THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

Benefits of the digitalisation of trade processes and cross border barriers to their adoption

Final Report
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This is the final report for research, carried out by LSE's Trade Policy Hub, on behalf of the Department for Business and Trade.

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Glossary of terms

Term	Description
Ad valorem equivalent (AVE)	A trade cost or saving expressed as a percentage of the value of the trade
Blockchain	A shared, immutable ledger that facilitates the process of recording transactions and tracking assets in a network
Certificate of origin	Trade document that certifies that goods in a particular export shipment are wholly obtained, produced, manufactured, or processed in a particular country
Computable general equilibrium (CGE) model	A model that uses actual economic data to estimate how an economy might react to changes in policy, technology, or other external factors
Customs declaration	Customs document that lists and gives details of goods that are being imported or exported
E logistics platform	A digital environment within which information relating to transport, logistics and the distribution of goods, for both national and international transit, can be edited, stored, and verified
Enablers of e-transactions	E-contracts, e-authentication, and other solutions for paperless trade.
Electronic data interchanges (EDIs)	Computer-to-computer exchange of documents in a standard electronic format between partners
Non-tariff measures (NTMs)	Non-tariff measures (NTMs) are policy measures other than tariffs that can potentially have an economic effect on international trade in goods.
Price index for private consumption expenditure	GTAP variable that measures changes in the overall price of commodities for private consumption
Sanitary and phytosanitary (SPS) certificate	Trade document that lists compliance with regulations to protect human, animal and plant health
Single trade windows	A facility that allows parties involved in trade and transport to lodge standardised information and documents with a single-entry point to fulfil all import, export, and transit-related regulatory requirements
Transferable records	Trade documents that entitle the holder to claim the performance of the obligation indicated therein and that allow the transfer of the claim to that performance by transferring possession of the document or instrument.
Welfare / equivalent variation	The amount of additional income needed to give an entity the level of utility reached under a simulated scenario

1. Executive summary

Trade digitalisation is the improvement or enabling of processes through leveraging digital technologies and digitised data. In the context of international trade, this involves the digitalisation of trade-related information flows. Digitalisation will enable the exchange of trade-related data, documents, and electronic authorisations between parties in the supply chain.

Trade digitalisation is attracting greater policy attention as a means to reduce transaction costs, boost trade, lower prices and yield economic growth. The UK government has recognised this potential with important policy initiatives under the umbrella of its 2025 Border Strategy. These include the Electronic Trade Documents Bill and the development of a Single Trade Window, along with commitments negotiated in FTAs and Digital Trade Agreements supporting the development of digital trading systems with trade partners.

In this context, the Department for Business and Trade (DBT) has commissioned LSE's Trade Policy Hub (TPH) to further develop the evidence base on three types of relevant technologies:

- **Digital trading systems** including;
  a) paperless, digitalised trade administration documents required by governmental authorities, e.g. customs declarations and SPS certificates
  b) paperless, digitalised commercial documentation supporting trade transactions, e.g. documents of title such as bills of lading
  c) advanced single window systems and other platforms that facilitate exchange of digital trade documents
- **Existing enablers of e-transactions**, with potential for greater roll-out, including e-contracts, e-authentication, and other solutions for paperless services trade (described in section 6).
- **Blockchain and AI,** as technologies with the potential to further develop and improve digital trading systems in future (described in section 4 and 5). Rather than a general study of the impact of these technologies on the economy, this report is focused on the extent to which they can further enhance and complement digital trading systems.

Specifically, this project aims to quantify the benefits associated with each of these technologies and identify possible barriers to implementation. After thoroughly reviewing the existing literature and conducting various econometric analyses, trade cost reductions associated with each technology are derived as inputs for CGE modelling. Simulations are then run to estimate their potential effects on the wider economy.

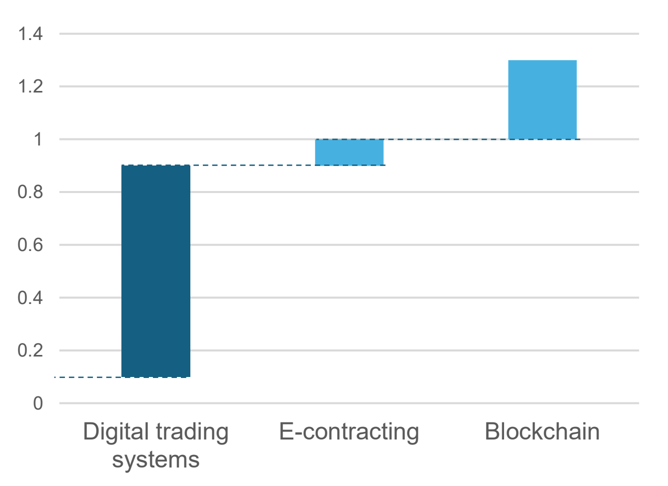
The first simulation estimates the impact of implementing advanced digital trading systems (including automatic information exchange of customs declarations, certificates of origin, SPS certificates, electronic transferable records etc.) between the UK and the US.

Immediate gains are evident, with UK bilateral exports estimated to increase by 3.9% in agriculture and 6.8% in non-agricultural goods relative to a baseline of existing digitalisation. Much of this trade is created as expedited trade facilitation reduces bilateral trade costs.

In subsequent scenarios, universal adoption of all three technologies is modelled. Advanced digital trading systems, integrated blockchain, and e-transactions for services are associated with an estimated rise in UK GDP of up to 0.9%, 0.3%, and 0.1%, respectively.[1] Combined then, adoption of all technologies could lead to a rise in UK GDP of up to 1.3%, as outlined in Figure 1. This rise can largely be attributed to technological change, with some allocative efficiency gains also evident.

In other words, by expediting the trading process and reducing associated labour and capital costs, these technologies will exhibit a downward effect on producer prices. Universal adoption of advanced digital trading systems and integrated blockchain is associated with an estimated reduction in the UK consumer price index of up to 0.7 and 0.2%, respectively. Conversely, the universal adoption of electronic contracts in services trade is associated with no discernible change in the UK price index for private consumption expenditure. This reflects the fact that derived time and cost savings are relatively slight and confined to a handful of services sectors, which are primarily business-to-business services rather than consumer services. Estimated changes to the UK price index for private consumption expenditure are outlined in Figure 2.

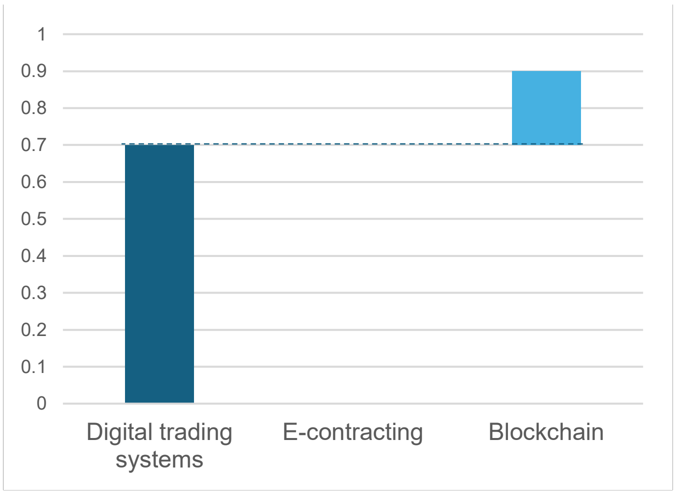
Figure 1: Potential increase in UK GDP associated with the widespread adoption of each technology (%)



Note. Figures for digital trading systems and e-contracting refer to an estimated increase in UK GDP that ranges from 0.1-0.9% and 0-0.1%, respectively. Further benefits of blockchain gains are calculated by subtracting lower range advanced digital trading systems results and are expressed as a single estimate, rather than a range. Source: Authors' calculations.

[1] As with trade, these GDP gains relate to the new long-term equilibrium estimated by the CGE model. Put simply, in a given year post-implementation, UK GDP would be 0.9% higher than it would have been had advanced digital customs not been universally adopted.

Figure 2: Potential reduction to the UK price index for private consumption expenditure associated with the widespread adoption of each technology (%)



Note. Price index for private consumption expenditure refers to the 'ppriv' variable in the GTAP model used. As an index, it is the product of the private consumption price for various commodities in region r and the share of private household consumption devoted to various commodities in region r. Figures for digital customs refer to an estimated reduction in UK ppriv that ranges from 0-0.7%. For E-contracting, there was no discernible reduction in ppriv under the lower- or upper-bound scenarios. Further benefits of blockchain are calculated by subtracting results from lower bound advanced digital trading systems scenario and are expressed as a single estimate, rather than a range. Source: Authors' calculations.

Several domestic and cross-border barriers to implementation were identified. These include interoperability issues and the adoption of model laws into domestic laws. However, in nearly all cases, experts cited the upfront investments and transition costs as principal impediments. With regards to blockchain, the technology is still in its infancy, with a considerable existing gap between "reality and expectations".

There are also several limitations to these findings. Like most nascent technologies, there is a limited source of reliable data on the benefits of trade digitalisation and modelling inputs are therefore subject to a high degree of uncertainty. Nevertheless, the UK's Electronic Trade Documents Bill along with the adoption of UNCITRAL's Model Law on Electronic Transferable Records (MLETR) by other states is likely to scale up the market for trade digitalisation platforms, by removing legal disincentives to possession of digital trade documents for SMEs. This may increase sources of reliable data over time.

Moreover, this study focuses on legislation and implementation, with a subsequent *assumption* of universal adoption. Whilst the potential associated with implementing each of these technologies is estimated to be significant, caution must be exercised in drawing conclusions from the data presented. Barriers to uptake across the private sector should not be underestimated. Industry led initiatives by the ICC Centre For Digital Trade and Innovation and Digital Container Shipping Association (amongst others) demonstrate the importance of iterative progress in building the foundations for transformational systems. But further policy and promotion frameworks must be developed to encourage ubiquitous adoption by stakeholders.

2. Introduction

2.1 Why the digitalisation of trading processes matters now

As payable duties for UK exports gradually converge towards zero, thanks to plurilateral and preferential liberalisation, regulatory convergence and trade digitalisation have attracted greater attention in trade policy. These efforts coincide with a growing focus on digitalising the trading process.

In particular, the digitalisation of customs clearance through paperless trading, single trade windows (STWs) and electronic data interchanges (EDIs) offer significant productivity gains by improving speed, security and reducing the costs associated with border compliance in shipping. Using blockchains in the production and shipping process or using artificial intelligence (AI) and machine learning (ML) in customs inspections could theoretically unleash further gains, albeit at very high implementation costs. Meanwhile, domestic reforms provide legal certainty on electronic contracting by using model laws for cross-border interoperability between jurisdictions.

Such possibilities are particularly pertinent today when there is less appetite for bilateral or plurilateral trade liberalisation due to the limited opportunities for export-led growth during inflationary cycles. Investment requirements for digital trade systems can be significant, but such reforms can, to some extent, be implemented with no duty or VAT revenues foregone. Furthermore, reducing trade costs can lower import prices without altering quotas or tariffs.

2.2 UK Government strategy in context

As such, the digitalisation of trade processes is increasingly recognised as a policy priority for the UK government under the **2025 UK Border Strategy.** The strategy aims to create the most effective border in the world, to focus on "greater automation" and "simplifying communication" for border users to improve their experience (UK Government, 2020).

Under this umbrella, the **Electronic Trade Documents Bill** recognises electronic trade documents on an equal legal footing to physical trade documents. This will allow for paperless trade on commercial documents of title following the preferences of firms and technology coordination across industries (UK Government, 2022). Elsewhere, UK Government has also committed to building a UK Single Trade Window to reduce trade costs by streamlining trade interactions with border agencies (UK Government, 2022).

A significant body of research has been devoted to digital trade processes on goods. However, the existing evidence base suffers from imprecise estimates due to ambiguous definitions of technologies and baselines. Complexities involved in translating micro-level time or cost savings into comprehensible national or macro-level trade effects often make such estimates overly specific or anecdotal, rather than expressed in more tangible metrics, such as estimated changes to exports or prices.

Moreover, many of the relevant technologies are contingent on a level of interoperability among commercial and customs organisations. Therefore, to fully realise the benefits of digitised trade processes, more needs to be done to understand prospective barriers to implementation.

With these knowledge gaps in mind, the Department for Business and Trade (DBT) has commissioned LSE's Trade Policy Hub (TPH) to further develop the evidence base on three types of technologies:

1. **Digital trading systems** including;
    a. paperless, digitalised trade administration documents required by governmental authorities, e.g. customs declarations and SPS certificates
    b. paperless, digitalised commercial documentation supporting trade transactions, e.g. documents of title such as bills of lading
    c. advanced single window systems and other platforms that facilitate exchange of digital trade documents
2. **Existing enablers of e-transactions**, with potential for greater roll-out, including e-contracts, e-authentication, and other solutions for paperless services trade (described in section 6).
3. **Blockchain and AI,** as technologies with the potential to further develop and improve digital trading systems in future (described in section 4 and 5). Rather than a general study of the impact of these technologies on the economy, this report is focused on the extent to which they can further enhance and complement digital trading systems.

Specifically, this project aims to quantify the benefits associated with each of these technologies and identify possible barriers to implementation. By doing so, it is hoped that this research will help to contextualise trade digitalisation and guide the priorities of digital trade advocacy efforts by the UK government.

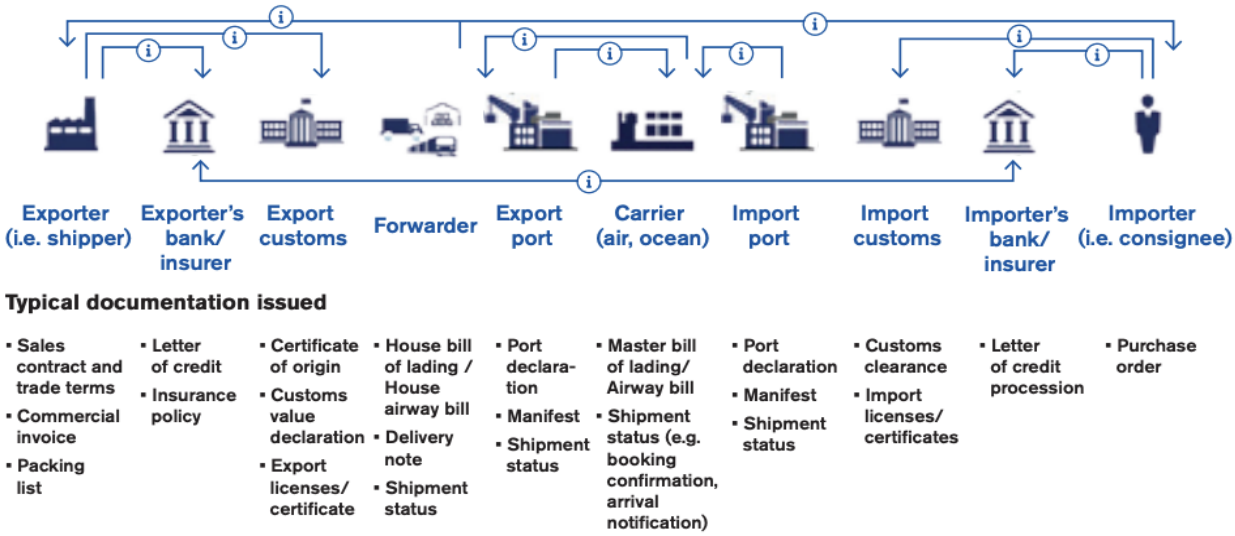
3. Digital Trade Systems

3.1 Concept of digital trade systems

This section draws on the reviewed research and structured interview findings to define digital trading systems and outline their benefits and prospective barriers to implementation. Structured interviews were conducted with government experts among G7 countries, commercial IT suppliers, and academics.

For this project, digital trading systems refer to technology-driven systems that facilitate paperless trade in goods. Information must be passed between relevant parties when goods cross borders. These include suppliers, logistics providers, customs, regulatory agencies, sellers, and buyers (WEF, 2017). The documentation typically associated with international trade in goods is outlined below in Figure 3.

Figure 3: Typical international trade documentation issued



Source: (Ganne, 2017)

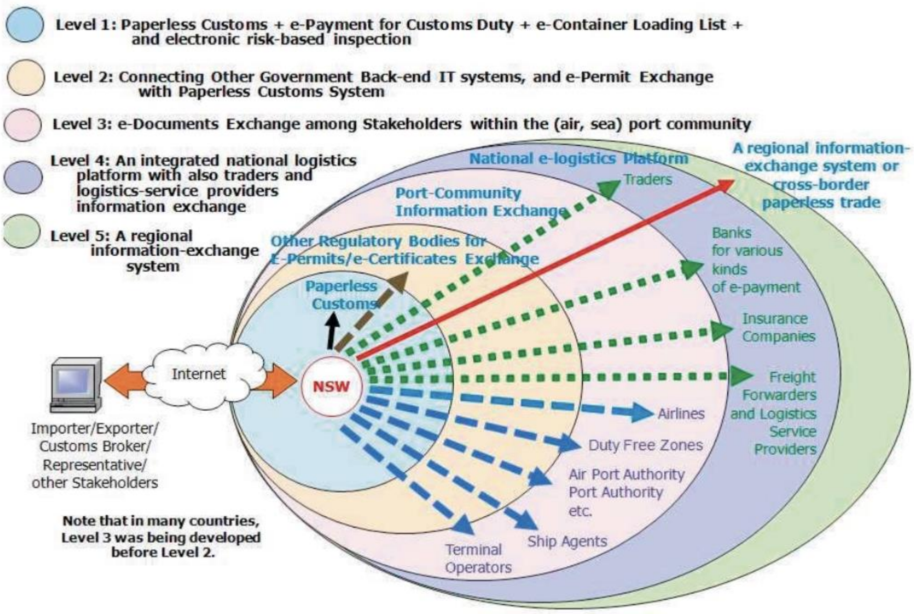
In addition to the documentation outlined in the figure above, specific products may require additional documentation that can range from a Phytosanitary Certificate to Marketing Authorisation for Medicinal Products. Such can be the burden of international trade documentation that a shipment of roses from Kenya to Rotterdam can generate a pile of paper 25 cm high, and the cost of handling it can be higher than the cost of moving the containers (Allison, 2016). On average, a cross-border transaction requires the exchange of 36 documents and 240 copies (WTO, 2022).

Digital trading systems aim to alleviate this burden by facilitating the sharing of paperless documentation amongst relevant parties. The sophistication of these systems can range from basic paperless customs systems that can accept digital customs documentation and the e-payment of customs duties and fees to more complex "single window" systems.

Broadly speaking, single windows refer to "a facility that allows parties involved in trade and transport to lodge standardised information and documents with a *single-entry* point to fulfil all import, export, and transit-related regulatory requirements" (WCO, 2014).

However, single window systems can "differ substantially with regards to functionalities and service coverage" (OIC, 2017). For instance, certain single window systems are predominantly focused on customs procedures and pertain to a small number of customs authorities. By contrast, a more full-scale implementation like Australia's Customs and Border Protection Service Integrated Cargo System connects a range of customs authorities, quarantine authorities, and meat producers. Integrated actors can work closely throughout the production and trade processes, conducting inspections and issuing sanitary certificates (World Bank, 2017). The diverse functionality of single window systems is outlined below in Figure 4.

Figure 4: Diverse functionality of single window systems

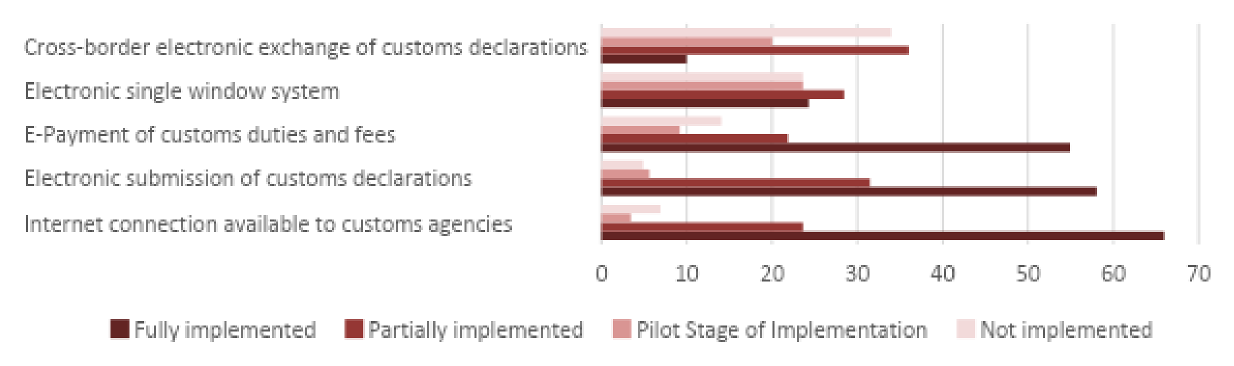


Note. As illustrated, national e-logistics platforms facilitate digital commercial documents (bills of lading etc.) as well as digital customs documentation (SPS certificates etc.). Regional information exchange refers to the ability of single windows of two or more countries to exchange information and use the information that have been exchanged to meaningfully facilitate regulatory-related requirements for the movement of goods across those countries. Source: (UN ES, 2013)

Many digital trade systems have now been implemented worldwide. According to data from UNESCAP's Digital and Sustainable Trade Facilitation Survey, at least eighty per cent of country respondents had fully or partially implemented systems to facilitate the electronic submission of customs declarations and the e-payment of customs duties and fees in 2021 (ESCAP, 2022). Meanwhile, fifty-two per cent of country respondents had fully or partially implemented some form of an electronic single window system (ESCAP, 2022).

Increasingly, artificial intelligence (AI) and machine learning (ML) are also deployed to simplify and reduce the complexities involved in customs processing. The simplest use cases involve automation for tasks such as identifying correct customs classifications in the Harmonized Schedule or scraping information from documents to auto-complete required customs filings.

Figure 5: Implementation of selected digital trading systems in 2021 (% of country respondents)



Note. Respondents include 128 countries across all income categories. Source: (ESCAP, 2022)

3.2 Benefits of digital trading systems

Drawing on these implementation efforts, an abundance of literature has sought to quantify the benefits of digital trading systems. Given the range of systems deployed and the host of metrics used to assess their performance, researchers tend to accept certain trade-offs between coverage and depth. For example, cross-national research may compare the performance of broad categories of digital trading systems following a single metric, while country-level research tends to dive deeper into the incremental implementation of a specific system. In either case, associated benefits are typically expressed in terms of time or cost savings for traders and/or customs officials.

In one of the only worldwide studies on this topic to date, Ferro et al. draw on World Bank Doing Business data to estimate the effects of different customs systems across a sample of 165 territories (World Bank, 2017). More specifically, trade compliance times are modelled as a function of customs system dummies while controlling for income per capita.

Ferro et al. found that hybrid (accepting both paper and electronic documents) customs systems were associated with a 22% reduction in export compliance times relative to conventional processes. Meanwhile, exclusively digitalised custom procedures were associated with a 70% reduction in export compliance times relative to paper-based processes. Time savings for import compliance times were similar. Relative to paper systems, hybrid customs systems were associated with a 25% reduction in import compliance times, while electronic customs systems were associated with a 66% reduction in import compliance times.

While interesting, these results should be treated with some caution. Grouping customs systems into three, somewhat arbitrary, groups tend to overlook established heterogeneity in digital trading systems. Furthermore, the study fails to account for other factors that could affect trade compliance times.

Nonetheless, recent, country-level research lends broad support to these findings. Drawing on survey data, the implementation of New Zealand's Trade Single Window has led to a 50% reduction in import compliance times and a 20-50% reduction in import compliance costs (UK Government, 2020).

Interestingly, the benefits of implementing certain digital trading systems appear more pronounced in low- and middle-income economies. In a series of case studies on single window systems amongst member states, the OIC (2017) found that implementation in Cameroon had cut customs clearance times from 6 days (for imports and exports) to less than 3 hours. Similarly, the implementation of the PortNet Single Window in Morocco reduced port dwell times from 13 days to less than 6. These gains are perhaps reflective of previous customs procedures that may have been less efficient, to begin with. Further estimates for time and cost savings associated with digital customs procedures are outlined in the technical annex.

In addition to these savings, researchers have identified other benefits to digital trading systems. Digital trading systems can have a significant environmental benefit. For instance, it is estimated that a complete transition to paperless trade would eliminate 36 million tons of carbon dioxide (CO_2) emissions per year by reducing demand for paper, removing the need for physical delivery of documentation, reducing emissions associated with office labour and reducing cargo storage times (Duval and Hardy, 2021). With that said, it should be acknowledged that any form of trade creation could alter these benefits, depending on the carbon-intensity of the sectors that stand to benefit.

Digital trading systems also help to facilitate more inclusive trade. The International Chamber of Commerce (2021) estimates that a complete transition to paperless trade could lead to a 13 per cent increase in the international business of small and medium enterprises (SMEs). Looking ahead, the ICC projects that complete digitalisation of transferable documents (airway bills, bills of exchange, bills of lading, cargo insurance certificates, marine insurance policies, promissory notes, seaway bills, ships' delivery orders etc.) would lead to an astonishing 75% reduction in processing times. This assumption has also informed more advanced experiment scenarios involving blockchain.

Elsewhere, digital trading systems can support women-led businesses. According to research by the OECD (2021), digital trading systems are important for women-led SMEs not only because they reduce the costs of processing documentation, but also because they dematerialise formalities, thereby sheltering female entrepreneurs from potential harassment and discrimination.

3.3 Trade modelling of digital trade systems

3.3.1 Setting up the computable general equilibrium modelling

To estimate the benefits associated with digital trading systems, we run simulations using a CGE (Computable General Equilibrium) model that is highly suited to identify the impact of exogenous shocks on trade flows and other macroeconomic variables. Specifically, we use the GTAP (Global Trade Analysis Project) model, which is a multi-sector, multi-regional CGE model that effectively captures the direct linkages and indirect interactions in the economy.

The GTAP model is widely used for policy analysis owing to its capability to effectively model supply-chain effects, macro-economic aspects, economy-wide equilibrium constraints and linkages between different sectors and countries. The model also demonstrates the factor-use effects of various commodities to predict economic variables like GDP, productivity, trade balances, investments, innovation, welfare (a monetary equivalent of how much better off the citizens are), employment, and wages. A pre-release version of the GTAP11 database has been used for the experiments.

- We draw upon an aggregated model with four regions: **the UK**, **the US**, other **high-income economies** (HIEs) as defined by the World Bank, and **the developing countries** (or the rest of the world, RoW).
- The model also distinguishes between the three principal sectors: **agriculture**, **manufacturing** (i.e., all other non-agricultural goods except fuels), and **services**. The experiments on digital trade systems will only affect the two goods categories. Full details of the aggregation process are outlined in the technical annex.

In this section, we have conducted two principal experiments:

- **Experiment #1:** Lower- and upper-bound estimates (see 3.3.2) for the benefits of digital trade systems applied to bilateral trade between the UK and the US only.
- **Experiment #2:** Lower- and upper-bound estimates (see 3.3.2) for the benefits of a universal digitalisation scenario where all regions fully upgrade to digitalised trade systems **on an MFN basis**.

In all experiments, the benefits of full implementation (relevant technology universally implemented with total uptake from all stakeholders) of digitalised trade processes are modelled **against the counterfactual or "baseline" of existing levels of implementation**. To quantify the benefits of digitalised trade processes using GTAP, we estimate the effects of implementation in terms of tariff-equivalent changes to trade costs from digitalisation, taking into account how digitalisation impacts digital trade systems. The inputted changes in trade costs are specific to each technology, sector, and bilateral pair.

3.3.2 Defining the impact on trade costs

To estimate the percentage change in trade costs associated with digital trading systems relating to goods trade, we have tested three different methodologies for reliability:

1. Real-life surveys of country-specific *border compliance costs* and observed reduction of trading costs in pilot studies of digital STWs, EDI.
2. An econometric approach using the relationship between paperless dimensions of trade facilitation index scores against trade costs.

These methodologies are described in further detail in the technical annex. However, only the survey and econometric methods yielded consistent and significant results.

Estimating the trade cost reduction from digital trading systems is challenging due to the limited implementation of some technologies. According to the UN ESCAP Global Survey on Digital and Sustainable Trade Facilitation, just over 20% of countries had fully implemented an electronic single window in 2021, while the full electronic exchange of trade-related data and documents remained on a pilot or partial basis. The methodologies adopted in this paper use data from the existing implementation of digital trading systems to estimate the trade cost reductions associated with full implementation.

In the **survey-based approach**, we rely on actual trade cost data surveyed for documentary and border compliance that informs actual real-life costs. Specifically, we use observed documentary and border compliance costs per country, for both imports and exports (World Bank Doing Business, 2020) while avoiding the known errors in this data.[2] Assumptions behind the transformation into tariff equivalents are described in the Technical Annex. We then apply a cost reduction on this baseline, based on ex-post estimates from various pilot studies conducted in developed and developing countries.

In a second **econometric approach**, bilateral trade costs are modelled as a function of digital implementation scores derived from ESCAP's survey on Digital and Sustainable Trade Facilitation, and various control variables. Regression results provide us with sector-specific elasticities for the trade cost reductions associated with implementing digital trading systems. Using the latest Digital and Sustainable Trade Facilitation survey results, we can estimate the trade cost reductions associated with the bilateral implementation of advanced digital trading systems (with national e-logistics platforms and international information exchanges).

In conclusion, the two approaches provide us with two sets of bilateral and sector-specific estimates of trade cost reductions based on (a) the ex-post results seen in some recent pilot projects and (b) theoretical results based on the comprehensive implementation of digital trade systems, i.e. an advanced interoperable digital trade system with national e-logistics platforms and information exchange). Model inputs and shocks derived from each approach are available in the Technical Annex.

The econometric approach yielded shocks that are generally higher than the survey-based results except in a few cases. Lower bound and the upper bound results derived from the two approaches are presented in Tables 1 and 2, respectively, while the Technical Annex contains detailed results from each approach separately.

Table 1: Lower bound reductions in trade costs associated with full implementation of digital trading systems (%)

Exporter (across) / Destination (down)	UK Agri	UK Mfcg	USA Agri	USA Mfcg	HIEs Agri	HIEs Mfcg	DCs/ROW Agri	DCs/ROW Mfcg
UK	-	-	0.80	0.30	1.04	0.50	2.02	1.40
USA	1.00	0.10	-	-	0.57	0.50	1.55	1.30
HIEs	1.04	0.30	0.57	0.50	0.42	0.80	1.40	1.80
DCs/ROW	2.02	1.00	1.55	1.40	1.40	1.90	2.38	3.00

Source: Authors' calculations. Header row shows importer/destination.

Table 2: Upper bound reductions in trade costs associated with full implementation of digital trading systems (%)

Exporter (across) / Destination (down)	UK Agri	UK Mfcg	USA Agri	USA Mfcg	HIEs Agri	HIEs Mfcg	DCs/ROW Agri	DCs/ROW Mfcg

[2] The known errors and manipulation in this dataset do not impact the results since we are working with averages of very large country groups and costs on both import and export side.

UK	-	-	1.18	3.02	1.40	2.65	3.50	5.15
USA	1.18	3.02	-	-	1.30	1.45	2.60	3.95
HIEs	2.00	2.65	1.50	1.45	1.80	1.08	3.70	3.58
DCs/ROW	4.50	5.15	2.90	3.95	3.70	3.58	5.30	6.08

Source: Authors' calculations. Header row shows the importer / destination.

For example, under the lower bound scenario, the implementation of digital trading systems leads to a 1% reduction in trade costs for UK agriculture exports to the US. Conversely, under the upper bound scenario, the implementation of digital trading systems leads to a 6.08% reduction in trade costs for ROW manufacturing exports to other ROW countries.

Estimates for the reductions in trade costs associated with the full implementation of digital trading systems are broadly comparable with similar research. For example, according to an analysis by the ASEAN secretariat "paperless implementation of the TFA measures, together with enabling the seamless electronic exchange of trade data and documents across borders, will help to significantly reduce trade costs by nearly 8.2% for ASEAN as a whole" (ASEAN, 2022).

3.4 Experiment #1: Implementation in the UK and the US

In the first experiment, a digital trading system is applied to bilateral trade between the UK and the US, with full uptake in the private sector. This experiment is conducted with two scenarios, based on cost reductions observed in recent pilot projects and a theoretical estimate of an advanced interoperable system with e-logistics platforms and regional information exchange.

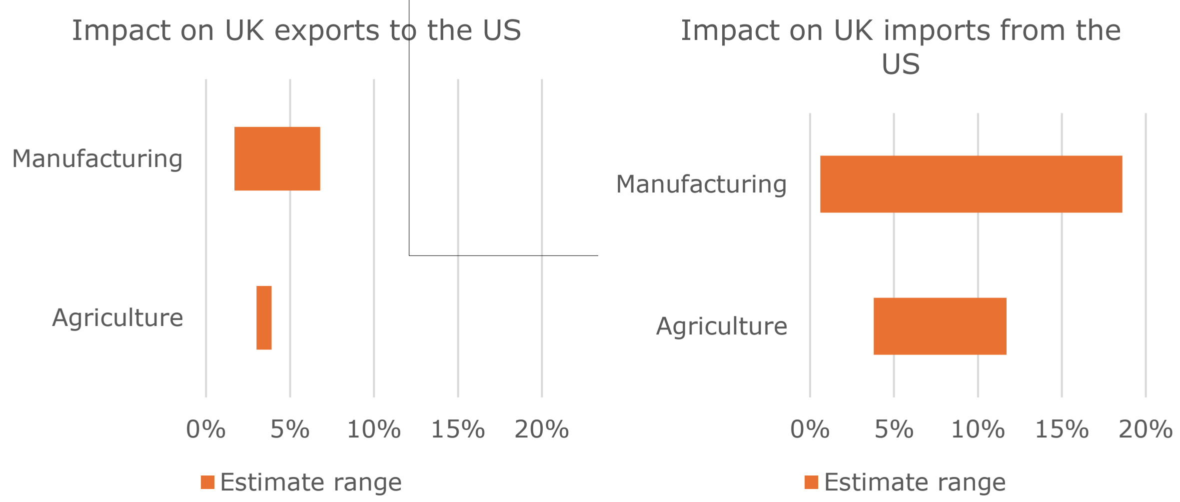
This experiment provides an indicative answer to the effects of implementing interoperable advanced digital trading systems between the UK and another G7 economy (including automatic information exchange of customs declarations, certificates of origin, SPS certificates, electronic transferable records etc.). While the universal adoption of such interoperable digital trading systems is some way away, this scenario is modelled to estimate an example of the benefits that may be realistically attainable for the UK through bilateral cooperation.

To estimate the benefits of implementing interoperable advanced trading systems, trade cost reductions are applied to bilateral trade only. In other words, the experiment assumes that the UK and another country (in this case, the US) sets up digital trading systems with advanced regional information exchange. However, it should be noted that, in reality some aspects of trade facilitation (including paperless trading) are often applied on an MFN basis to all trading partners.

As with all experiments, results are subject to certain caveats on the availability of reliable data (and subsequent uncertainty around modelling inputs) and assumptions of full adoption. See section 7.1.2 for more information.

The result on **UK bilateral exports** to the US ranges from a 1.7 to 6.8% increase in manufactured goods, and a 3 to 3.9% increase in agricultural products. As expected, expedited trade facilitation lowers trade costs resulting in a reduction in import prices, and an overall increase in bilateral trade flows.

Figure 6: UK-US bilateral trade (% change in volumes)



Source: Authors' calculations

The estimated impact on UK imports from the US is larger than UK exports to the US. For instance, manufacturing imports increase by up to 18.6% and agriculture imports increase by up to 11.7%.

The results demonstrate how lower bound shocks are more likely to lead to comparatively symmetrical effects for UK trade in agriculture and manufacturing. While upper bound shocks could lead to a relatively large increases in imports of agriculture and manufacturing goods. This is due to heightened specialisation and the UK's relative factor endowments. In other words, the US is better placed to produce some of these goods due to its stocks of factor endowments like land and unskilled labour. More broadly, percentage changes in trade also reflect the parity of the economies in question. Put simply, the US economy is much bigger, is less dependent on imports and less responsive to changes in import prices.

Despite the relatively large increase in imports, GDP and welfare gains for the UK are more pronounced in the upper-bound scenario as consumers enjoy access to cheaper goods, and subsequently increase savings, investment, and spending on other sectors, such as services.

Results are subject to some caveats as underlying regulations (such as production and food safety standards) are not specifically accounted for in the model. In reality, these would remain unchanged and limit the extent of increases in bilateral trade across specific products, particularly certain agriculture goods.

Table 3: Macroeconomic impact (% change in volumes)

Variable	UK	USA
GDP	**0 to 0.08**	**0.0**
Price index for private consumption expenditure	0.0 to 0.1	0 to 0.04
Welfare gains (GBP millions)	295 to 2,733	171 to 1,774

Note: The first figure always represents lower-bound modelling inputs. Welfare gains were derived in USD and converted to GBP at the rate of 0.82.
Source: Authors' calculations

Nonetheless, the experiment shows that both the UK and the US would benefit from digitalising their trading relationship. There are large welfare gains of up to £2.7 billion in the UK and £1.8 billion in the US. Both countries also see an increase in GDP, although the relative size of each trading partner means that these increases are proportionately smaller (<0.01%) to the US economy as a whole. Moreover, global GDP is unaffected given that shocks are applied to bilateral trade only.

3.5 Experiment #2: Digital trading systems implemented globally

In the second experiment, all regions implement advanced digital trading systems which are applied to all trading partners on an MFN basis, with cost reductions that are specific to each bilateral pairing.

Although UK trade increases under both scenarios, imports exhibit a small decline in the lower bound scenario, while exports fall in the higher bound scenario. These effects can occur when very large shocks are introduced to CGE models as extraordinary (and simultaneous) reductions in trade restrictions and subsequent increases in demand lead to certain shortages and the reallocation of various endowments.

For example, with the reduction of trade costs, we see a discernible reduction in import prices, particularly in agriculture and manufacturing goods. In turn, this leads to a noticeable fall in **consumer prices** (of up to 0.7% in the UK). In this sense, the anti-inflationary power of technology shifts should not be underestimated.

As a consequence of falling import prices worldwide, UK exports are crowded out by products from other countries. For example, in the upper-bound scenario, agricultural exports are displaced by products from other regions (developing countries and the US) who specialise in agriculture, in accordance with their stocks of land and other associated factor endowments. In this sense, universal trade cost reductions for agriculture and manufacturing products could expand the UK's goods trade deficit as a result of relative factor endowments.

However, this does not coincide with diminished GDP. On the contrary, in the upper-bound scenario UK GDP gains (0.9%) are the most pronounced. This is because import price reductions in agriculture and manufacturing products are more pronounced in the UK than in the US and other HIEs, leading to greater consumption, savings, and investment. In the upper-bound scenarios, shocks are sufficiently large to induce further specialisation by UK producers, with rises in the output of other sectors like logistics, services and capital goods.

Reflecting increases in investment, consumption and overall output, **UK welfare gains** amount to £25 billion per year and are predominantly attributed to technological change, with some gains attributed to reactive allocative efficiencies.

Estimated GDP gains are broadly in keeping with other CGE simulations on trade facilitation. For instance, Walmsley and Minor (2015) estimate that full implementation of the WTO's Trade Facilitation Agreement (TFA) would lead to an increase in GDP of up to 0.63% (cf 0.3-0.5% in our experiment) in high-income economies, and 1.0% (cf 0.5-1%) in low-income economies. When making these comparisons, it is important to note that the WTO TFA covers concepts and processes beyond trade digitalisation. Conversely, the trade digitalisation modelled here goes beyond the policies necessitated by the WTO TFA. In this sense, Walmsley, and Minor's (2015) estimates provide a useful yardstick for results in the absence of other literature. However, the two scenarios are by no means identical.

With that said, interpretation of the outputs listed below are subject to some specific caveats given the scale and breadth of the shocks. As with the UK US experiment outlined above, certain domestic regulations and product standards are not specifically accounted for in the model. These would remain in place, and likely limit the extent of increased imports across certain products, particularly for high-standards economies like the UK. More broadly, the theoretical model relies on prices and income to predict demand and supply with little distinction for the characteristics of the goods produced. Once more then, results likely over-estimate the true effect on changes in trade and UK imports.

On balance, the effects of experiment #2 on UK imports and exports (and the trade balance) are inconclusive. As demonstrated by differences in the lower and upper bound scenarios, results depend on the level of trade cost reductions actually achieved, both in the UK and abroad, particularly in primary target markets.

Nevertheless, the effects on UK GDP are unconditionally positive as a consequence of reduced trade costs and an overall increase in trade under both scenarios. This is also the case for global GDP which is estimated to increase by between 0.3 to 0.7%.

Table 4: Total exports (% change in volumes)

Exports	UK	USA	HIEs	DCs/ROW
Agriculture	4.1 to -3.8	4.2 to 3.9	0.4 to 3.2	1.9 to 4.2
Manufacturing	-0.2 to 3.4	1.3 to 6.0	0.4 to 0.9	4.1 to 9.0

Note: The first figure always represents lower-bound modelling inputs.
Source: Authors' calculations

Table 5: Total imports (% change in volumes)

Imports	UK	USA	HIEs	DCs/ROW
Agriculture	0.1 to 3.4	-0.4 to 0.2	0.4 to 1.2	3.5 to 7.7
Manufacturing	-0.6 to 4.0	-0.3 to 1.9	0.7 to 0.6	4.6 to 9.6

Note: The first figure always represents lower-bound modelling inputs.
Source: Authors' calculations

Table 6: Macroeconomic impact (% change in volumes)

Variable	UK	USA	HIEs	DCs/ROW
Exports	1.1 to -0.2%	2.3 to 5.7%	0.5 to 1.3%	1.9 to 4.2%
Imports	-0.7 to 3.6%	-0.7 to 0.7%	0.4 to 0.1%	3.5 to 7.3%
Price index for private consumption expenditure	-0.7 to 0.0%	-0.9 to -1.5%	-0.4 to -1.1%	0.1 to 0.1%
Welfare (GBP million)	-493 to 24,895	1,661 to 27,545	63,812 to 96,837	141,319 to 294,981
GDP	**0.1 to 0.9%**	**0.1 to 0.3%**	**0.3 to 0.5%**	**0.5 to 1.0%**

Note. Welfare gains were derived in USD and converted to GBP at the rate of 0.82.
Source: Authors' calculations

3.6 Impediments to implementation

While there are considerable GDP gains of up to 0.9% for the UK, there are also significant impediments to the implementation of advanced digital customs systems which should not be underestimated.

The time it takes to successfully implement digital trading systems is regarded as a major barrier, with the typical process outlined below, in Figure 7. For instance, it can take up to eighteen months to go through legal and governance procedures, business process analysis and data harmonisation, and contractual and tender procedures. It can take a further twelve months to build the requisite digital architecture, and a further twenty-four months for deployment, development, and testing (ESCAP, 2013). On average, it takes four years to implement a single window system (OIC, 2017).

Figure 7: Typical implementation process for digital trading systems

Source: (OIC, 2017)

The financial costs of establishing digital trading systems are another barrier to implementation. These vary greatly depending on the information technology interface, the level of sophistication, the number of adopted modules and overall trade volumes (World Bank, 2017). Yet, even relatively simple systems, such as Guatemala’s single window for exports, cost nearly £1 million, with ongoing operational costs of approximately £1 million per year.

Complex systems can be decidedly more expensive. The UK government has already allocated £180 million for its forthcoming single window system (UK Government, 2021). Despite the initial costs, digital trading systems do offer some of the largest long-term cost savings among trade facilitation initiatives (World Bank, 2017). Such costs are a fraction of the GDP gains envisaged in experiments #1 and #2. However, there is also an asymmetry between the main beneficiaries – i.e., consumers and trading businesses – and the payer, i.e. government agencies under fiscal constraints. Even if government agencies may also enjoy certain benefits – including increased tariff revenue with better compliance and improved organisational efficiencies.

Indeed, political will and coordination problems are other significant barriers to implementing digital trade systems. Given the prospective number of stakeholders and organisations involved, single-window systems can become limited by conflicting interests over technical standards, data harmonisation and information sharing (World Bank, 2017). The mobilisation of cross-government support is therefore vital for a project's success (OIC, 2017).

Coordination problems may be even more apparent in the context of international systems. For instance, regional systems mandate reconciliation between distinct customs regimes, legislation, and data formatting (World Bank, 2017). This issue is somewhat exemplified by the incremental uptake of UNCITRAL’s Model Law on Electronic Transferable Records (MLETR). In effect, the MLETR provides a legal framework that recognises standardised electronic transferable records as functionally equivalent to transferable documents or instruments (bills of lading, bills of exchange, promissory notes and warehouse receipts), provided that electronic transferable records are identifiable, controllable and retain their integrity. In this sense, MLETR is a vital component for the international proliferation of advanced digital trading systems that have been modelled above.

It is envisaged that the adoption of the MLETR will facilitate commerce by improving the speed and security of transmission, permitting the reuse of data and automating certain transactions through "smart contracts” or e-contracting (UNCITRAL, 2017). Despite these benefits, only seven countries have adopted legislation based on or influenced by the MLETR (Manaadiar, 2022). The UK’s efforts are ongoing as part of the Electronic Trade Documents (ETD) Act. For example, as 80% of global trade transactions choose English and Welsh law as the governing law of contract, the adoption of the ETD Act removes a key barrier to the global expansion of digital trade documents (UK government, 2022). Globally, the gradual reconciliation of national legislation with multilateral efforts and the MLETR illustrates the extent of some of the legislative barriers to implementing advanced digital trade systems, as well as the requisite political will to overcome these barriers.

4. Hypothetical impact of blockchain

4.1 Blockchain in trade

Although the integration of blockchain technology is still very much in its infancy – and despite the many impediments to its deployment – industry and policy influencers have pointed to the potential use of blockchain to facilitate international trade. The use of blockchain in paperless trade does not make customs procedures redundant, but advocates of this technology believe it could reduce trade costs, increase transparency, and safeguard against fraud. If so, blockchain would further expedite already digitised customs processes.

From the onset, it should be said that wide-scale deployment of blockchain in customs is a long-term prospect that still lies years ahead. It is also pending on many financial, technical and process impediments that make any prospective benefits a theoretical possibility. Pilot projects such as TradeLens (between Maersk and IBM) have been discontinued. Both Marco Polo (an Irish startup) and we.trade platform (a joint venture between IBM and twelve banks) for trade finance have been dissolved.

In the general case, blockchain works differently from conventional records of transactions. Any transaction and its specifications are cryptographically logged onto a block of data, creating a "shared, immutable ledger that facilitates the process of recording transactions and tracking assets in a business network" (IBM, 2022). Pending the approval of the majority of members within a distributed network, data can be added to a blockchain, creating a permanent record of the transaction or transformation.

In other words, the network itself is a record of all transactions, and the blockchain is accessible to all of the members of that network in real time. In theory, this creates a permanent record where each new transaction (or transformation) contains information about previous events that can be consulted at any time. Applied to international trade, blockchain can store information on any shipment – whether it be proof of purchase, clearance form, bill of lading, or insurance – as part of a block. Blocks form a transparent chain of custody, which is accessible to suppliers, transporters, buyers, regulators, and auditors (Botton, 2018).

For example, a Reducing Friction in International Trade (RFIT) project in the wine industry (via the "Chainwine" platform) has proven that integrating STW and Distributed Ledger Technology could remove the need for traders to generate data that is required for customs and regulatory requirements. By standardising data formats (including supply chain and upstream data from wine producers) this data can be distributed securely within a blockchain and integrated into HMRC's Customs Declaration and Food Standard Agency (FSA) systems, making additional declarations redundant (UK Government, 2022; House of Lords 2020)

While not removing actual compliance requirements, having all this information in one location would lower documentation, auditing, and accounting costs. Used in customs handling, exporters could upload all of the requisite documents onto a customs office blockchain and instantly prove their abidance with import rules – for example, qualification for preferential rates through rules of origin, sanitary and phytosanitary (SPS) rules, or compliance with embargoes (e.g., against conflict minerals). The technology could also facilitate the implementation of new concepts like border tax adjustments for carbon or any other production process methods (PPMs).

Through smart contracts, blockchain can store and execute certain tasks automatically – like releasing payments upon delivery or issuing certificates of conformity upon fulfilling certain criteria. In other words, once properly implemented with all relevant authorities and assessment bodies, blockchain technology could remove the need for trust between trading partners in different jurisdictions by providing a tamper-proof record of compliance across the value chain. It can facilitate the transfer of data and documents as digital assets, or it can also be used to exchange value via customs payments, fees, and charges (ADB, 2020).

4.2 Examples of customs pilot projects

Aside from the aforementioned RFIT pilot in wine, several ongoing studies are integrating blockchain technology into trade processes across both the public and private sectors.

Among customs authorities, the Taiwan Customs Administration has already launched a blockchain-enabled platform that allows traders, logistic firms, and government agencies to transmit and verify digital trading documents in real time for its preferential agreements with Singapore and New Zealand (Taiwan Customs Administration, 2020).

Similarly, US CBP had also rolled out a pilot (now discontinued) where blockchain was used to enforce intellectual property rights and tackle counterfeit goods. By verifying each step, in a given supply chain, the tamper-resistant nature of the technology can enable the secure verification of authentic products at the border. In addition, highly trade-dependent developing countries, such as the Maldives and Vietnam, have implemented pilot projects with the assistance of multilateral institutions.

Among trade applications within the private sector, Maersk, Microsoft, Ernst & Young and several insurance companies have developed Insurwave, a blockchain-enabled platform that allows shipping companies, brokers, insurers, and other suppliers to access and update the same ledger which can then be used for marine insurance contracts (Burgess & Azimkanov 2017). Similarly, Everledger uses blockchain to track diamonds with complete ownership histories to detect illicit trade.

The aforementioned projects like TradeLens, we.trade and Marco Polo each endeavoured to leverage blockchain technology and create platforms connecting all parties across the supply chain to allow information sharing and verification in real-time (WCO, 2018). While TradeLens in particular was regarded as a successful proof of concept, the platform struggled with industry uptake as discussed in the "impediments to implementation" section below.

4.3 Experiment #3: Universal blockchain deployment

In most of these early-stage case studies, the main benefit of blockchain is more expedient compliance with import requirements, such as rules of origin (RoO) verification procedures, that converge towards zero days and are eliminated through the end-to-end deployment of blockchain.

Given the absence of empirical evidence on the isolated effects of blockchain, we assume incremental cost savings on digital trading systems. Specifically, we repeat the *MFN* experiment (experiment #2) but cut costs uniformly by 80 per cent, accumulating also the impact from single window and paperless trading. This ensures also that reductions are at least equal (or higher) to the original digital STW scenario for all country-product pairings.

However, some caution is warranted here, as the modelling of trade effects does not take into account the costs and investment necessary to unleash these benefits. Moreover, full digitalisation and STW are assumed to have been achieved while the current technical and organisational impediments surrounding blockchain are also assumed to be solved.

This experiment cannot be modelled without first accounting for the benefits of digital trading systems, and further trade cost reductions to the upper-bound scenario in experiment #2 would yield overly distortive and wholly unrealistic results. Therefore, experiment #3 relies on an adaption of lower-range shocks from the previous exercise with results expressed in terms of a single, indicative estimate rather than a range.

As this experiment builds on technologies from previous experiments, these highly hypothetical results must be studied in comparison to the lower bound estimates from experiment #2. While we see similar or lower trade effects for the UK (due to dynamic effects from increased competition, particularly from US exports), we do see a more significant drop in **consumer prices** -0.9% (cf -0.7%) and effects on **GDP** that are fourfold compared to the original digital customs experiment.

Table 7: Total exports (% change in volumes)

Variable	UK	USA	HIEs	DCs/ROWs
Agriculture	2.6	4.8	4.1	5.7
Manufacturing	-0.3	3.3	1.2	4.8

Source: Authors' calculations

Table 8: Total imports (% change in volumes)

Variable	UK	USA	HIEs	DCs/ROWs
Agriculture	1.7	2.6	3.5	7.6
Manufacturing	-0.1	0.3	1.8	5.2

Source: Authors' calculations

Table 9: Macroeconomic impact (% change in volumes)

Variable	UK	USA	HIEs	ROWs	World
Exports	1.0	4.1	1.0	3.1	
Imports	-0.2	-0.3	1.4	4.1	
Price index for private consumption expenditure	-0.9	-1.2	-0.5	-0.3	

Welfare (GBP million)	5,152	11,881	161,881	184,066	
GDP	**0.4**	**0.2**	**0.7**	**0.7**	**0.6**

Note. Welfare gains were derived in USD and converted to GBP at the rate of 0.82.
Source: Authors' calculations

4.4 Impediments to implementation

While blockchain technology is promising, it is still in its infancy. As is often the case with early technologies, project resources and expertise consulted uniformly point to a gap between expectations and reality. While multinational corporations are exploring blockchain innovations within their organisation, authentication of compliance and widespread uptake from customs authorities and other commercial stakeholders could take many years.

So far, ledgers do not have the current scale to warrant creating a standard-setting authority. The technology is still vulnerable to fraud (via so-called "51% attacks") to execute transactions, steal valuable information, and disrupt a supply chain. Moreover, the fact that blockchain makes all information available to all participants – not just to government agencies but also to other participants in the network – may disincentivise its adoption, particularly if it involves sharing sensitive information on production methods, sourcing, or suppliers. That said, effective technical fixes to this are being developed to ensure data is only shared with those who need it to transact.

Resources consulted for this report uniformly quote implementation costs as an impediment. Aside from systems development and integration costs, blockchain competencies are in high demand. Moreover, the technology requires a critical mass of participants to be viable. For instance, full Implementation of SPS documentation will require smallholders to collect and input data on fertilisers used, date of harvest packaging etc. Many of these practical caveats have been raised by WCO (Okazaki, 2018).

In this context, several customs agencies, including the US CBP, are moving away from blockchain despite trials with a 100 per cent success rate. Simply put, returns on investment were deemed "inconclusive", and the focus is now shifting towards open government APIs and multi-platform interoperability.

Elsewhere, commercial platforms leveraging blockchain, like TradeLens, we.trade and Marco Polo, have demonstrated proof of concept to varying degrees but ultimately failed to reach a level of commercial viability. While each of these failures is the consequence of its own unique cause, industry players have exhibited a reluctance to "buy in" amidst concerns over security and data-sharing in the context of fledgling technology. Rival shipping companies were reluctant to embrace TradeLens, a platform backed by industry behemoth, Maersk. In this sense, commentators have speculated whether not-for-profit or nationalised, neutral entities have a better chance of success as the technology matures (Wragg, 2022).

5. AI and machine learning (ML) in customs

5.1 AI/ML-based anomaly detection

Given recent congestion in major maritime ports due to various sanctions, AI and ML have also made strides within port management. Rotterdam, Singapore, Dubai, Los Angeles and other major ports have begun to use AI tools to build a decision-making support system based on predictive models using ML to recognise patterns that may improve operations, including detailed prediction times of when vessels, lorries, and containers will be at the terminals.

Customs authorities are in the early stages of testing technologies for scanning and detection by combining AI, sensor technology, and algorithm-based detection. AI increases the ability of customs officials to identify anomalies and pilot projects using neural networks and data mining to identify risk factors, achieving an accuracy rate close to 90% (Alqaryouti et al., 2022,). Elsewhere, unverified PR statements indicate that using AI in port and customs increases their production capacity by 10% (Geronimo, 2019).

Similar ML-based fraud detection has wide applicability, including regulatory non-compliance, undeclared values by businesses and consumers, or detection of dual-use items. However, these applications and subsequent estimates for productivity gains are naturally fraught with uncertainties. Deploying ambitious big data solutions for national customs authorities comes with considerable technical and ethical issues, including potential biases demonstrated by ML, with limited scalability of the solutions developed due to data access and privacy issues (Mikuriya & Cantens, 2020).

Developing reliable detection algorithms requires large amounts of data from past customs inspections that do not just unleash privacy concerns, but the problem of “false negatives”. Since there is only data available on detected cases (i.e. correct positive identification) the algorithms could never learn from undetected cases. As algorithms only learn from data from cases where inspectors have targeted a shipment, ML-based inspections will struggle to perform better than humans.

Specialised AI infrastructure, expertise and organisational resources for data analytics are also costly to maintain. Integrating such technology and resources into an existing customs process requires a high degree of coordination, data management and compatibility that adds to such costs.

But most importantly, the use of AI is still in its infancy and entails a considerable trade-off. Cost savings and productivity gains depend on a political decision about what is an acceptable compromise between efficiency and accuracy. This is why a scenario based on efficiency gains against a ceteris paribus outcome on security cannot be developed at this stage.

Looking forward, it may be possible to model the benefits of AI and ML in digital customs procedures with the availability of case studies documenting associated time or cost savings within the context of a clearly defined policy framework that is explicit on the compromise between efficiency and accuracy.

6. Electronic contracts in services

6.1 Paperless trading in services

Where previous scenarios have looked at trade in goods, digital technologies will also facilitate services trade. Electronic contracts, supported by e-signatures and digital identities, are necessary for a truly paperless trading system in goods. But they also enhance productivity for trade in services in a similar manner.

Electronic contracts, also known as e-contracts, already play a significant role in improving cross-border trade in services by providing an efficient and reliable means of establishing and enforcing business agreements without the physical exchange of signed contracts across long distances. Contract processing is typically faster and more efficient when executed online.

Effective digital contract formation will also facilitate the cross-border supply of services (modes 1, 2 and 4). Similar to how EDI proves compliance with customs standards, it may also be used to demonstrate compliance for services. For instance, digital identities vastly shorten compliance procedures in retail banking, as evidenced by Know Your Customer processes and anti-money laundering laws (AML).

Therefore, digital identities can also play a significant role in improving services trade. Although digital identities are often tied to a specific national jurisdiction, their interoperability greatly supports digital contracting that creates verifiable and tamper-proof records, reducing the risk of errors and disputes between jurisdictions in cross-border trade. Moreover, reliable means of verifying the identity of service providers and consumers expedite the contracting process, enhancing trust, compliance and regulatory oversight that reduces the risk of illicit activities.

In recent years, legal instruments have been developed that recognise functional equivalence with paper-based documents or the legal effect of digital signatures. Noteworthy examples include UNCITRAL Model Law on the Use and Cross-border Recognition of Identity Management and Trust Services; the Model Law on Electronic Transferable Records (MLETR); Electronic Communications Convention; or Model Law on Electronic Signatures (MLES). Model laws are also frequently referenced in trade agreements, signalling their importance for digital trade as they create predictable legal frameworks, although these may not be interoperability mechanisms in themselves.

6.2 Experiment #4: Universal adoption of e-transactions enablers for services

While digital contracting and signatures are core components of digital customs, this section looks exclusively to services trade to avoid double-counting with previous scenarios.

Estimating such benefits – like any trade simulations in services – is fraught with methodological difficulties. Current models on trade in services cannot be easily disaggregated to specify actionable costs via electronic contracting and digital identities.

Furthermore, it is difficult to utilise various services trade indices, such as OECD Services Trade Restrictiveness Index (STRI), as proxies. This is because qualitative information is transformed into a quantitative measure that gauges the permissiveness of the regulatory environment rather than the actual use of the technology itself. Also, none of the restrictiveness criteria of the indices relates directly to electronic contracts or identities across relevant sectors.

Nonetheless, anecdotal evidence indicates, that physical contracting slows down services trade. Corporate materials indicate that e-contracting may lead to an average reduction in contract turnaround times of 15 days, as well as a 37 per cent improvement in productivity, and $36 saved per agreement compared with printing, sending, and storing physical contracts (Docusign, 2017). While savings are evident in multinational services operations that involve hundreds of thousands of contracts, it is difficult to transform such data points into modelling shocks.

It is also well-established that regulatory compliance costs are considerable in services trade. Financial services are one of the most regulated sectors in services, and a survey among over a thousand banks estimates that total compliance expenses represented 7% of all operational (non-interest) expenses in 2018 (Community Banking, 2018). Data processing rules alone account for 1%. These cost levels are similar to the global average cost of cross-border remittances, which encapsulates primarily documentation costs that conventional (non-digital) payment intermediaries must recoup. In 2022, the global average remittance cost was 6.8% (World Bank, 2022)

Using these yardsticks, we hypothesise that 1 to 7% of sectoral NTMs are contractual or compliance documentation costs – and that only 75% (0.75 to 5.25%) of these NTMs are reduced through e-contracting. This range is extrapolated via NTM AVEs (provided by Fontagne et al., 2016) for all sectors and regions. It should be noted that these technology-induced cost reductions are far lower than the general practice used in FTA impact assessments, where 10 to 25% of service NTMs are assumed to be eliminated through mere legal certainty (e.g. Francois, 2013) without any market access or efficiency gains involved.

In this experiment, the shocks (listed in the technical annex) are assumed to be implemented by all regions on an MFN basis and Tables 13, 14 and 15 provide results for exports, imports, and output under this scenario.

Table 10: Total exports (% change in volumes)

Variable	UK	USA	HIEs	DCs/ROW
Agriculture	-0.1 to -0.5	0.1 to 0.3	0.0 to -0.1	0.0 to 0.2
Manufacturing	-0.1 to -0.9	0.1 to 0.4	0.0 to -0.1	0.0 to 0.2
Logistics	-0.1 to -0.4	0.0 to 0.2	0	0.0 to 0.2
Services	0.3 to 2.0	0.4 to 2.9	0.4 to 2.5	0.4 to 2.8

Note: Lower and upper bound estimates
Source: Authors' calculations

Table 11: Total imports (% change in volumes)

Variable	UK	USA	HIEs	DCs/ROW
Agriculture	0.0 to 0.2	0.0 to -0.1	0.0 to 0.1	0
Manufacturing	0.0 to 0.1	0.0 to -0.2	0.0 to 0.1	0
Logistics	0.1 to 0.4	-0.0 to -0.1	0.0 to 0.1	0
Services	0.2 to 1.6	0.3 to 2.3	0.3 to 2.3	0.5 to 3.5

Note: Lower and upper bound estimates
Source: Authors' calculations

Sectoral results for this scenario are broadly as we would expect. In the UK, services **exports** increase by 0.3% in the lower bound scenario, and 2.0% in the higher bound scenario. Increases in output are more modest. Modest declines in UK exports of agriculture, manufacturing and logistics reflect increased specialisation and the comparative advantage enjoyed by UK services. These are also likely overstated, as the model does not account for the direct benefits of e-transactions on goods trade. Rather, it estimates the impact on services in isolation in this experiment.
With the universal adoption of electronic contracts, e-signatures, and digital identities, we see a significant increase in services exports and services imports across all four regions. There is also a minor (but noticeable) increase in goods trade thanks to enhanced trade in services inputs. Surprisingly, global services output is very marginally reduced in terms of value. This can be explained by the increased mobility of services leading to lower prices and greater allocative efficiency in supporting output gains in goods.

On balance, implementing electronic contracts, e-signatures, and digital identities erga omnes has a positive impact on the world economy. Although **services output** marginally declines (in terms of value), services become more tradeable, further lowering consumer prices and leading to a small increase in global GDP.

The macroeconomic results associated with the universal implementation of such technologies are displayed below, in Table 16.

Table 12: Macroeconomic impact (% change in volumes)

Variable	UK	USA	HIE	DCs/ROW	World
Exports	0.0 to 0.1	0.1 to 0.9	0.0 to 0.2	0.1 to 0.5	
Imports	0.1 to 0.4	0.0 to 0.1	0.1 to 0.4	0.0 to 0.3	
Price index for private consumption expenditure	0	-0.0 to -0.1	-0.0 to -0.1	-0.0 to -0.2	
Welfare (GBP million)	392 to 2,890	668 to 4,898	6,019 to 41,476	3,465 to 23,512	

GDP	**0.0 to 0.1**	**0**	**0.0 to 0.2**	**0.0 to 0.1**	**0-0.1%**

Note: Lower and upper bound estimates
Source: Authors' calculations

Worldwide adoption of electronic contracts, e-signatures and digital identities is associated with a small rise in **GDP** in all regions. **Welfare** increases in the UK are noticeable, at £2.9 bn per year. As with previous experiments, most of these welfare gains are derived from technological change, with allocative efficiency gains making a smaller contribution.

As with digital customs, heightened aggregate output can largely be attributed to the overall increase in world trade flows fostered by the universal implementation of digital contracts and supporting technologies.

6.3 Impediments to implementation

Digital contracting and supporting technologies for services trade face similar barriers to adoption and implementation as other digitalisation processes. However, discussions with service providers reveal that the inevitable absence of globally interoperable standards in digital contract formats or digital signatures leads to inconsistencies.

On one hand, the variety of solutions drives innovation and competition, but on the other hand, it could also make the transition to paperless trade more costly for businesses and consumers. However, the upfront investment in digital contracts is limited to software rather than physical infrastructure, making it relatively fast to develop and deploy.

Instead, the barrier to digital contracts concerns legal recognition and security. Many markets, especially in Asia, still have laws that require physical signatures or stamps on paper documents to be considered legally binding and digital contracts can be more easily challenged in courts. There are still concerns about unauthorised access or accidental deletion of digital contracts, especially when they are stored in the cloud.

Similar legal and trust-related impediments affect digital signatures. As noted, the legal frameworks, standards and suppliers around digital signatures vary from country to country, affecting available certification and verification. Technical barriers may also involve specific hardware or encryption methods not available in all territories. Electronic IDs are inevitably limited by national jurisdictions, with limited possibilities of cross-border interoperability. This is why the mass provision of services requiring such solutions is largely still localised.

7. Conclusions

7.1 Key findings

The digitalisation of customs and services facilitation offers significant potential for a consumer and business-oriented UK trade policy – especially at a time when opportunities for export-led growth may be limited.

This report has sought to estimate the benefits associated with the full implementation of the following technologies:

- **Digital trading systems** including;
  a) paperless, digitalised trade administration documents required by governmental authorities, e.g. customs declarations and SPS certificates
  b) paperless, digitalised commercial documentation supporting trade transactions, e.g. documents of title such as bills of lading
  c) advanced single window systems and other platforms that facilitate exchange of digital trade documents
- **Existing enablers of e-transactions**, with potential for greater roll-out, including e-contracts, e-authentication, and other solutions for paperless services trade (described in section 6).
- **Blockchain and AI,** as technologies with the potential to further develop and improve digital trading systems in future (described in section 4 and 5). Rather than a general study of the impact of these technologies on the economy, this report is focused on the extent to which they can further enhance and complement digital trading systems.

The UK/US experiment is indicative of the impact of implementing advanced digital trading systems (including automatic information exchange of customs declarations, certificates of origin, SPS certificates, electronic transferable records etc.) between the UK and another advanced G7 or OECD economy with a high degree of market compatibility.

Immediate gains are evident, with UK exports estimated to increase by between 3.0-3.9% in agriculture and 1.7-6.8% in non-agricultural goods, relative to the baseline of existing digitalisation.

Turning to the erga-omnes scenarios, universal adoption of all three technologies (advanced digital customs, integrated blockchain and e-transactions for services) is associated with an estimated rise in UK GDP ranging from 0.1-0.9%.[3] This rise can largely be attributed to technological change, with some allocative efficiency gains also evident.

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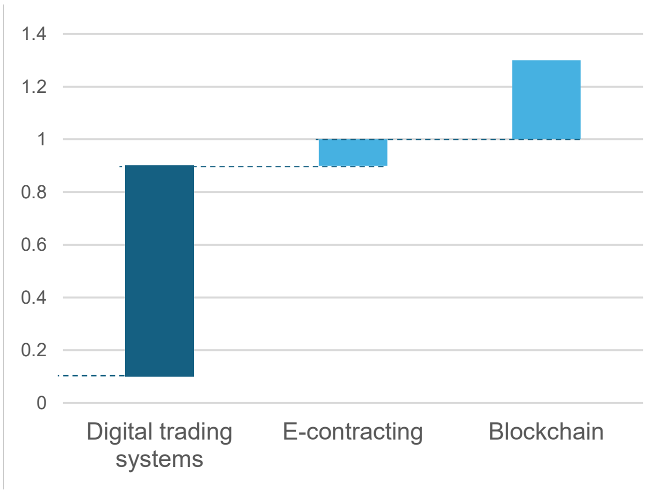
[3] *As with trade, these GDP gains relate to the new long-term equilibrium estimated by the CGE model. Put simply, in a given year post-implementation, UK GDP would be 0.9% higher than it would have been had advanced digital customs not been universally adopted.*

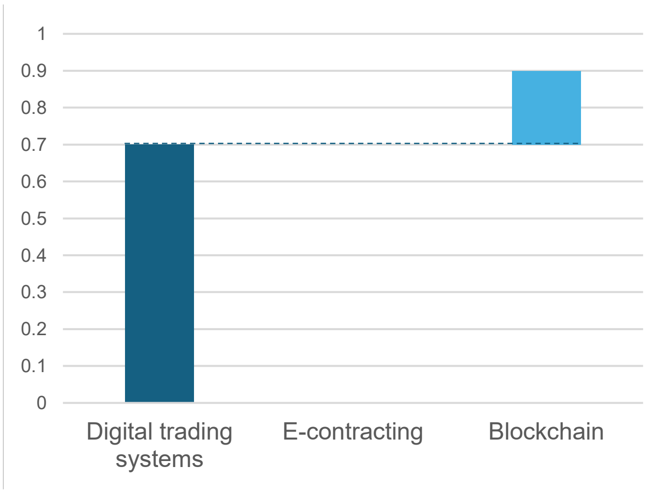
Figure 8: Potential increase in UK GDP associated with the widespread adoption of each technology (%)



Note. Figures for digital customs and e-contracting refer to an estimated increase in UK GDP that ranges from 0.1-0.9% and 0-0.1%, respectively. Further benefits of blockchain gains are calculated by subtracting lower range advanced digital trading systems results and are expressed as a single estimate, rather than a range. Source: Authors' calculations.

Universal adoption of advanced digital trading systems and integrated blockchain technology is also associated with an estimated reduction to the UK price index for private consumption expenditure of 0.7 and 0.2%, respectively. In this sense, these technologies offer a means to lower import prices without changing quotas or tariffs or sacrificing government duty revenues.

Figure 9: Potential reduction to UK price index for private consumption expenditure associated with the widespread adoption of each technology (%)



Note. Price index for private consumption expenditure refers to the 'ppriv' variable in GTAP. As an index, it is the product of the private consumption price for various commodities in region r and the share of private household consumption devoted to various commodities in region r. Figures for digital customs refer to an estimated reduction in UK ppriv that ranges from 0-0.7%. For E-contracting, there was no discernible reduction in ppriv under the lower- or upper-bound scenarios. Further benefits of blockchain are calculated by subtracting results from lower-bound advanced digital trading systems scenario and are expressed as a single estimate, rather than a range. Source: Authors' calculations.

Several domestic and cross-border barriers to implementation were identified. These include interoperability issues and the adoption of model laws into domestic laws. However, in nearly all cases, experts cited the upfront investments and transition costs as principal impediments. With regards to blockchain, the technology is still in its infancy, with a considerable gap between “reality and expectations”.

These findings carry certain implications. Full implementation of each of the technologies identified is estimated to result in a reduction in trade costs and subsequent economic benefits that are similar to those typically associated with trade liberalisation. In particular, the universal adoption of advanced digital trading systems has the potential to boost output and pave the way for further innovation in trade facilitation (with the integration of technologies such as blockchain). Benefits are most evident with the universal implementation that includes developing economies where existing systems are most cumbersome. To complement its 2025 Border Strategy, the UK should continue to support and develop similar initiatives elsewhere, through bilateral and multilateral channels.

7.2 Limitations

There are several limitations associated with the methodologies employed in this study. Like most nascent technologies, there is a limited source of reliable data on advanced digital customs, integrated blockchain and certain enablers of e-transactions. Existing data also often suffer from certain biases in view of fluid definitions, technological diversity, and high expectations. In this context of uncertainty, the project team have endeavoured to produce a grounded range of the benefits associated with each technology. Relative to other research (e.g. ASEAN, 2022), our estimates appear relatively conservative, and quotation of upper bound estimates does not seem unrealistic.

Inputs used for modelling are derived from existing reductions in trade costs that have already been observed. Looking forward, each technology may be associated with certain externalities that provide further reductions. For instance, digital technologies may (by providing better data on risk, consignment value, routes, and ownership) reduce premiums for insurance or export finance.

It is also worth noting that the numerical estimates outlined do not consider the significant implementation costs for governments and the private sector. Rather, these macroeconomic projections help to contextualise the investment roadmap and UK multilateral advocacy for digitalisation.

Finally, perhaps the most significant limitation of this study is its focus on legislation and implementation and the subsequent *assumption* of universal adoption. Barriers to adoption across the private sector should not be underestimated as exemplified by the recent failure of platforms like TradeLens, we.trade and Marco Polo. Even with a degree of “buy in”, progress can be slow. In February 2023, several major shipping container companies committed to 100% adoption of electronic bills of lading (eBL) in tandem with the Digital Container Shipping Association (DCSA). But the process is forecast to take as long as ten years (Ledger Insights, 2023). Whilst the potential associated with implementing each of these technologies is estimated to be significant, caution must be exercised in drawing conclusions from the data presented. In particular, further policy frameworks must be developed to encourage ubiquitous adoption by stakeholders.

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9. Technical annex

9.1 Approach to qualitative interviews

Structured interviews with industry stakeholders offered greater insight on digital trade processes. In total, the project team conducted fourteen structured interviews each lasting between 30 minutes to 1 hour. Interviewees ranges from customs officials and academics to business representatives from the private sector in the UK and elsewhere. In addition, continuous consultations were held with academics regarding the methodology.

Interviewing is a time-consuming and resource intensive endeavour, which allows a researcher to learn about the participant's experience, by observing, listening, and gathering information that is not directly accessible via desk research. The use of interviews in this project played several roles:

- It allowed us to understand important use cases associated with each technology.
- It allowed us to understand barriers to implementing each technology.
- It allowed us to check some of the assumptions we had made in formulating model shocks.

The interview process was supported by interview lists, which are tools designed to guide and customise the interviewing process, ensuring that the same general areas of information will be collected from each interviewee. While still allowing for flexibility and adaptability in the data collection process, an interview tool guarantees that detailed and explicit information will be secured from the participant.

After the interviews, we followed four steps to integrate interview findings in report:

- Raw data management (working with the words and notes from transcriptions
- Data reduction (the process of selecting, focusing, simplifying, and transforming raw data into workable "chunks" or categories)
- Data analysis and interpretation (the process of analysing data to fill the gaps and reflect the essence of the participants' perspective)
- Data representation (the process of compressing an array of information into an organised pattern of findings that allows for conclusions and recommendations)

9.2 Aggregation of the GTAP model

To simulate the introduction of digital trading systems, a pre-release version of the GTAP11 database has been aggregated in accordance with the following specifications.

Table 13: Regional aggregations of GTAP 11 database

Aggregated region	GTAP 11 regions
GBR	gbr
USA	usa
HIE	aus nzl hkg jpn kor twn brn sgp can chl ury pri tto aut bel cyp cze dnk est fin fra deu grc hun irl ita lva ltu lux mlt nld pol prt svk svn esp swe che nor xef hrv rou xer bhr isr kwt omn qat sau are

RoW	Xoc chn mng xea khm idn lao mys phl tha vnm xse bgd ind npl pak lka xsa mex xna arg bol bra col edcu pry per ven xsm cri gtm hnd nic pan slv xca dom jam xcb alb bgr blr rus ukr xee kaz kgz xsu arm aze geo irn jor tur xws egy mar tun xnf benbfa cmr civ gha gin nga sent tgo xwf xcf xac eth ken mdg mwj mus moz rwa tza uga zmb zwe xec bwa nam zaf xsc xtw

Source: Authors' calculations

Table 14: Sectoral aggregations of GTAP 11 database

Aggregated sector	GTAP 11 sectors
Agri	pdr wht gro v_f osd c_b pfb ocr ctl oap rmk wol frs fsh cmt omt vol mil pcr sgr ofd b_t
Mfcg	tex wap lea lum ppp p_c crp nmm i_s nfm fmp mvh otn ele ome omf
Lgcs	trd otp wtp atp
Serv	cns cmn ofi is robs ros dwe
Othr	coa oil gas omn ely gdt wtr osg

Source: Authors' calculations

9.3 Applied shocks in the GTAP model

9.3.1 Survey-based approach to digital trading systems

First, the World Bank estimations of documentary and border compliance costs provide country-specific documentary and border compliance costs (measured in US dollars) on both the import and export side per 20ft container (TEU), expressed as both time (in hours) and costs (in US dollars). As we conduct the experiments on averages across a large group of countries, we are also able to verify that the estimation errors discovered in this dataset do not affect the results of the experiments.[4]

For example, the average border compliance for exports among the entire HIEs (n=65), the average border compliance for exports takes 24 hours (22 hours for import) which is equivalent to US$ 253. In the specific case of the UK, both the export and import processing times and costs are very low (24 hours, US$25 for exports; 3 hours, or $0 for imports). The severe underestimation of import-side is likely due to an assumption that the typical case of UK imports is internal circulation within the EU Single Market – an assumption that no longer applies.

Such compliance costs also typically vary as the underlying regulatory requirements or hurdles vary depending on the proximity of regulations of the trading partners. Therefore, in the second step, the costs are weighted based on the UN ESCAP/World Bank data on bilateral NTMs, which provide specific observations of NTM per sector (agriculture or manufacturing) and country pairing, unique observations for each combination of importing and exporting country). This weighting reflects the severity of the underlying technical requirements (sanitary and phytosanitary requirements, technical standardisation, processes, and production method requirements) that need to

[4] See World Bank's internal review filed under: https://thedocs.worldbank.org/en/doc/791761608145561083-0050022020/original/DBDataIrregularitiesReviewDec2020.pdf

be documented. Thus, this step allows for an accurate extrapolation of border costs to each bilateral relation by sector.

In the third step, border costs (expressed in US$) are converted to percentage trade costs. Here, we extrapolate the conversion from US$ to percentage trade costs, based on actual costs, NTM AVEs from ESCAP and business surveys in FTA impact assessments (Copenhagen Economics) that indicate that $138 in border compliance costs are equivalent to 1% of AVE manufacturing, and $262 is equivalent to approximately 3% in agriculture in the case of Japan. This somewhat crude final step allows for the isolation of border compliance cost where the extrapolation of border compliance costs that vary with the severity of underlying NTMs (that cause the requirements), and the fact that compliance costs in AVE terms differ significantly between agriculture and manufacturing.

While it would have been possible to treat border costs (expressed in absolute value) as a form of specific tariff, which is converted into AVEs by using average prices, such an approach would be based on a hypothetical value on the size of shipment that would be constant across very large regions and sector definitions and introduce far worse sources of error. Moreover, UNCTAD has calculated the average value of a container shipment, but such a valuation would assume that one shipment is always one container and that shipments are valued at same price across all regions and products, thereby grossly understating AVEs in agriculture and developing countries while overstating them for manufacturing. Having considered alternative approaches (and consulted methodological reviewers within GTAP consortium), we conclude that our extrapolation that assumes linear and constant ratios is less distorting than assuming constant prices that are fictive.

The results of these three steps provide a reasonable baseline of border costs based on destination, origin, and sector for the model, from which a hypothetical reduction can be applied. As for the reduction in border costs, we consider the following studies to create a reasonable assumption for developed (Table 19) and developing countries (Table 20):

Table 15: Ex-post observations in HIEs (reductions in %)

Study	Territory	System	Export Time	Import Time	Import Cost
Ferro et al. in World Bank (2017)	165 territories	Single Window	Low: 22 High: 70	Low: 25 High: 60	
Ferro et al. in World Bank (2017)	75 territories	EDI only	52		
ICC (2021)	Worldwide	Transferrable records		75*	
UK Government (2020)	NZL	Single window		50	Low: 20** High: 50**
WCO (2019)	KOR, air	Single window		63	

WCO (2019)	KOR customs clearance	Paperless		56	
ESCAP (2018)	KOR	EDI		98*	
ESCAP (2018)	KOR	Single Window		24	19
Shephard (2014), UNNExT (2010)	JPN	Single Window		63	
Shephard (2014), UNNExT (2010)	SGP	Single Window		99*	Low: 20*** High: 35**
APEC (2011)	KOR to TWN	Paperless	22 (KOR)****	34 (TWN)****	
CeFACT (2005)	SGP	Single Window		Low: 96* High: 100*	Low: 33 High:66
CeFACT (2005)	SWE	Single Window	50	Low: 20 High: 50	
CeFACT (2005)	SWE	Single Window		40	

Note: * Processing approval times only and ex-ante; ** government savings (rather than trader savings); *** processing fees; **** processing times translated to costs

Table 16: Ex-post observations from DC/LDCs (reductions in %)

Study	Territory	System	Export Time	Import Time	Import Cost
OIC (2017)	AZB	Single Window		89	
OIC (2017)	SEN	Paperless		75*	
OIC (2017)	CMR	Single Window		98	
Nizeyimana & De Wulf (2015)	RWA	Single Window	55	44	
Shephard (2014), UNNExT(2012)	THA	Single Window	42	41	Low: 24 High: 26
CeFACT (2005)	MUS	Single window		94	
FTEC (2001)	APEC	Paperless			Low:1.5** High: 15**

Note: * Exporter document collection time; ** cost savings expressed as AVEs, ex ante.
Source: Various

These ex-post studies show some interesting conclusions. To begin, the case studies that combined cost savings from digitalisation and STW imply that documentary compliance can be substantially reduced (WCO, 2017). However, the indirect costs arising from procedural delays, inventory holding, and other opportunity costs could vary widely between the regions given cost levels, direction of trade, and commodities involved (between 19 and 99%). Interestingly, some studies (World Bank) also show that exporter-side border compliance costs can be as high as the importer-side.

Based on the ex-post pilot studies, we assume the following reductions as shown in Table 19. Taken all four steps together, they translate to trade cost reductions for the CGE model outlined in the main body of this report.

Table 17: Summary of reductions based on ex-post studies

Region	Export	Import
GBR	40%	0%
USA	30%	30%
HIE	40%	30%
RoW	80%	70%

Source: Authors' calculations. Header row shows the proposed reduction of total border compliance costs in this approach.

Table 18: Survey based estimates for trade cost reductions associated with full implementation of digital trading systems (%)

Exporter / origin (down)	GBR Agri	GBP Mfcg	USA Agri	USA Mfcg	HIE Agri	HIE Mfcg	ROW Agri	ROW Mfcg
GBR			0.8	0.3	1.4	0.5	3.5	1.4
USA	1	0.1			1.3	0.5	2.6	1.3
HIE	2	0.3	1.5	0.5	1.8	0.8	3.7	1.8
ROW	4.5	1	2.9	1.4	3.7	1.9	5.3	3

Source: Authors' calculations. Header row shows importer / destination.

Econometric approach to digital customs

In the second approach, we estimate the cost savings associated with Digital Trading Systems by replicating and adapting the approach adopted by Duval et al. (2018).

Data from ESCAP's Survey on Trade Facilitation and Paperless Trade Implementation can be used to estimate progress on the implementation of digital trade facilitation and distinguish the effects of these measures from other trade facilitation reforms.

The ESCAP survey poses more than fifty questions relating to the implementation of various trade facilitation reforms in 144 countries in 2013, 2015, 2017 and 2019. Countries report whether measures are not implemented, at the pilot stage of implementation, partially implemented or fully implemented.

Duval et al. (2018) use these responses to develop a "general TF" score, reflecting countries' implementation of the WTO TFA, and a "paperless TF" score reflecting countries' implementation of more advanced digital trade facilitation measures. Survey questions relating to the computation of each score are outlined in the table below. Survey questions are weighted equally, with a score ranging from 0 for non-implementation, to 3 for full implementation. Importer and exporter scores can be combined to calculate a bilateral score for both "general TF" and "paperless TF".

Table 19: Computing trade facilitation scores from ESCAP survey results

Score	Category	Question
General TF	Transparency	2. Publication of existing import-export regulations on the Internet

		3. Stakeholder consultation on new draft regulations (prior to their finalisation) 4. Advance publication/notification of new regulation before their implementation (e.g., 30 days prior) 5. Advance ruling (on tariff classification) 9. Independent appeal mechanism (for traders to appeal Customs and other relevant trade control agencies' rulings)
	Formalities	6. Risk management (as a basis for deciding whether a shipment will be or not physically inspected) 7. Pre-arrival processing 8. Post-clearance audit 10. Separation of Release from final determination of customs duties, taxes, fees and charges 11. Establishment and publication of average release times 12. Trade facilitation measures for authorised operators 13. Expedited shipments 14. Acceptance of paper or electronic copies of supporting documents required for import, export or transit formalities.
	Institutional arrangement and cooperation	1. Establishment of a national trade facilitation committee or similar body 31. Cooperation between agencies on the ground at the national level 32. Government agencies delegating controls to Customs authorities 33. Alignment of working days and hours with neighbouring countries at border crossings 34. Alignment of formalities and procedures with neighbouring countries at border crossings
Paperless TF	Paperless trade	15. Electronic/automated Customs System established (e.g., ASYCUDA) 16. Internet connection available to Customs and other trade control agencies at border-crossings 17. Electronic Single Window System 18. Electronic submission of Customs declarations 19. Electronic Application and Issuance of Trade Licenses 20. Electronic Submission of Sea Cargo Manifests 21. Electronic Submission of Air Cargo Manifests 22. Electronic Application and Issuance of Preferential Certificate of Origin 23. E-Payment of Customs Duties and Fees 24. Electronic Application for Customs Refunds
	Cross-border paperless trade	25. Laws and regulations for electronic transactions are in place (e.g. e-commerce law, e-transaction law) 26. Recognised certification authority (CA) issuing digital certificates to traders to conduct electronic transactions 27. Engagement of the country in trade-related cross-border electronic data exchange with other countries 28. Certificate of Origin electronically exchanged between your country and other countries 29. Sanitary & Phyto-Sanitary Certificate electronically exchanged between your country and other countries 30. Banks and insurers in your country retrieving letters of credit electronically without lodging paper-based documents

Source: (Duval et al., 2018)

To assess the effects of trade facilitation implementation on bilateral trade costs, bilateral, sector-specific trade costs from 2019 (the last year data is available) can be derived from the World Bank-ESCAP Trade Cost Database. These costs can be modelled as a function of bilateral trade facilitation scores from the same year. Similar to Duval et al. (2018), the following specification can be estimated:

$$\ln(T_{ijk}) = \beta_0 + \beta_1 \ln(gtariff_{ijk}) + \beta_2 \ln(distcap_{ij}) + \beta_3 congtig_{ij} + \beta_4 comlang\_off_{ij} + \beta_5 comlang\_ethno_{ij} + \beta_6 col\_dep\_ever_{ij} + \beta_7 col45_{ij} + \beta_8 smctry_{ij} + \beta_9 rta_{ij} + \beta_{10} landlocked_{ij} + \beta_{11} \ln(creditindex_{ij}) + \beta_{12} \ln(LSCI_{ij}) + \beta_{13} \ln(generaltf_{ij}) + \beta_{14} \ln(paperlesstf_{ij}) + D_i + D_j + \varepsilon_{ij}$$

Table 20: Variables in the cost model estimation

Variable	Definition	Source
T	Bilateral, sector-specific trade costs between countries i and j in 2019.	World Bank-ESCAP Trade Cost Database
$gtariff$	Sector-specific geometric average tariff factor (1+rate) that each reporting country (i) charges to its trade partner (j) and vice versa, which can be expressed as $gtariffij = \sqrt{tariffj} \times tariffji$	World Bank-ESCAP Trade Cost Database
$distcap$	Geographical distance between country i and j.	CEPII
$congtig$	1 if country i and j share a common border and zero otherwise.	CEPII
$comlang\_off$	1 if country i and j use the same common official language and zero otherwise.	CEPII
$comlang\_ethno$	1 if a language is spoken by at least 9% of the population in both countries and zero otherwise	CEPII
col_dep_ever	1 if country i and j were ever in colonial relationship and zero otherwise.	CEPII
$col45$	1 if country i and j had a common coloniser after 1945 and zero otherwise.	CEPII
$smctry$	1 if country i and j were or are the same country and zero otherwise.	CEPII
rta	1 if country i and j are members of the same regional trade agreement in 2019 and zero otherwise.	CEPII
$landlocked$	1 if either country i or j is landlocked and zero otherwise	CEPII
$creditindex$	Geometric average depth of credit information index 2019	World Bank Doing Business
$LSCI$	Geometric average score of liner shipping connectivity index 2019	UNCTAD
$generaltf$	Implementation of TFA score 2019	Derived from ESCAP's Survey on Trade Facilitation and Paperless Trade Implementation
$paperlesstf$	Implementation of digital trade facilitation score 2019	Derived from ESCAP's Survey on Trade Facilitation and Paperless Trade Implementation

D	Dummy variables for income groups 2019	World Bank

Source: Authors' calculations

Results for the effects of trade facilitation implementation on bilateral trade costs in manufacturing and agriculture are pictured below in Table 14.

Table 21: Trade facilitation and bilateral trade costs in (1) manufacturing and (2) agriculture

VARIABLES	**Results (1) Mfg**	**Results (2) Agr**
	logtij	logtij
gtariff	0.887***	0.380***
	(0.173)	(0.114)
distcap	0.304***	0.292***
	(0.00969)	(0.0103)
contig	-0.402***	-0.393***
	(0.0331)	(0.0366)
comlang_off	0.0350	0.0735*
	(0.0376)	(0.0421)
comlang_ethno	0.0175	0.00786
	(0.0365)	(0.0407)
col_dep_ever	-0.0942*	-0.257***
	(0.0500)	(0.0564)
col45	-0.337***	-0.236***
	(0.0548)	(0.0615)
smctry	0.103	0.0167
	(0.0683)	(0.0708)
rta	-0.0683***	-0.0671***
	(0.0151)	(0.0159)
landlocked	-0.0231	-0.0781***
	(0.0274)	(0.0294)
creditindex	-0.0367	-0.104***
	(0.0324)	(0.0351)
LSCI	-0.146***	-0.204***
	(0.0126)	(0.0133)
generaltf	-0.274***	-0.136**
	(0.0508)	(0.0541)
paperlesstf	-0.230***	-0.0885**
	(0.0341)	(0.0349)
Constant	5.245***	4.922***
	(0.176)	(0.189)
Observations	2,957	3,246
R-squared	0.563	0.438

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The advantage of adopting an approach based upon ESCAP's Survey on Trade Facilitation and Paperless Trade Implementation is that country-, sector- and base year-specific inputs can be derived for CGE modelling. To take an example, the UK and China had a bilateral $generaltf$ score of 78.3% in 2019. Therefore, we can estimate that full implementation of remaining TFA measures will be associated with a 5.36% reduction in manufacturing trade costs, and a 2.95% reduction in agriculture trade costs.

Similarly, the UK and China had a bilateral score of 74.4% in 2019. Therefore, we can estimate that full implementation of remaining digital trade facilitation measures will be associated with a 5.88% reduction in manufacturing trade costs, and a 2.27% reduction in agriculture trade costs.

Using the established elasticities, the estimated trade cost changes are associated with a full implementation of the *remaining* advanced digital trade facilitation measures. To calculate the most recent, bilateral survey results from 2021 (the latest year available) are used. Scores for High-income economies (HIE) and Rest of the World (RoW) are calculated as the simple average of all survey respondents (excluding the UK) in the associated income classifications. Given there are no index scores for the USA, we have interpreted these from the available information from US CBP.

When calculating trade cost changes, we assume a baseline level of digital trading systems by assigning each region a base score of 15.

Table 22: Econometric estimates for trade cost reductions associated with full implementation of digital trading systems (%)

Exporter (across) / destination (down)	GBR Agri	GBP Mfcg	USA Agri	USA Mfcg	HIE Agri	HIE Mfcg	ROW Agri	ROW Mfcg
GBR	-	-	1.18	3.02	1.04	2.65	2.02	5.15
USA	1.18	3.02	-	-	0.57	1.45	1.55	3.95
HIE	1.04	2.65	0.57	1.45	0.42	1.08	1.40	3.58
ROW	2.02	5.15	1.55	3.95	1.40	3.58	2.38	6.08

Source: Authors' calculations. Header row shows importer / destination.

9.3.3 Alternative econometric approach to digital trading systems

The project also produced estimates for AVE trade cost reductions associated with digital customs using a gravity model. Specifically, we conducted we conducted an approach broadly based upon OECD (2021), using a PPML estimator to specify the following equation:

$$Q_{ijkt} = \exp\left(\beta_1 T_{ijkt} + \beta_2 RTA_{ijt} + \beta_3 generaltf_{ijt} + \beta_4 paperlesstf_{ijt} + \delta_{it} + \delta_{jt} + \delta_{ij}\right) u_{ijkt}$$

Table 23: Variables in gravity model estimation

Variable	Definition	Source
Q	The quantity of agriculture or manufacturing products traded between exporter	USITC Gravity Portal

	country i and importer country j in year t.	
T	The tariff imposed by importer j on agriculture or manufacturing products from exporter i in year t. The logarithm of this variable + 1 is considered in the estimation.	World Integrated Trade Solution (WITS)
RTA	Is a dummy variable equal to 1 if countries i and j belong to the same regional trade agreement.	Mario Larch's Regional Trade Agreements Database
generaltf	Bilateral implementation of TFA score in year t.	Derived from ESCAP's Survey on Trade Facilitation and Paperless Trade Implementation
paperlesstf	Bilateral implementation of digital trade facilitation score in year t.	Derived from ESCAP's Survey on Trade Facilitation and Paperless Trade Implementation

Source: Authors' calculations

The trade effects associated with paperless scores would then be combined with import demand elasticities to determine their AVE equivalent. Unfortunately, results were statistically non-significant at all confidence intervals.

9.3.4 Blockchain

This scenario builds on low-range estimates for the erga omnes (Experiment #2, survey-based based approach) where 80% of existing documentary and border compliance costs are uniformly reduced.

Table 24: Reductions in trade costs associated with full implementation of blockchain (%)

Exporter (across) / destination (down)	GBR Agri	GBP Mfcg	USA Agri	USA Mfcg	HIE Agri	HIE Mfcg	ROW Agri	ROW Mfcg
GBR	-	-	1.83	0.61	3.22	1.11	5.09	2.09
USA	1.81	0.61	-	-	3.33	1.25	4.16	2.04
HIE	3.22	1.11	3.35	1.25	4.12	1.73	5.4	2.6
ROW	5.09	2.09	4.16	2.04	5.4	2.83	5.68	3.22

Source: Authors' calculations. Header row shows importer / destination.

For example, the implementation of digital trading systems *with blockchain* leads to a 1.81% reduction in trade costs for UK agriculture exports to the US.

9.3.5 Enablers of e-transactions in services

The shocks assume 0.75 to 5.25% of NTMs established by CEPII 2016 are reduced for services sectors.

Table 25: Lower bound reductions in trade costs associated with full implementation of enablers of e-transactions (%)

Importer /Destination	Services
GBR	0.20
USA	0.38
HIE	0.43
ROW	0.65

Source: Authors' calculations

Table 26: Upper bound reductions in trade costs associated with full implementation of enablers of e-transactions (%)

Importer /Destination	Services
GBR	1.53
USA	2.77
HIE	2.97
ROW	4.43

Source: Authors' calculations

For example, under the lower bound scenario, the implementation of enablers of e-transactions leads to a 0.2% reduction in trade costs for UK services imports from each region. Conversely, under the upper bound scenario, the implementation of enablers of e-transactions leads to a 1.53% reduction in trade costs for UK services imports from each region.

9.3.6 General note import and export shocks

All shocks introduced in the experiments conducted in this report are ams-shocks, which are import-augmenting technology changes. Shocks to ams represent the negative of the rate of decay on imports of commodity or service with falling import prices which was specifically developed to facilitate the simulation of efficiency improvements such as customs automation or e-commerce. These shocks are always introduced on the importer side.

However, the experiments on digital customs and blockchain implements both costs and cuts that are specific for the exporter side. As all such shocks were unique for each bilateral pairing (e.g. UK exports to US) rather than horizontally (i.e. all UK exports), the standard model of GTAP could accommodate all two-sided effects as sums of import and export shocks.

The model with similar exporter costs is not in any officially published GTAP model extension. Rather, it is explained briefly in a research paper published in the Journal of Global Economic Analysis. The code for incorporating it is not shown comprehensively enough to be directly incorporated in the GTAP model, why its implementation could not be finalised within the project in a rigorous manner matching its description.

Controls showed that the results were either identical or well within the rounding up applied to the data presented. These conclusions align with the comparisons conducted by Walmsley and Strutt (2021) showing that results are remarkably similar between ams and axs, while both generated results that are higher than any tax or willingness to pay (wtp) function. In theory, an axs shock impacts the model before the importing market (and before the Armington function) why AXS has a smaller technological effect but a marginally larger trade effect than AMS.