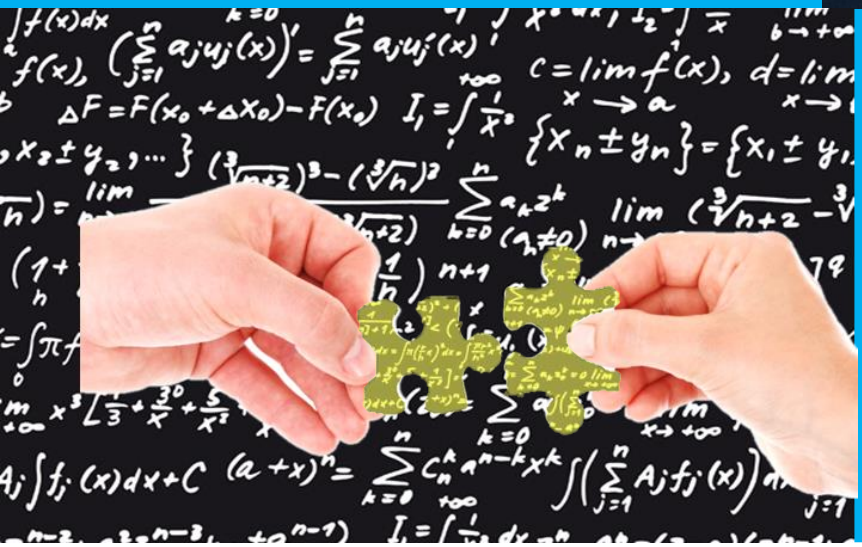
ARTNeT

UNITED NATIONS ESCAP
Economic and Social Commission for Asia and the Pacific

A primer on quantifying the environmental benefits of cross-border paperless trade facilitation



Yann Duval and Simon Hardy

ASIA-PACIFIC RESEARCH AND TRAINING NETWORK ON TRADE

Working Paper

No. 206 | 2021

The Asia-Pacific Research and Training Network on Trade (ARTNeT) is an open regional network of research and academic institutions specializing in international trade policy and facilitation issues. ESCAP, WTO and UNCTAD, as key core network partners, and a number of bilateral development partners, provide substantive and/or financial support to the network. The Trade, Investment and Innovation Division of ESCAP, the regional branch of the United Nations for Asia and the Pacific, provides the Secretariat of the network and a direct regional link to trade policymakers and other international organizations.

The ARTNeT Working Paper Series disseminates the findings of work in progress to encourage the exchange of ideas about trade issues. An objective of the series is to publish the findings quickly, even if the presentations are less than fully polished. ARTNeT Working Papers are available online at https://artnet.unescap.org. All material in the Working Papers may be freely quoted or reprinted, but acknowledgment is requested together with a copy of the publication containing the quotation or reprint. The use of the Working Papers for any commercial purpose, including resale, is prohibited.

Disclaimer:

The designations employed and the presentation of the material in this Working Paper do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries. Where the designation “country or area” appears, it covers countries, territories, cities or areas. Bibliographical and other references have, wherever possible, been verified. The United Nations bears no responsibility for the availability or functioning of URLs. The views expressed in this publication are those of the author(s) and do not necessarily reflect the views of the United Nations. The opinions, figures and estimates set forth in this publication are the responsibility of the author(s) and should not necessarily be considered as reflecting the views or carrying the endorsement of the United Nations. Any errors are the responsibility of the author(s). The mention of firm names and commercial products does not imply the endorsement of the United Nations.

ASIA-PACIFIC RESEARCH AND TRAINING NETWORK ON TRADE

WORKING PAPER

A primer on quantifying the environmental benefits of cross-border paperless trade facilitation

Yann Duval[1]

Simon Hardy[2]

Please cite this paper as:

Duval, Yann and Hardy, Simon (2021). "A primer on quantifying the environmental benefits of cross-border paperless trade facilitation", **ARTNeT Working Paper Series** No. 206, May, 2021, Bangkok, ESCAP

Available at https://artnet.unescap.org

[1] Chief, Trade Policy and Facilitation Section and Officer-in-Charge, Trade, Investment and Innovation Division, UN ESCAP. Email: duvaly@un.org

[2] Research Associate, Trade Policy and Facilitation Section, ESCAP, Bangkok, Thailand, e-mail: Simon.N.Hardy@protonmail.com. The authors would like to acknowledge useful suggestions and comments from Alexey Kravchenko, Armen Manukyan, Sang Won Lim and Soo Hyun Kim.

Abstract

The governance of international trade incurs major costs, including to the environment. Global supply chains are complex, and traditionally involve the printing, dispatching, processing, exchanging, and ultimately discarding of vast quantities of paper documents. Trade facilitation, and particularly the implementation of cross-border paperless trade, have the potential to significantly reduce these environmental burdens. We estimate the greenhouse gas savings for the Asia-Pacific and the World from implementing paperless trade by combining detailed descriptions of trade transactions, data on trading volumes and relevant emissions factors. Our results indicate that, even with conservative assumptions, the emissions savings from paperless trade implementation can be very high – driven especially by efficiency gains from handling data digitally. Still, the savings from trade digitization pale in comparison to the emissions from transport in international supply chains.

Keywords: international trade, trade facilitation, paperless trade, environment, emissions, CO2, digitalization, digitization

JEL Codes: F18, H83, Q56

Table of Contents

List of Tables

1. Introduction

While trade facilitation traditionally focuses on reducing the time and monetary cost of trade procedures (WTO, 2015), scant attention has been paid to the environmental burden these activities incur. Global supply chains depend on a complex network of procedures to coordinate activities across traders, regulators, and intermediaries, and to ensure laws and regulations are complied with (United Nations/CEFACT, 2012). Preparation of all associated trade documents and their exchange across borders have a cost: vast quantities of paper are printed, dispatched, processed, exchanged, and ultimately discarded, while international shipments are delayed.

Effective trade facilitation can play a major role in reducing these environmental burdens. Current efforts to switch to paperless trade, i.e., the use of electronic data and documents in trade transactions, hold especially great potential. Several reports have discussed in abstract how digital systems could reduce the use of paper in trade transactions, eliminate the need for physical delivery of documents and allow for the automation of wasteful activities (Tijan et al. 2019). Some supporting quantitative evidence also exists from the digitization of invoicing in private-sector firms (Tenhunen and Penttinen, 2010, Lichter et al. 2010). However, to our knowledge, no systematic efforts have been made to estimate the overall environmental benefits of digitizing trade procedures.

To begin addressing this gap, we estimate the potential carbon savings from paperless trade implementation. To do so, we apply standard emissions factors to a “typical” trade transaction, based on a dataset of detailed “Business Process Analysis” case studies of end-to-end trade transactions. Our initial results suggest that, all else equal, a complete transition to paperless trade procedures could eliminate between 9 and 23 million tons of carbon dioxide equivalent (CO2e) emissions per year for the Asia-Pacific region alone, with an average estimate of about 14 million tons. At the global level, emissions saved through paperless trade implementation average 36 million tons, equivalent to planting over a billion trees. While these estimates are naturally subject to large uncertainties, they may be considered to provide a lower bound for the environmental benefits associated with moving from paper-based to digital trade transactions.

2. How paperless trade implementation affects greenhouse gas emissions

We consider four main channels through which paperless trade implementation affects greenhouse gas emissions, as listed in table 1.

First, physically printed documents are eliminated. Paper is a major emitter – a single unrecycled A4 sheet produces around 56 grams of CO2e.[3] In our sample of transaction case studies, the average transaction involves a minimum of 63 pages of paper. Trade finance alone involves 4 billion documents (not pages) circulating at any one time, with an average of 20 to 30 documents per transaction (Warrington, 2021). The ink and electricity used for printing add yet more emissions.[4]

Second, paper documents no longer have to be physically moved between actors, e.g., for a signature, or to be collected from or submitted to relevant regulatory agencies. Preparation and submission of paper documents often involve environmentally damaging transport, including by motorbike courier services, as well as envelopes and/or other packaging material for the documents. By contrast, digital data exchange requires electricity for routers, networks, and servers with a comparatively minuscule carbon footprint.

Third, digitization is accompanied by simplification and automation. For example, implementation of Singapore's electronic Single Window reduced the number of documents which traders had to submit for certain procedures from up to 35 to just one (UNNExT, 2010). The European Commission calculated that implementation of its proposed Maritime Single Window would save shipping operators 22-25 million staff hours on reporting between 2020 and 2030 (Pape, 2019). These savings come from reductions in the number of documents and procedures which must be completed as part of each transaction, reductions in duplicate information, automation of some tasks (like checking for consistency), making it easier to retrieve archived information and more. This has important environmental consequences: working in an office environment is associated with emissions from heating or air conditioning, the electricity required to operate office equipment and lighting, petrol for employee

[3] Calculations based on data from Environmental Paper Network (2021).

[4] Ink accounts for about 1% of overall emissions from a printed page (EuPIA 2008).

commutes and garbage disposal. Paperless trade implementation reduces the amount of these emissions associated with each transaction. Meanwhile, paper-based systems already prepare and store documents on computers, meaning that the nature of those office emissions largely remains unchanged.

Finally, digitization expedites transactions, reducing the time that cargo must be stored until the transaction is complete (Shepherd, 2014). For example, the implementation of a national electronic single window system in Azerbaijan reduced average border crossing time from 180 to 20 minutes, while cargo dwell time in Benin was cut from 39 to 6 days (OIC, 2017). Storage, again, is associated with several emissions, notably from lighting, cargo handling and temperature control (if applicable).

Table 1. Channels through which implementing paperless trade affects greenhouse gas emissions

Elimination of physical documents	+Elimination of physical documents, requiring: • Paper • Ink • Electricity for printer
Replacement of physical delivery	+Reduced number of deliveries required to complete trade transactions. +Elimination of physical delivery, requiring: • Fuel for courier transport • Envelope -Replaced by digital data exchange, requiring electricity for: • Router • Networks • Servers
Productive hours	+Reduced productive hours required to complete procedures. Affects emissions associated with office labour (commute, office equipment, lighting, temperature control, other).
Storage time	+Reduced cargo storage time, affecting emissions from temperature control, lighting, cargo handling.

3. Methodology and data

3.1 Overview

Any carbon footprint is calculated by summing the footprints of inputs, multiplied by the volume of those inputs. Thus, if there are *e*=1...E inputs (for trade transactions, these might be pieces of paper or productive work hours), each repeated n_e times and each generating c_e grams of Co2e, the total impact is:

$$Carbon\ footprint\ = \sum_{e=1}^{E} n_e c_e$$

Finding standard emissions factors (c_e) for the inputs used in trade transactions in the existing literature is relatively straight-forward. Instead, the main challenge is that the quantity of inputs n_e required to complete trade transactions vary widely, depending on the country, nature of the product, type of financing, and how organizations choose to conduct their paperwork. Due to data and computational limitations, accounting for all these idiosyncrasies when trying to arrive at regional estimates is not feasible.

Our approach is to focus on quantifying the inputs for a "typical" trade transaction. This should cover all steps involved in purchasing, shipping, and paying for goods, as per the standard Buy-Ship-Pay model (United Nations/CEFACT, 2012). Hence, if n_{ei} are the inputs for a representative transaction *i*, its carbon footprint is:

$$Carbon\ footprint\ of\ transaction\ i\ = \sum_{e=1}^{E} n_{ei} c_e$$

This conceit allows us to draw on the extensive pre-existing literature in trade facilitation which describes common trade transactions and the average effects of digitization. We rely heavily on the UNNExT Trade Process Analysis Database (TPAD) of Business Process Analysis (BPA) case studies for detailed descriptions of trade transactions from across the Asia-Pacific, and on select case studies of past paperless trade implementations. We derive our results based on four core inputs from this literature: the number of documents used in paper-based trade transactions, the number of stakeholders, the productive hours saved from switching to paperless procedures, and the reduction in import/export time (or trade time).

Once we have an estimate for a representative trade transaction, this can be scaled up by multiplying it by the number of transactions t_r which occur in region *r* (which may be a country, the Asia-Pacific, or the World), to arrive at a regional estimate:

$$Total\ regional\ carbon\ footprint\ = t_r * \sum_{e=1}^{E} n_{ei} c_e$$

Of course, what constitutes a representative trade transaction depends on the context. Major assumptions are still needed to complete the calculations. To allow readers to see how our results change with different assumptions, and apply our calculations to different contexts, we provide our work on request in the form of an excel calculator with explanatory notes. An online version of the calculator will be made available as we continue research in this area, in collaboration with interested parties. Since this is still an emerging literature, the calculator is designed to be a useful starting resource to anyone else attempting to estimate carbon savings from trade digitization.

3.2 A representative trade transaction

We base our inputs for a "typical" trade transaction on a large body of pre-existing literature. There are four main variables from which we extrapolate our results: the number of documents (including copies) involved in a trade transaction, the number of stakeholders, and the changes in import/export time and productive hours required to complete trade transactions in the switch to paperless procedures. These variables are used, along with key assumptions, to arrive at estimates for the amount of paper, ink, electricity, petrol, office time and storage used by paper-based versus paperless trade procedures.

Table 2 summarizes 27 BPA case studies from 13 Asia-Pacific countries conducted between 2009 and 2015. These case studies provide detailed descriptions of the practical and mandatory steps for purchasing, shipping, and paying for products, based on detailed legal reviews and interviews with stakeholders. A major advantage of this dataset is that procedures in most countries were still overwhelmingly paper-based when these case studies were conducted, providing us with a relatively clear baseline of paper-based procedures.

Table 2. Summary of BPA studies

Origin	Destination	Transaction type	Product	Study period	# Documents (including copies)	# stakeholders	Import/Export time (days)
Bangladesh	India	Export	Woven garments		68		49
Bangladesh	Japan	Export	Shrimp		75		37
Bangladesh	India	Export	Jute Hessian bag		33		30
Cambodia	China	Export	Cassava		60		5
Cambodia	China	Export	Maize		60		5
Cambodia	France/Italy/Germany	Export	Rice		51	14	26
Cambodia	India	Export	Cashew nuts		36	13	23
Cambodia	Germany	Export	Silk		54	12	21
China	Japan	Export	Garments	2009 to 2010	26	11	9
China	Thailand	Export	Electronics	2009 to 2010	31	11	22
Lao PDR	Thailand	Export	Maize		10		17
Myanmar	Ivory Coast/Burkina Faso	Export	Rice		42		12
Myanmar	China	Export	Mango		23		11
Nepal	India	Export	Cardamon		38		13
Nepal	India	Export	Vegetable ghee	2009 to 2010	48		42
Nepal	China	Export	Vegetable ghee	2009 to 2010	48		11
Thailand	USA	Export	Jasmine Rice	2009 to 2011	72	16	15
India	Bangladesh	Import	Wheat		49		27
India	Bangladesh	Import	Cotton fabric		28		8
Thailand	Bangladesh	Import	Raw Sugar		19		10
Indonesia	Cambodia	Import	Pharmaceuticals		25	11	22
Japan	China	Import	Textiles	2009 to 2010	37	9	9
Japan	China	Import	Auto parts	2009 to 2010	37	10	12
Thailand	Lao PDR	Import	Animal feed		33		15
Malaysia	Myanmar	Import	Palm oil		61		11
India	Nepal	Import	Rice		49		18
India	Nepal	Import	Textiles	2009 to 2010	25		5

Source: ESCAP/ECE UNNExT, 2021

3.2.1 Paper and ink

There are a variety of reports which provide information on the number of documents involved in trade procedures. The World Bank Doing Business database gives an average figure of 7.29 documents for import transactions, and 6.2 documents for

export transactions across 190 economies between 2011 and 2015. However, these numbers only consider documents for regulatory compliance and do not include copies or application forms (World Bank, 2021a, 2021b, 2021c). At the other end of the spectrum, SITPRO (2008) detailed study on food trade procedures in the United Kingdom finds 150 documents are needed, for a total of 225 paper pages per transaction.

In table 2, the number of documents – including copies of documents that must be presented multiple times during the transaction – vary between 10 and 75, with an average of 42. The number of pages in a document usually vary around 1-3, with case studies like SITPRO (2008) (not part of the BPA database) using an average figure of 1.5 pages. We therefore estimate the average number of pages of paper per transaction to be 63, with a higher bound of 112 pages.

Ink consumption can be easily extrapolated from the number of pages by assuming a "coverage rate": the area of each page covered in ink. We use a coverage rate of 10 per cent – roughly equivalent to covering 2/3 of a page with text. At that rate, printing 25 pages consume an average of one gram of ink.[5]

3.2.2 Document delivery

The distance travelled by couriers delivering trade documents is estimated based on the number of stakeholders. Transactions in table 2 involve between 9 and 16 stakeholders, with an average of 11.9. In a paper-based environment, documents are transported at least once between traders and each stakeholder, creating a lower bound:

$$\min(j) = s - 1$$

Where: *j* = number of journeys, *s* = number of stakeholders

Detailed examination of select BPA case studies suggests that traders or their representatives must often visit the same agency multiple times. For example, once to apply and once to receive the document, with sometimes intermediary steps involved to collect signatures from other organization before a final document or certificate is issued. A more realistic estimate for the number of journeys required to

[5]Based on author's own calculations, with data drawn from InkPedia (2021).

complete a single trade transaction may therefore be twice the minimum figure mentioned above.

However, there is another complication: transactions are often handled by large firms or representatives (e.g., Customs agents and/or freight forwarders) which have the scale to submit documents from multiple transactions at once. Hence, while a full trade transaction may require many documents switch hands, the average number of journeys to deliver or collect them might be far less. To avoid overestimating the inefficiency of paper-based procedures, we therefore assumed an average of 10 documents are submitted with each journey. The average distance travelled by couriers will depend on local geography, infrastructure, and the locations of stakeholders. We assume an average round trip of 10 kilometres.

3.2.3 Storage

The average import/export time across the BPA studies listed in table 2 is 17.9 days, ranging from 5 to 49 days needed to complete all relevant import or export procedures, during which time goods typically need to be kept in storage. Sheperd (2014) finds that a full implementation of the paperless trade measures included in the Survey on Trade Facilitation and Paperless Trade would reduce export times for 29 Asia-Pacific countries by an average of 44 per cent, with a similar reduction for imports. This econometric study also includes country-specific estimations, reflecting the number of measures individual countries had yet to adopt, as of 2014. Applying these estimates to our set of BPA studies, full implementation of paperless trade measures is found to reduce import/export time by an average of 10.4 days, with a wide range from 1 day to 38.6 days depending on products and countries. We therefore assume that switching to paperless trade reduces the time that cargo must wait in storage while trade procedures are completed by an average of 10.4 days.

Our assumption is broadly consistent with other literature which look at time savings from paperless trade implementation, summarized in table 3. OIC (2017) examines several countries, finding that the implementation of National Single Window (NSW) programmes reduced Customs clearance time in Cameroon from 6 days to 3, while total cargo turnover/dwell time in Benin was reduced from 39 days to 6 days, and from 4 days to 2 days in Malaysia. UNNExT (2012) examines Thailand, finding that the time

to export fell from 22 days to 13 days between 2007 and 2009 among various preparatory efforts for Single Window implementation. The figures in these case studies are not only roughly in line with our average, but they also reflect a similarly large variation as our estimate[6].

3.2.4 Office work hours

Figures discussed in SITPRO (2008) suggest that it takes 13 minutes to generate a paper-based invoice, with a further 26.8 minutes needed for the receiver to open, process, audit and file it. Switching to e-documents cuts a total of 24.8 minutes for these same activities. Additionally, digitization (and especially the implementation and refinement of National Single Windows) cuts down on the number of documents which must be submitted. For example, UNNExT (2012) found that the number of documents which had to be submitted in Thailand fell 75 per cent and 56 per cent respectively for imports and exports between 2007 and 2011.

A switch to paperless trade also provides for additional time savings during the submission of documents. Figures in APEC (2011) suggest that paper-based transfers can require around 150 minutes in queuing and communicating with officials (note: we are not including transport time, and only considering time in an office environment). By contrast, online submissions rarely take longer than 10 minutes.

Further time might be spent in paper-based systems trying to find documents and retrieve them from archives or copying paper documents. However, we have not found any source or data that would enable us to quantify these activities.

Accordingly, again based on the number of documents that needs to be prepared in the BPA studies, we estimate that the implementation of paperless trade will save between 19.68 and 50.25 productive work hours per transaction across the various offices where the documents will be prepared and processed.

These estimates are found to be realistic and consistent when compared to aggregate-level studies. Ferro et al. (2016) finds that switching from a fully paper-based to fully paperless system reduces the manhours expended for border compliance (just on the

[6]This appears to largely be the result of differences in pre-implementation import/export times, since countries where trade was already fast have little absolute room for improvement.

trader's side) from 98 hours to 47 hours per transaction, based on data from 75 economies. Although it includes some activities which occur outside the office, this suggests that our estimates may actually underestimate savings in productive work hours when paperless trade is implemented.

3.2.5 Accounting for mistakes

Mistakes can further increase the number of pages consumed, distance travelled and work hours spent to complete trade transactions. In interviews with freight forwarders and traders, SITPRO (2008) noted that stakeholders significantly underestimate how often they made mistakes. After examining 562 transactions across two firms, they found that 10 per cent of consignments had at least one priority document missing, with an average 36.46 document issues encountered per month in each firm. Errors can introduce significant disturbances into the end-to-end trade process – especially in paper-based systems, where they are both harder to detect and to correct (Lighter et al. 2010). SITPRO (2008) find that mistakes add 10-14 hours of work for traders or freight forwarders to find the relevant documents and reclaim preferential tariffs. The competent authorities may spend an an addition 10 hours on their side. In this study, we use a 10 per cent error rate and conservatively assume that each mistake adds an additional document's worth of paper, an additional courier delivery of the corrected documents, and 20 hours of work (accounting for both the trader's and regulator's time).

Further resources may be spent by stakeholders who are unfamiliar with the trade procedures figuring out what is required from them. However, we do not consider these additional effects as we lack the data to quantify them.

Table 3. Selected literature on efficiency gains from paperless trade

Ferro et al., 2016.	Analyze impact of technology on trade facilitation, based on World Bank Doing Business database (DB).	Average export border compliance time is reduced from 98 hours to 47 hours with the adoption of electronic data exchange. Data from 75 economies, significant at 1 per cent level after controlling for per capita income.
APEC, 2011.	Case study of implementation of electronic certificates of origin (e-CO) between China and the Republic of Korea.	Introduction of e-CO reduce work time (in minutes) for documentary compliance in imports from 905 to 470, and from 610 to 350 for exports. Savings are the result of eliminating transmission, queuing and communication time required for submitting COs.
Sheperd, 2014.	Regress paperless trade implementation score (based on ESCAP Survey on Trade Facilitation) onto trade time (from DB).	Find 10 per cent improvement in paperless trade implementation is associated with 6 per cent reduction in trade time, on average in Asia-Pacific. Also note that Singapore Single Window reduced processing time from 4 days to 15 minutes and reduced processing time for permits from 4 hours-7 days to 10 minutes.
UNNExT, 2012.	Single Window case study of Thailand	Time to export fell from 24 days to 14 days between 2006 and 2009 among various preparatory effort for Single Window. Number of documents required fell 75 per cent and 56 per cent for import/export between 2007 and 2011, while time required fell 41-42 per cent.
OIC study, 2017.	Review >400 documents and surveyed 19 industry participants across 6 case studies.	Implementing NSW reduced border crossing time in Azerbaijan from 180 minutes to 20 minutes. In Cameroon, Customs clearance procedures were reduced from 6 days to 3. In Benin, total cargo turnover/dwell time was reduced from 39 days to 6 days, and from 4 days to 2 days in Malaysia.
SITPRO 2008.	Examine cost of paper documentation in UK perishable foods sector. Combined interviews with wide variety of industry participants (across 6 countries) and national statistics.	Processing paper document takes average 13 minutes, compared to 6 minutes for digital document. Freight forwarders require 3-5 minutes per consignment to fill in paperwork, while importers require 24 minutes per consignment. Single Window would cut this down to 9 minutes. Port Health Authorities could be twice, if not more, productive if e-documentation enabling automated document verification. Collecting documents from handler takes freight forwarders 10 courier man-hours. Freight forwarders make 7.6 trips per day. 10 per cent likelihood of at least 1 priority document missing (range from 2 to 60 per cent depending on transaction). Significant financial cost of having to store paper documents for a number of years (for both government agencies and freight agencies).

3.3 Emissions factors and scaling

Table 4 identifies the emissions factors used in this study. An emissions factor is a representative value relating the quantity of a pollutant released into the atmosphere with an activity associated with the release of that pollutant (Cheremisinoff, 2011). Emissions factors are typically reported in “CO2 equivalent” (CO2e). This means the factor is a sum of several pollutants, normalized to the 100 year Global-Warming-Potential of Caron Dioxide (CO2).

A range of assumptions, from basic to more significant, are also made to arrive at our results. These include everything from the type, thickness, and weight of paper, to the type of transport used in courier journeys. Table 4 provides a full list.

These emission factors can be applied to our reference paper-based trade transaction and associated efficiency gains from moving to paperless trade discussed above, to calculate the savings in CO2e per transaction. These estimates are then scaled up to the regional (Asia-Pacific) and global level using trade data from United Nations Comtrade, assuming an average transaction size of $50,000, the same figure as used by the World Bank Doing Business Database (World Bank, 2021c).

This transaction size is found to be a reasonable assumption when compared to aggregate Customs declaration data from Armenia and the Republic of Korea. Average export declarations in 2020 amounted to $56,000 and $43,000 respectively in these two countries. Average import declarations amounted to $21,000 and $15,000, suggesting that our assumption may indeed underestimate the actual number of transactions and associated pollution from their processing, particularly for net importing countries or regions.

Table 4. Emissions factors

Input	Assumptions/Parameters	Factors	Sources
Paper	5 per cent recycling rate Uncoated freesheets A4, 100gsm thickness, 6.25g/page	8.98gCO2e/g unrecycled paper 3.81gCO2e/g recycled paper	Environmental Paper Network (2021) See Schultz and Suresh (2018) for methodology.
Ink	One gram of ink on average covers 12.6 pages (10 per cent coverage rate, average of data on 44 cartridges, with data from InkPedia [2021])[7]	2.5gCO2/g ink	Amon-Tran et al. (2012)
Printer electricity	400W, assume 90 per cent efficiency. 30 seconds of use per page.	497gCO2e/kWh	EnergyUseCalculator (2021) Carbon Footprint TM (2020)
Document delivery	Journey using motorcycle courier service.	0.11551kgCO2e/km	BEIS (2020)
Network/ Server electricity	10W/hour for network/data centres, 5W/hour for router, 90 per cent efficiency.	497gCO2e/kWh	Ericsson (2020) Carbon Footprint TM (2020)
Productive work hours	Office environment with heating/cooling system.	1389.4gCO2/hour	Tenhunen and Penttinen (2010)
Storage facilities	Storage at ambient temperature.	5.4kgCO2e/t in ambient storage[8]	GLEC (2021)

[7] For methodology of printer yields, see:

https://www8.hp.com/h71041/learn-about-supplies/us/en/ink.html

https://learn-about-supplies.ext.hp.com/measuring-ink-yield

[8] Emission factors for temperature-controlled storage estimated at 11.7kgCO2e/t; and 30.1kgCO2e/container at maritime container terminal.

4. Results and discussion

Table 5 provides a summary of our initial estimates of emissions saved from implementing cross-border paperless trade, in Asia and the Pacific and globally. These results should be taken as indicative of the significant potential environmental benefits from paperless trade implementation, keeping in mind the uncertainties associated with both the emission factors and the wide variation in the characteristics of each trade transaction. The latter is illustrated in part by the wide range between our low and high estimates.

Table 5. Emissions saved from implementing cross-border paperless trade

Emissions per transaction (gCO2e)	**Average**	**Low**	**High**
Emissions from paper	4,763	1,418	8,819
Emissions from ink	14	3	25
Emissions from transport of paper documents	1,906	1,016	4,066
Emissions from printing of documents	78	18	138
Emissions saved from reduced storage once paperless trade is fully implemented	154	15	572
Emissions saved from reduced productive hours spent once paperless trade is fully implemented	44,044	30,150	72,666
Estimated emissions savings per transaction once paperless trade is fully implemented	**50,958**	**32,621**	**86,284**
Trees required to match these savings in a year	2	1	3
Aggregate Estimates (metric tons CO2e)			
Asia-Pacific estimated emissions savings	**13,841,231**	**8,860,414**	**23,436,637**
Trees required to match these savings in a year	439,404,144	281,282,975	744,020,222
World estimated emissions savings	**36,146,171**	**23,138,841**	**61,204,434**
Trees required to match these savings in a year	1,147,497,490	734,566,371	1,942,997,918

Even with the conservative assumptions made in this study, the amount of emissions that can be saved from paperless trade implementation are very significant. Our results suggest that, ceteris paribus, digitalization can reduce the greenhouse gas emissions of an average trade transaction by 32-86kg. For the Asia-Pacific, this translates into saving between 8.9 million and 23.4 million tons of CO2e, with an average of 13.8 million tons. To put this figure in context, it is equivalent to

planting between 281 and 744 million trees.[9] When scaled to cover world trade, our estimate suggests potential savings of 36.1 million tons of CO2e, equivalent to planting 1.1 billion trees.

We reach these figures despite making very conservative assumptions whenever data was lacking. This is particularly relevant to our estimates of emissions from delivering physical documents, which could be much higher with a few still-realistic changes. There are also some activities which are simply excluded from our calculations due to lack of data, such as the time spent by traders figuring out how trade procedures worked.[10] This is important, since information barriers have long been acknowledged as a major drag on trade costs, and policies designed to reduce such costs[11] could have significant environmental benefits.

We also did not consider embodied emissions. These are the emissions generated during the production of the fixed capital used to carry out procedures, e.g., the computers and office buildings, say, or the motorcycles used by a courier service to deliver documents. Excluding such emissions is common practice due to the complexity of calculating them and vagueness of attributing the results to specific activities. If embodied emissions were included, they would likely increase our estimated greenhouse gas savings, given that the switch to digital systems relies on relatively little new fixed capital (most firms already have computers) and reduces the need for storage facilities while trade procedures are conducted. It is therefore reasonable to see our estimates as "lower bound" for the true greenhouse gas savings from switching to paperless trade.

The environmental benefits from paperless trade implementation are not driven by the savings in paper or ink, but by efficiency gains from handling data digitally. Most savings come from the reduction in office work needed to complete trade transactions. For the average trade transaction, 85 per cent of the estimated

[9] Crowther et al. (2015) estimate there are about 3.04 trillion trees in the world.

[10] Going further, for example, expedited clearance from paperless trade can reduce waste for perishable goods, either by reducing spoilage in the supply chain or by increasing shelf life for end consumers. This can reduce greenhouse gases released during decomposition (notably methane, from the decomposition of organic matter). Expedited clearance can also reduce land border congestion, eliminating some emissions from trucks standing idle. These types of emission savings from paperless trade have not been accounted for in this study.

[11] For example, though the creation of an integrated "Trade Information Portal".

emissions savings are due to reductions in work hours. This is not entirely surprising: office work includes a range of inputs, and in most carbon footprint studies the savings from efficiency gains outweigh any direct effects. The next-most important input is the elimination of paper (10 per cent of the total) and physical transport of documents (4 per cent). Conversely, the elimination of ink and electricity for the use of printers is relatively insignificant. This finding suggests that trade facilitation policies which increase productivity have the greatest ceteris paribus potential for environmental benefits.

Still, emission savings from paperless trade implementation pale in comparison to the emissions from international transport of goods in global supply chains. Our average emission saving estimates from paperless trade implementation represents only 1.2 per cent of the emissions from fuel used in global supply chains in 2015, which have been estimated at 2.9 billion tons of CO2e, accounting 23 per cent of global greenhouse gas emissions (GLEC, 2021).

This also points to the dynamic effects associated with paperless trade implementation. Reducing transaction costs encourages more trade and more transactions of smaller sizes (i.e., cross-border e-commerce). Full implementation of cross-border paperless trade is estimated to increase exports in Asia and the Pacific by $257 billion (Sheperd, 2014). The emissions from transporting these additional exports would certainly offset the emission savings from paperless trade. At the same time, slow implementation of paperless trade systems at a time when e-commerce is booming would certainly result in increasingly high emissions per dollar of goods traded as transaction size continues to shrink.[12] What this suggest is that **acceleration of paperless trade implementation should be accompanied by decarbonization of international transport and other necessarily physical processes if it is to result in indisputable environmental benefits**.

For complete transparency, a trade transaction emissions calculator in Excel is being made available upon request for those interested in studying how different

[12] Our results suggest that moving to paperless trade so deeply cut emissions associated with trade documentation (on a per transaction basis) that it would take a many fold increase in the number of these transactions before total emission in a paperless trade system reach those observed in a paper-based system – but only if emissions from physical movement of the goods are excluded. Faster import/export time may also encourage narrower delivery windows which blunt many opportunities for environmental efficiency in transport (Muñoz-Villamizar et al. 2021).

assumptions and emission factors change the results, and to develop estimates more adapted to their countries or sector of activities. An online version of the calculator will be made available as we continue research in this area, in collaboration with interested parties.

5. Limitations and further research

The estimates presented in this paper have several limitations, which are worth reiterating here to avoid misuse of the results and encourage further research in this area. First, what constitutes a representative trade transaction at the regional or global level is necessarily subject to a high degree of uncertainty. It is well understood that transactions vary greatly in terms of number of documents, complexity, procedures, and number of actors, depending on the country, the nature of the product, type of financing, and the specifics of how stakeholders choose to conduct trade procedures. The environmental impact of similar trade transactions may also vary depending on the energy mix of a country, its trade and border infrastructure, and many other factors.

The BPA case studies on which we base our average calculations are very detailed, but they were conducted for their relevance to trade facilitation policy – not as a representative sample of all transactions occurring in the Asia-Pacific. They are skewed towards agricultural and textile products in low-income countries. The upper and lower bounds give some indication of the uncertainty this introduces. Using our emissions calculator, it is possible to see how our results change if only BPA studies from a particular industry or country are included.

Additionally, some of the assumptions or data used is likely to be relevant in some context, but less so in others. For example, the emissions factor we used for paper was calculated by SCS Global using a very sophisticated methodology which goes into great detail – down to the technology used at individual paper mills (Schultz and Suresh, 2018). However, this detail is specifically based on the North American paper industry, making it unclear how applicable their results are to paper used in Asia-Pacific developing countries.

Targeted primary research would be helpful in deepening our understanding of how trade facilitation affects climate goals, and to verify the robustness of the initial

estimates presented here. First, BPA and/or Single Window case studies could record a few key variables which are critical to calculating the environmental impact of trade transactions. Most importantly, this would include the amount of office work required to complete and verify documents, the amount and type of transport used to exchange them and the procedures required to fix mistakes. Estimating the environmental impact of trade transactions[13] should become a routine step in future BPA case studies. This would increase awareness of the environmental cost of trade governance and, over time, build up a dataset with which environmental questions can be answered and progress tracked.

Second, previous work on the environmental impact of e-invoicing and the postal sector provides some useful inspiration for future case studies in trade facilitation. Specifically, while we have pursued a "bottom-up" approach based on a typical trade transaction, many environmental accounting studies of complex systems go in the other direction: first generating an overall estimate based on industry surveys or detailed examination of an organization's expenditures, and then allocating those emissions to individual transactions. Work of this type in trade facilitation would provide a useful counterpoint to our estimates.

6. Conclusion

Our study identified four main channels through which the implementation of paperless trade facilitation affects greenhouse gas emissions. Paperless trade eliminates physical documents and the need to transport them; it also reduces office work and storage. We estimate the size of these effects for the Asia-Pacific and the World by combining detailed descriptions of trade transactions, data on trading volumes and relevant emissions factors. Our results indicate that, even with conservative assumptions, the emissions savings from paperless trade implementation can be very significant. At the global level, they are equivalent to planting at least a billion trees, driven especially by efficiency gains from handling data digitally. Still, the savings from trade digitization pale in comparison to the emissions from transport in international

[13] For example, with the use of tools like our Excel emissions calculator.

supply chains. For digitization to have unambiguous environmental benefits, it must be accompanied by a decarbonization of transport.

Our estimates are subject to significant limitations stemming from the difficulty of characterizing a representative trade transaction and data limitations. We hope that both our findings and their shortfalls provide direction for future research on the environmental consequences of trade facilitation.

7. References

Amon-Tran I., Anayath R., Pai A. S., Kamath N., Shenoy S., Harikrishnan A. (2012). "An Approach to Minimize Carbon Footprint for an Environmental Friendly Printing by Optimizing an Offset Machine in a Printing Facility", Procedia - Social and Behavioural Sciences, Volume 37, Pp. 514-527, ISSN 1877-0428. Accessed February 2021. https://www.sciencedirect.com/science/article/pii/S1877042812007951?via%3Dihub

APEC (2011). "Facilitating Electronic Commerce in APEC: A Case Study of Electronic Certificate of Origin", Asia Pacific Economic Cooperation #211-SE-01.14. Accessed April 2021. https://www.apec.org/Publications/2011/11/Facilitating-Electronic-Commerce-in-APEC-A-Case-Study-of-Electronic-Certificate-of-Origin

BEIS (2020). "Greenhouse gas reporting: conversion factors 2019", GOV.UK. Accessed March 2021. https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2019

Carbon Footprint TM (2020). "Country specific electricity grid greenhouse gas emissions factors", v1.3. Accessed February 2021. https://www.carbonfootprint.com/docs/2020_07_emissions_factors_sources_for_2020_electricity_v1_3.pdf

Cheremisinoff, N. P. (2011). "Chapter 31 - Pollution Management and Responsible Care", Waste: A Handbook for Management, pp. 4087-502, Academic Press, West Virginia, USA. Accessed February 2021. https://www.sciencedirect.com/topics/earth-and-planetary-sciences/emission-factor

Crowther, T.W. et al. (2015). Mapping tree density at global scale. Nature. Vol. 525. Macmillan Publishers, 10 September 2015. https://nature.com

EnergyUseCalculator (2021). "Electricity usage of a Printer". Accessed May 2021. https://energyusecalculator.com/electricity_printer.htm

Environmental Paper Network (2021). "Paper Calculator". Accessed May 2021.https://c.environmentalpaper.org/individual.html

Ericsson (2020). “A quick guide to your digital carbon footprint”, *ericsson.com/industrylab*. Accessed April 2021. https://www.ericsson.com/4907a4/assets/local/reports-papers/consumerlab/reports/2020/ericsson-true-or-false-report-screen.pdf

EuPIA (2008). “EuPIA Annual Report”, CEPE. Accessed February 2021. https://www.eupia.org/fileadmin/FilesAndTradExtx_edm/CEPE_EUPIA.pdf

Ferro, C., Youbi, M. F. M., Georgieva, D. P., Saltane, V., Mugica, I. Z. (2016). “Trade across borders: technology gains in trade facilitation”, *Doing Business 2017, World Bank*. Accessed March 2021. https://www.doingbusiness.org/en/reports/case-studies/2016/tab

GLEC (2021). “Global Logistics Emissions Council Frameworkfor Logistics Emissions Accounting and Reporting”, *Version 2.0, Smart Freight Centre*. Accessed February 2021. https://www.smartfreightcentre.org/en/how-to-implement-items/what-is-glec-framework/58/

InkPedia (2021). “Inkjet Cartridge Volumes and Page Yields”, *InkSell.com, San Antonio, Texas, USA*. Accessed February 2021. https://www.inksell.com/ipd-inkvolumes.html

Lazzari, Z., (2020). “How Many Watts Does a Computer Use?”, *Techwalla*. Accessed March 2021. https://www.techwalla.com/articles/how-many-watts-does-a-computer-use

Lichter, G., Liezenberg, C., Bryant, C., Nienhuis, J. J. (2010). “E-invoicing European Market Guide”, *Euro Banking Area Association, Innopay*, ISBN/EAN978-94-90587-04-8. Accessed March 2021. https://www.abe-eba.eu/media/azure/production/1360/market-guide-on-e-invoicing-2010.pdf

Muñoz-Villamizar A., Velázquez-Martínez J. C., Haro P., Ferrer A., Mariño R. (2021). “The environmental impact of fast shipping ecommerce in inbound logistics operations: A case study in Mexico”, Journal of Cleaner Production, Volume 283, 125400, ISSN 0959-6526. Accessed May 2021. https://www.sciencedirect.com/science/article/pii/S0959652620354469?casa_token=yf36aOYwXHUAAAAA:H8KrxPJaENmt30fKk1O-iRTirn1gqoBqfT-MATpnheJJHilE5mzp8j1TqJmpJjLFst1ZI_GgmaSo

OIC (2017). “Single Window Systems Conceptual Framework and Global Trends and Practices”, *COMCEC Trade Working Group*. Accessed March 2021. http://www.comcec.org/en/wp-content/uploads/2017/03/9-TRD-PRE-2.pdf

Pape, M. (2019). “European Maritime Single Window: Harmonised digital reporting for ships”, *European Parliament Research Service, PE 633.179*. Accessed March 2021. https://www.europarl.europa.eu/RegData/etudes/BRIE/2019/633179/EPRS_BRI(2019)633179_EN.pdf

Schultz, T., Suresh, A. (2018). “Life Cycle Impact Assessment Methodology for Environmental Paper Network Paper Calculator v4.0”, *SCS Global Services Report*. Accessed February 2021. https://c.environmentalpaper.org/pdf/SCS-EPN-PC-Methods.pdf

Shepherd, B. (2014). “Estimating the Benefits of Cross-Border Paperless Trade”, *ESCAP*. Accessed February 2021. https://www.unescap.org/sites/default/d8files/knowledge-products/Benefits%20of%20Cross-Border%20Paperless%20Trade_Apr2019.pdf

SITPRO (2008). “The Cost of Paper in the Supply Chain”, *SITPRO Ltd., London, UK*. Accessed April 2021. https://www.scribd.com/document/146277049/ebk1074#download

Tenhunen, M., Penttinen, E. (2010). “Assessing the Carbon Footprint of Paper vs. Electronic Invoicing”, *ACIS 2010 Proceedings, 95*. Accessed February 2021. https://aisel.aisnet.org/acis2010/95/

Tijan, E., Agatić, A., Jović, M., Aksentijević, S. (2019). "Maritime National Single Window—A Prerequisite for Sustainable Seaport Business" *Sustainability* 11, no. 17: 4570. Accessed April 2021. https://www.mdpi.com/2071-1050/11/17/4570/htm

United Nations/CEFACT (2012). “The Buy-Ship-Pay Reference Models”, *Trade Facilitation Implementation Guide*. Accessed April 2021. http://tfig.unece.org/contents/buy-ship-pay-model.htm

UNNExT (2010). “Best Practice Cases in Single Window Implementation: Case of Singapore’s TradeNet”, *Brief No. 2, Towards a Single Window Trading Environment*. Accessed March 2021. https://www.unescap.org/resources/unnext-

brief-no-2-best-practice-cases-single-window-implementation-case-singapore%E2%80%99s

UNNExT (2012). “Developing a National Single Window for Import, Export and Logistics in Thailand”, *Brief No. 8, Towards a Single Window Trading Environment*. Accessed March 2021. https://www.unescap.org/sites/default/files/brief8.pdf

UNNExT (2021). “Trade Process Analysis Database (TPAD)”. Accessed April 2021. https://unnext.unescap.org/tpad/

Warrington, J. (2021). “Exclusive: Scrapping paper documents could boost UK trade by £25bn”, *Citya.m*. Accessed May 2021. https://www.cityam.com/exclusive-scrapping-paper-documents-could-boost-uk-trade-by-25bn/

World Bank (2021a). “Trading across borders: documents to import (number)”, Doing Business, DB06-15. Accessed May 2021. https://databank.worldbank.org/reports.aspx?source=3001&series=TRD.ACRS.BRDR.DOCS.IMP.NO.DB0615

World Bank (2021b). “Trading across borders: documents to export (number)”, Doing Business, DB06-15. Accessed May 2021. https://databank.worldbank.org/reports.aspx?source=3001&series=TRD.ACRS.BRDR.DOCS.EXPT.NO.DB0615

World Bank (2021c). “Trading across Borders methodology”, Doing Business. Accessed May 2021. https://www.doingbusiness.org/en/methodology/trading-across-borders

WTO (2015). “Estimating the benefits of the Trade Facilitation Agreement” *World Trade Report*. Accessed April 2021. https://www.wto.org/english/res_e/booksp_e/wtr15-2d_e.pdf

The Asia-Pacific Research and Training Network on Trade - ARTNeT - is an open network of research and academic institutions and think-tanks in the Asia-Pacific region. Since its inception, ARTNeT aims to increase the amount of high quality, topical and applied research in the region by harnessing existent research capacity and developing new capacities. ARTNeT also focuses on communicating these research outputs for policymaking in the region including through the ARTNeT Working Paper Series which provide new and policy–relevant research on topics related to trade, investment and development. The views expressed in this publication are those of the authors and do not necessarily reflect the views of the United Nations and ARTNeT secretariat or ARTNeT members.

This and other ARTNeT publications are available from **artnet.unescap.org**

ARTNeTontrade

@ARTNeTontrade

ARTNeT Group

artnetontrade@un.org

ARTNeT Secretariat, United Nations ESCAP
Rajadamnern Nok Avenue
Bangkok 10200, Thailand
Tel: +66(0) 22881410
Fax: +66(0) 22881027