.0691***	-0.246***	-0.227***	-0.223***	-0.189***	0.00217	0.00727
	(0.00711)	(0.00747)	(0.0380)	(0.0191)	(0.0480)	(0.0431)	(0.0159)	(0.0151)
L2.e-certification		0.000654		-0.0220		-0.0725		-0.00924
		(0.00744)		(0.0357)		(0.0576)		(0.0160)
RTA	0.00142	0.00142	-0.00512	-0.00514	-0.00666	-0.00660	-0.00312	-0.00313
	(0.00944)	(0.00944)	(0.00751)	(0.00750)	(0.0197)	(0.0197)	(0.00752)	(0.00752)
Constant	0.829***	0.829***	0.690***	0.690***	0.524***	0.524***	0.556***	0.556***
	(0.00626)	(0.00627)	(0.00510)	(0.00510)	(0.0146)	(0.0146)	(0.00541)	(0.00541)
Observations	521,378	521,378	911,704	911,704	136,329	136,329	1,069,474	1,069,474

Note: Clustered standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.
Source: OECD estimations.

Table A E.3. Total value effects of electronic certificates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Section I	Section I	Section II	Section II	Section III	Section III	Section IV	Section IV
ln(tariff)	-0.0345***	-0.0344***	-0.00580*	-0.00579*	-0.0202***	-0.0202***	-0.0137***	-0.0137***
	(0.00299)	(0.00300)	(0.00298)	(0.00298)	(0.00643)	(0.00643)	(0.00222)	(0.00222)
L1.e-certification	0.151***	0.0646***	0.323***	0.268***	0.00592	-0.0494	0.279***	0.203***
	(0.0104)	(0.00890)	(0.0509)	(0.0449)	(0.0437)	(0.0437)	(0.0206)	(0.0201)
L2.e-certification		0.121***		0.0637***		0.113**		0.133***
		(0.00872)		(0.0224)		(0.0452)		(0.0166)
RTA	0.0208*	0.0220**	0.00314	0.00323	-0.0320*	-0.0321*	-0.00317	-0.00315
	(0.0107)	(0.0107)	(0.00702)	(0.00703)	(0.0166)	(0.0166)	(0.00655)	(0.00655)
Constant	1.538***	1.537***	1.413***	1.413***	1.543***	1.544***	1.509***	1.509***
	(0.00795)	(0.00798)	(0.00626)	(0.00626)	(0.0156)	(0.0156)	(0.00615)	(0.00614)
Observations	521,378	521,378	911,704	911,704	136,326	136,326	1,069,474	1,069,474

Note: Clustered standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.
Source: OECD estimations.

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Comments are welcome and can be sent to tad.contact@oecd.org.