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A conceptual model for networking of carbon markets on distributed ledger technology architecture

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Abstract

In spite of the apparent lack of success of international emission trading under the Kyoto Protocol, numerous jurisdictions are implementing mitigation mechanisms that put a price on carbon, whether by taxing activities that cause release of carbon to the atmosphere, or by creating markets through which the cost of atmospheric release of carbon is internalised to the relevant activities by way of emission trading schemes. These diverse and heterogeneous mechanisms – in particular the emission trading schemes – might achieve greater efficiency, larger scale, and other benefits, were they to be connected. Against this background, this paper sets out a proposal for a conceptual model for the networking of emission trading schemes, built on the architecture of distributed ledger technology. In this way, it is argued, the interconnection of these emission trading schemes might be achieved flexibly, cost effectively and efficiently, while taking account of the requirements for cooperative approaches, evidenced in the Paris Agreement. The purpose of the paper is to stimulate, and provide a starting point for, more detailed, intensive discussion of what the technical requirements might be of some such scheme.

Keywords

Networking, emission trading schemes, distributed ledger technology, blockchain, international transfer, mitigation outcomes, Paris Agreement

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I Introduction

At the Twenty-first Conference of Parties (COP21) to the UN Framework Convention on Climate Change (UNFCCC) in Paris in 2015[1], there was agreement to pursue the goal of limiting global warming due to anthropogenic emissions of greenhouse gases (GHG) to 1.5°C.[2] The current scientific consensus is that global warming is fast approaching this limit already and that, in the absence of significant measures to mitigate emissions, it will soon be exceeded.[3]

Mitigation of GHG emissions means changing behaviour across a range of vectors, thus changing the way many economic activities are carried out and so, it is assumed, their effects. Imposing a climate-change related price on atmospheric carbon is one way to do this, whether by taxing activities which generate atmospheric release of carbon, or (in conjunction with environmental regulation) by creating a market by means of which the environmental cost of atmospheric carbon becomes internalised in the relevant economic activities by way of emissions trading schemes (ETSs).[4]

Previously, the Kyoto Protocol[5] attempted to create such a GHG emissions trading market on a top-down basis, that is, through a supranational body (the Conference of Parties (COP)

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Please Note: Table of Abbreviations at end of the text.

1 FCCC/CP/2015/10/Add.1, at: http://unfccc.int/resource/docs/2015/cop21/eng/10a01.pdf

2 Article 2, paragraph 1(a), Paris Agreement.

3 *"Without additional efforts to reduce GHG emissions beyond those in place today, global emissions growth is expected to persist, driven by growth in global population and economic activities. Global mean surface temperature increases in 2100 in baseline scenarios—those without additional mitigation—range from 3.7°C to 4.8°C above the average for 1850–1900 for a median climate response. They range from 2.5°C to 7.8°C when including climate uncertainty (5th to 95th percentile range) (high confidence)."* 3.4 Characteristics of mitigation pathways, IPCC Climate Change 2014 Synthesis Report Summary for Policymakers, at: http://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf; see also, for example, World Meteorological Organization Greenhouse Gas Bulletin (GHG Bulletin) No.12: The State of Greenhouse Gases in the Atmosphere Based on Global Observations through 2015.

4 There is an extensive body of academic literature on tradable permit schemes and emissions trading. A useful review of the origins is provided in: Cédric Philibert and Julia Reinaud (2004) 'EMISSIONS TRADING: TAKING STOCK AND LOOKING FORWARD' COM/ENV/EPOC/IEA/SL T(2004)3 OECD ENVIRONMENT DIRECTORATE/ INTERNATIONAL ENERGY AGENCY.

5 FCCC/CP/1997/L.7/Add.1, 10 December 1997, at: http://unfccc.int/resource/docs/cop3/l07a01.pdf

to the UNFCCC, acting as the Meeting of Parties (MOP) to the Kyoto Protocol) policing[6] the emissions limits to which signatory states had committed themselves. For a number of reasons this has been unsuccessful.[7] Nevertheless, numerous jurisdictions – regional (the European Union), national and sub-national (provincial, municipal, city) – have implemented mitigation mechanisms that put a price on the release of GHGs to the atmosphere (a 'carbon price').[8]

Such diverse mechanisms, although reflecting local preferences, are fragmented and heterogeneous; differences in design, implementation and standards detract from their effectiveness. Greater efficiency and larger scale might be achieved if these schemes were interconnected, so as to generate a more globally consistent and stable carbon price, making such measures more attractive to investors, in order that markets: achieve greater liquidity, more depth and better price discovery; are more effective in changing the behaviour of emitters; reduce the risk of carbon leakage; and, as a whole, are more encouraging of investment in climate-related projects.

There has been discussion of how various jurisdictions' ETSs might be better linked to one another,[9] but there are few instances where such linking has actually taken place.[10] In order to establish useful links, however, such diverse jurisdictions may need to adapt to each other, even to converge, and linking processes, where they occur, will probably (perhaps inevitably) favour the economically larger of the linked jurisdictions. In addition, jurisdictional economies and emissions profiles will not necessarily remain static relative to one another, leading also to potential difficulties for linked jurisdictions in the future.

The Paris Agreement offers encouragement for international trading by recognising that signatory parties (the "Parties") may engage voluntarily in cooperative approaches involving the use of internationally transferred mitigation outcomes (ITMOs) towards their Nationally

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[6] Through the Compliance Committee: Decision 27/CMP.1, FCCC/KP/CMP/2005/8/Add.3; the objective of the procedures and mechanisms under which the Compliance Committee is established are: *"to facilitate, promote and enforce compliance with the commitments under the Protocol."*

[7] These reasons include: the withdrawal from the Kyoto Protocol of the world's largest emitter at the time, the United States; the non-inclusion of major emitter developing economies such as China, India and Brazil; the issue over 'hot air' allocations to economies in transition (EIT) in the wake of the collapse of the Iron Curtain country economies; inflexibility of the legal regime (e.g., re Kazakhstan joining); over-allocation, especially in the context of declining economic activity after the global financial crisis; over-supply from project credit mechanisms, especially certified emissions reductions in the EUETS.

[8] See, e.g.: World Bank, 2016, State and Trends of Carbon Pricing 2016, Washington DC, World Bank (and earlier annual publications) https://openknowledge.worldbank.org/handle/10986/25160; and International Carbon Action Partnership (ICAP), Emissions Trading Worldwide Status Report 2016 (and earlier annual publications) www.icapcarbonaction.com

[9] For a summary of academic research and issues relating to linking emissions trading schemes, see: Kachi, A, Unger, C, Boehm, N, Stelmakh, K, Haug, C, Frerk, M (January 2015) Linking Emissions Trading Systems: A Summary of Current Research, ICAP, accessed 6/9/16, at: https://icapcarbonaction.com/en/?option=com_attach&task=download&id=241

[10] The linking arrangement between the ETSs of the US state of California and the Canadian province of Quebec stands out as the only significant example to date.

Determined Contributions (NDCs).[11] Such engagement by the Parties should promote sustainable development, ensure environmental integrity and transparency, including in governance, and apply robust accounting, in particular to ensure the avoidance of the double counting of emission reductions.[12]

An alternative to the linking of jurisdictions with one another is the less rigid approach of networking, which does not require of jurisdictions that they aim for increased homogeneity. The networking of carbon markets (that is, of ETSs) takes as a given that ETSs in various jurisdictions[13] are diverse and heterogeneous, having differences in design, implementation and standards that make them difficult to align with one another. The jurisdictions from which they originate may also differ from each other in many respects, including economically, institutionally and legally. Such areas of difference between jurisdictions and economies will be dynamic,[14] thereby indicating a necessity also to re-evaluate them periodically relative to one another.

Networking is based on the idea that the ETSs, designed and implemented to achieve the mitigation of GHG emissions to the atmosphere, will have mitigation outcomes upon which it is possible to place a measurable value. How such a mitigation value (MV) is arrived at, while integral to the concept of a networked carbon market (NCM), is not the focus of the model presented here: for present purposes, it is assumed that there is (or can be) a methodology for determining such MV, as an expression of the effective mitigation of the emission entitlement unit traded in the ETS of a given jurisdiction.[15]

Furthermore, the construct of an NCM proceeds on the basis of recognizing and valuing the differences, rather than by trying to make jurisdictions adapt their ETSs to one another, so as to align and converge with one another. By establishing a measure of the value of the respective ETS mitigation outcomes of divergent jurisdictions, MV can be used to derive conversion/ exchange/discount rates (or ratios) between the differing ETSs, thereby facilitating trade among or between such regional, national or local schemes.[16]

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[11] Article 6, paragraph 2, Paris Agreement.

[12] Ibid.

[13] A "jurisdiction" for present purposes would normally conform with the usual (English) language sense of the term, that is a geographical unit in the form of a "state", and the assumption is that any ETS is based on a legislative-administrative framework. A jurisdiction, though, could be, for instance, a state/province/region within a (quasi-) federal system, just as much as a unitary or federal (national) state. Depending on the nature of the ETS there may be other possible variations, e.g. one established by a (large) metropolitan unit, or one in which a coalition of sovereign states has its own fully integrated (and thus "internal") ETS (as presently within the EU).

[14] E.g., different rates of economic growth, differences and changes in industrial and other economic policies.

[15] Based on the emission entitlement units in all participating jurisdictions being normalized to a value of one metric tonne carbon dioxide equivalent gas (1t CO_2-eq).

[16] As to Networked Carbon Markets more generally, see: Macinante, Justin (2016) Networking Carbon Markets: Key Elements of the Process, World Bank https://openknowledge.worldbank.org/handle/10986/25750

This short paper sets out a proposal for a specific conceptual model for the networking of ETSs, built on the architecture of distributed ledger technology (DLT, also referred to as 'blockchain'). The discussion of such a model of a distributed network addresses here, in particular, the following issues:

i) beginnings;
ii) alternative approaches to transaction mechanisms;
iii) institutions and information technology (IT) architecture;
iv) smart contracts;
v) participants; and
vi) legal, market and other issues.

The purpose of proposing this particular conceptual model is to stimulate, and provide a starting point for, more detailed and intensive discussion of the technical requirements of some such scheme. Because of its very specific constructional nature, the proposal is accompanied by a brief description of DLT itself and its modus operandi (set out in the Annexure to this paper).

The proposal for the model put forward here addresses some of the components that are considered as constituting the skeleton on, and around which, the architectural flesh of market IT infrastructure could grow and be moulded. The proposal should be seen as an initial step towards assessing the viability of some such approach, without attempting to suggest a final determinative shape.

II Beginnings

There is, at present, no such trading network of ETSs as that proposed here. Thus the first issue is, how such a network of ETSs might actually come into being. Although this is necessarily a hypothetical question involving rather speculative conclusions, there are at least plausible responses that can be suggested to this essential initial concern.

A Global agreement

On the one hand, the likelihood an NCM would spontaneously or automatically come into existence as part of a multilateral agreement is virtually zero. On the other hand, however, the Paris Agreement has provided an international law framework within which an NCM could well be established and developed. Important elements agreed upon by the Parties – ambition, transparency, robust accounting, environmental integrity, cooperative approaches – are all compatible with and could be convincingly addressed by the NCM approach, as will become evident from the model outlined.

B Bilateral, multilateral linking and clubs

Academic writers describe possible scenarios of how jurisdictions might link with each other bilaterally, or perhaps multilaterally, on the basis of shared values, comparable ambition, similar economic profiles, or simply because their respective ETSs can be relatively easily

aligned with one another.[17] These scenarios may come to be realized but, on the evidence of the linking between jurisdictions thus far, they are, at the very least, likely to require years of patient negotiation and face potential political hurdles not only up to the point of their initial establishment, but also subsequently. In most cases, whether bilateral or multilateral, there would be one jurisdiction whose economy is larger than that of the other(s), and thus more likely to be favoured by the terms on which any linking would occur. Further, economies are dynamic and likely to change relative to one another over time, including in relation to their respective emissions profiles. Also, as the Paris Agreement provides for the Parties to take cooperative approaches, the linking agreements would probably need to provide for the possibility of eventual de-linking, should cooperation in fact cease.

Thus, while bilateral or multilateral linking, or the formation of comparable clubs, are possible pathways for the international transfer of, and trade in, mitigation outcomes to commence, they are unlikely to be followed in the short-term; the same would probably also be the fate of the NCM. International negotiations take considerable time and no participating jurisdiction can be assured of achieving fully the outcome it desires.

C Organically, demand driven, public-private arrangements

More viable would be a system with sufficient flexibility to allow jurisdictions (including Paris Agreement Parties) to participate – or not – in international transfers (i.e., trading) of mitigation outcomes, depending on their perception of what best suits their domestic situation and requirements existing at any particular time. Joining or departing from such a system could, though, clearly not occur completely spontaneously or instantaneously but, subject to a Party satisfying the rules applicable, should ideally be available within a relatively short timeframe (say, weeks or months, rather than years). How might such a flexible system be achieved?

Firstly, there would be a need, above all, for transparent and binding rules, established from the beginning. In other words, jurisdictions proposing to join would need to be able to understand fully the extent and nature of their commitments. A jurisdiction might, then, decide to join the distributed network having identified an immediate and/or specific economic, political, or environmental benefit[18] (or a combination of these) to be derived from allowing economic actors within its own ETS to participate in a bigger international market.

Secondly, one particular jurisdiction could alone set up such a market, one which, though, would not be (inter-jurisdictionally) 'networked' until actors from a second jurisdiction began trading with those of the first. Nevertheless, the actors interacting within the initial jurisdiction (and already complying with the rules and framework of that initial market) could, therefore, already be trading via a DLT structure based on rules which would be universally applicable across any NCM (rules such as those outlined below), and thus

[17] Fn. 9 supra.

[18] E.g., better price disclosure, more stable carbon price.

effectively using a "distributed" network. While still only infra-jurisdictional, however, the MV-element (and its applicability to determining inter-jurisdictional conversion rates) would not yet be relevant. Nevertheless, the infrastructure – methodologies, standards and institutions – required to implement conversion rates based on MVs could exist, and even be operational. Who might establish and/or administer a system of MV assessments and conversion rates, and how it might be done, is explored[19] in Section IV below.

Thus, the conceptual model proposed here envisages that the application of DLT as the basis for an emissions market could begin in a single (founding) jurisdiction. It is noted that, as a leader-by-example, such a jurisdiction would not expose itself to any external risk simply by employing DLT as the basis for its domestic ETS. Rather, it (or more precisely, the entities trading in its ETS) in any case would derive all the benefits that could be expected from doing so (e.g., the first mover advantage through early understanding and implementation of the rules and practices involved). Other jurisdictions, joining later, would then simply be able to become participants by agreeing to the rules applying in the original market and then by implementing them.

A further necessary and constitutive element of such a distributed network would be the ability to account for jurisdictions joining (that is, opting in) or leaving (opting out), while maintaining, or avoiding any negative impact on, the integrity of the distributed ledger in relation to the existing (or remaining) participant jurisdictions. For example, since the ledger is accumulative, it would need to recognize the departure of a participant jurisdiction in such a way as to block trading on the network by the accounts of entities authorized by that jurisdiction at that point in time. Those entities would continue to be able to trade, but only within the ETS in their own jurisdiction, and no longer in the networked market. Similarly, the ledger would need to reflect the state of the departing jurisdiction's domestic registry at the moment of departure.

III Alternative approaches to transaction mechanisms

A Direct transfers of units across jurisdictional boundaries

Transactions in ETSs involve exchanges of emission entitlement units between counterparties,[20] implying transfers between their registry accounts. Where a transaction takes place within a single jurisdiction, the transfer would be of the relevant transacted amount of emission entitlement units (EEUs)[21] within the ETS concerned, in exchange for a money payment.

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[19] This is explored only superficially, as the purpose of this conceptual model is to provide a basis for examining the feasibility of the IT architecture, rather than the climate change conceptual elements of NCM. The assumption is, for the purposes of this model, that there will be MV values and that these can be used to derive ratios, or conversion rates, between the units traded in each participating jurisdiction.

[20] These entities might be entities with compliance obligations under the ETS ("compliance entities"), or market makers, or other traders authorised to engage in transactions under that ETS.

[21] In terms of this being a cap-and-trade, these could also referred to as "allowances", or in the context of international transfers, as "mitigation outcomes" (or units thereof), or in terms of this being a financial market,

The same transaction between counterparties in two different jurisdictions involves the movement of EEUs from one jurisdiction (that is, in accounting terms, from the ETS registry in that jurisdiction) to the (registry of the) second jurisdiction, and the corresponding currency transfer in the opposite direction. This assumes above all that the second jurisdiction would admit those EEUs to its registry.[22] If the two jurisdictions have fully aligned their respective ETSs, then the transferred EEUs can be expected to be accorded the same value as those within the domestic framework (or at least a value agreed as part of the alignment process). If not, there would be a need, upon transfer, for the administrator of the recipient ETS to place a value on them.[23]

In the proposed networked context, the two jurisdictions would in fact have MVs that would translate into a conversion rate for the transferred EEUs, as between themselves (comparable, for example, with currency exchange rates). In effecting the transaction, the EEUs from the first jurisdiction would be accorded a value based on the conversion rate applicable at the time of being recorded in the registry of the second jurisdiction. In practical terms, though, it might be more likely that, on settlement, the EEUs in the first jurisdiction registry would in fact be cancelled, and the equivalent value (based on the conversion rate of the receiving jurisdiction's EEUs) credited in the receiving jurisdiction's registry.

B Transaction units

An alternative to the movements of EEUs from one jurisdiction to another (as above) would be to have instead, for certain reasons, a 'transaction unit' (TU)[24] (see further below). In terms of the mechanics of a transaction and transfer, the first (*transferring*) jurisdiction would convert its units into TUs (at the applicable rate),[25] following which, the buyer having purchased them, the *receiving* jurisdiction would convert the TUs concerned into its domestic ETS units (at the rate applicable).[26]

Transaction units could be based on an index, for example the weighted average of MVs for all participating jurisdictions. It is not necessary, though, to propose here the conclusive basis upon which such TUs might be founded, but simply to note that conversions into and out of TUs would, ideally, be steps in the transactional process, especially once the distributed network went beyond two participant jurisdictions. Properly understood, and for the purpose of this conceptual model, the TU serves as the medium of exchange (e.g., on

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as "carbon assets" (or units thereof); however, for the sake of simplicity, they are referred to in this paper just as 'EEUs'.

[22] This question in itself creates a number of administrative complications, which are noted, but not delved into, for the purpose of setting out this model.

[23] If this were to be the case, it is unlikely the transaction would proceed, as the uncertainty risk, most likely, would be unacceptable to the buyer.

[24] The role of such a transaction unit would be analogous to the role played by the US$ in foreign exchange currency transactions.

[25] The transferring jurisdiction's units would be cancelled when the transaction units are created.

[26] The transaction units would be cancelled when the receiving jurisdiction's units are created and credited in its registry.

the basis of an index, as mentioned, reflecting a compilation of conversion rates for jurisdiction-based MVs).[27]

C Reasons for using transaction units

The interposition of TUs as a medium of exchange is proposed for the following reasons:

- reduction of the number of conversion rates needed within a multilateral system; for example, in an NCM of five jurisdictions, there would be ten MV conversion rates (whereas, using a TU, there would be only five);[28]
- the advantage of fewer, larger and more liquid markets with fewer mitigation outcome asset (unit) balances;
- reduction of the informational needs of participating jurisdictions and trading entities, thereby fostering simpler and cheaper operation;
- faster and more efficient networking transactions, and reduction of both scope for error and capacity for manipulation and fraud; and
- generally reduced administration and transaction costs across the system.

Being only a medium of exchange, the TU should not necessitate a settlement platform being interposed between transacting parties. Transactions could still proceed peer-to-peer, the seller converting its (local) units into their equivalent in TUs to be taken by the buyer, which would convert them, in turn, into its domestic units.[29]

IV Institutions and IT architecture

Before elaborating on the transaction mechanism and on rules that could apply (in the form of so called "smart contracts")[30], it is useful firstly to consider the broader institutional framework of governance applicable to the transactions and the associated smart contracts.

A Setting and changing the rules

Who should set the rules of a networked carbon market? If the market starts on a basis such as that suggested above, namely domestically within a single jurisdiction relying on DLT, then clearly that jurisdiction would set the rules initially applicable.[31] This might seem to offer a first mover advantage, which itself might trigger strategic behaviour between various (international) actors. However, it should be expected that such rules would be simple, operational ones, and so neutral in terms of potential jurisdictional impact, not offering a strategic advantage to the first state which implements them. Additionally, the rules should include a "rule-immutability rule" (i.e. a form of entrenchment): once set, they should, in

[27] In reality, the transaction unit might also have other purposes, e.g., as an investment vehicle in its own right, or as a store of value.

[28] With ten participant jurisdictions, there would be 45 exchanges rates (as opposed to ten, with a TU); if the remaining thirty participant jurisdictions in the EUETS (assuming the UK leaves) were to operate on this basis, there would be 435 exchange rates (as opposed to 30, with a TU).

[29] This could proceed via a platform for converting, settling and clearing if, for instance, the transaction units were stores of value/investment vehicles in their own right.

[30] See infra Section V.

[31] In fact, a set of standard rules is proposed as part of this conceptual model.

fact, remain unchanged unless unworkable or have unexpected or previously undisclosed (perverse) environmental or economic impacts. In this way, a predictable framework would be provided for jurisdictions joining subsequently.

Notwithstanding the 'rule-immutability rule', there would inevitably be a need for a review and amendment mechanism. While the details of such a mechanism are not essential for the broad conceptual presentation here, it should not be overlooked as, in fact, an essential component. Such a mechanism might typically be subject to the joint authority of the participating jurisdictions and involve decision-making relying on a qualified-majority voting rule of some kind. Dissatisfaction with the outcome of such decisions could, given the basic flexibility for joining and leaving referred to at the outset, find its ultimate expression in departure of a dissatisfied jurisdiction from the distributed network.

1 An overriding supervisory body

Bearing in mind that the model, transactions, and market being discussed in this paper are designed principally to give effect to the international transfer of mitigation outcomes (as understood in the terms of the Paris Agreement), ultimately the overriding supervisory body would have to be, or need to operate in conjunction with, the Parties to the Agreement (CMA).[32] Given the nature of the proposed networked market as a financial market, there should be an institutional relationship between the CMA (or at least one of its subsidiary bodies) and an overriding international financial regulatory body. However, neither the exact nature of this relationship nor the determination of the (sub-)bodies involved, needs to be addressed further here.

2 Determining mitigation values

Within the suggested scheme there would be a need for both (1) a structured and consistent process and/or set of rules, and (2) a governance structure, for the determining of mitigation values (MVs). The governance structure should be ultimately answerable to the overriding body mentioned above. Again, though, it is not necessary to address this further for the purpose of outlining this conceptual model, but merely to foreshadow this as an issue ultimately requiring attention.[33] Nevertheless, it would be helpful to note two possible methods of determination of MVs and consequent conversion rates.

Broadly, MVs could be quoted, relative to the TU (thereby providing the conversion rate) by:

- either a number of private sector organisations (analogous, perhaps, to credit rating agencies) accredited to assess or determine MVs on the basis of approved methodologies (subject to authorisation and/or supervision by a regulatory authority established subject to the ultimate overriding supervisory institution of the distributed network);
- or a public institution is set up by the distributed network's overriding body.

[32] The Conference of Parties to the Convention serving as the Meeting of Parties to the Paris Agreement.
[33] See generally: Macinante, fn. 16 supra.

Which of such alternatives might be preferable, or any other possible methodological approaches, and for what reasons, would no doubt be subject to considerable debate.

3 Determination of price

What buyers are willing to pay would be, ultimately, for the market to determine. Nevertheless, one should observe, for a certain completeness, that such market-generated prices would be themselves subject to often important influences. The degree of enterprise concentration in a given jurisdiction, the nature of the resources (including non-fossil energy resources) and resource markets and their prices, the stringency of climate-protective emissions standards, the effectiveness of the national enforcement of emission standards, the ulterior strengths and weaknesses of national/jurisdictional economies, and the stringency of national and/or regional competition law are among factors which may all exert substantial influence.

These and other such factors are likely to feature to some degree or other in the determining of MVs for any given jurisdiction. Prices for EEUs should, ultimately, correlate with MVs. It is noted, however, that prices will also be affected by market factors such as supply and demand, market liquidity and depth, as well as the marginal cost (in a given jurisdiction) of the actual mitigation of emissions by an entity, as opposed to that entity buying mitigation outcomes in order to acquit its compliance obligations (marginal abatement cost). None of the matters can, at this early stage in the development of such a model, be properly considered, but one should not lose sight of them as such a system takes more detailed shape.

4 Funding the costs

The jurisdiction that initially establishes a scheme, such as that proposed here, would fund its own costs of the domestic implementing and application of DLT architecture to emissions trading. Each additional participant jurisdiction would be obliged to meet the cost of expanding the system to accommodate their participation, and to share in covering any joint fixed and running costs of the system. Upon joining, participant jurisdictions would be required, in case they later choose to leave, to provide security for their share of the costs while participating.[34] While there are a number of options[35] for achieving this, what form such security might take is not considered in this paper.

B Settlement of transactions

1 Centralised settlement

While centralised settlement would, to an extent (and at least symbolically), run counter to the underlying ideas of the distributed IT architecture, it is conceivable that it might nevertheless be included in the structure if the TU became an investment vehicle in its own

[34] The security would include cover also for any costs arising as a result of their decision to leave the networked ledger.

[35] These might include, e.g., security over assets in the form of International Monetary Fund (IMF) Special Drawing Rights (SDRs).

right. However, for the purpose of the outlining the model here, it is proposed that settlement (with the TU as just the medium of exchange) be peer-to-peer, rather than via a centralised instance.

2 Peer-to-peer settlement

The rules of the smart contract (see below) would provide for settlement of transactions directly between the counterparties to a transaction. This might be interpreted as the networked market in EEUs being entirely over-the-counter (OTC), which could be seen as running contrary to the direction taken by financial regulators since the global financial crisis of 2008.[36] However, in spite of a transaction being peer-to-peer, the fact that it occurs through a 'permissioned' distributed ledger[37] may suggest an alternative interpretation.

In addition, counterparties from different participating networked jurisdictions would need a means of signifying the EEUs which they wished to sell or buy. This necessity points to a requirement for some form of listing, which might include both the quantity and the jurisdiction(s) of units offered or sought, as the case may be, as well as the prevailing conversion rates between EEUs of participating jurisdictions and the TU.

The fact that participants would be conducting transactions on a permissioned ledger, the necessity of some form of listing arrangement, and the permanent immutable nature of the record of transactions on the distributed ledger would appear to negate potential claims that transactions settled peer-to-peer should be categorized as OTC.

C Ownership, management, operation and maintenance of the distributed network

A participant jurisdiction would own, manage and be responsible for that part of the distributed network operated within its geographical boundaries. To the extent that the distributed network, or some element of it, is in some way outside jurisdictional boundaries (i.e., to be regarded as international or supranational), for instance the IT infrastructure such as internet connections located outside individual jurisdictional boundaries, the participating jurisdictions would need to carry joint responsibility for operation and maintenance, and bear the costs of this collectively.[38]

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[36] E.g., see: European Market Infrastructure Regulation (EMIR) **Regulation (EU) No 648/2012 of the European Parliament and of the Council of 4 July 2012 on OTC derivatives, central counterparties and trade repositories.** In September 2009, at the G-20 Pittsburgh Summit, the leaders of the 19 biggest economies in the world and the European Union agreed that "all standard OTC derivative contracts should be traded on exchanges or electronic trading platforms, where appropriate, and cleared through central counterparties by end-2012 at the latest." Furthermore, they acknowledged that "OTC derivative contracts should be reported to trade repositories and that non-centrally cleared contracts should be subject to higher capital requirements." European Commission Press Release Database, Brussels, 29 March 2012, http://europa.eu/rapid/press-release_MEMO-12-232_en.htm

[37] The concept of 'permissioning', or 'permissioned versus permissionless' networks in DLT, is described in Section V and the Annexure.

[38] This would probably necessitate the existence of a service entity (company) collectively owned by the participating jurisdictions, although much of the extra-jurisdictional network would simply be the internet.

D Review, reporting and accountability

Each participating jurisdiction would continue to be accountable for its own ETS, including the operation and integrity of its registry. In fact, without a properly functioning local ETS it would be impossible for a jurisdiction to participate in the distributed network at all. However, the jurisdictional registries would also be part of the distributed ledger network, which itself would in turn facilitate their record keeping, accounting, audit, and reporting. The inclusion of TUs in this process, as proposed above, would facilitate the auditing of registries (which constitute the distributed ledger as such). Participating jurisdictions would collectively be accountable for the network overall, that is, the market between their domestic ETSs, including in regard to reporting obligations vis-à-vis the overriding supervisory body.

E IT architecture

The distributed ledger should have the capability of adapting to the joining by a new jurisdiction (and all associated entities authorized to trade on that jurisdiction's ETS) and to a jurisdiction's departure from the network. The use of the TU is integral to this adaptability. Each individual participating ETS (that is, its registry as its component of the overall distributed ledger) would record all the transactions settled in the network, the precise function of the distributed ledger. However, a registry's account balances, that is, both those of the individual entities from a particular participant jurisdiction and the total balance for that jurisdiction, would need to be separately recorded in that jurisdiction's registry.

At the moment that an ETS first opts into the distributed network, the holdings (of its domestic units) as recorded in its registry would become identifiable by the other jurisdictional participants and, from that moment, be operable upon in the course of transactions with entities from any other participant jurisdictions.[39] Equally, the holdings on a domestic register would be inoperable via the distributed ledger at the moment a jurisdiction signifies that it has resolved to leave the network.

On the basis proposed in this paper, each transaction added to the blockchain should record only deletions of domestic units (from a seller's account) and corresponding additions of domestic units (to a buyer's account), the TU interposed in the transaction being solely mechanistic (and thus netted out in the transaction). In other words, the fact that TUs are used to facilitate the transaction would not need to be recorded as a material element on the record of the transaction. The transaction in its entirety would be expected to take a form involving the following steps (where J = jurisdiction):

1) seller A converts 'n' number of 'J_A'-EEUs into 't' number of TUs
2) buyer B converts 't' number of TUs into 'm' number of 'J_B'-EEUs
3) B pays A the price of 'c' (in relevant currency, as agreed by A and B).

[39] This would be subject to the application of the trading rules and permissioning, as set out in Section V.

4) the blockchain (the distributed ledger) records the transaction as: (n x J_A-EEUs) purchased and converted to (m x J_B-EEUs) for price of 'c'.

V Smart contracts

A "smart contract" is a term of art now used commonly in relation to DLT applications. It refers to transactional terms and conditions embedded in computer code which allow automatic execution of the relevant transaction once precise conformity with those terms and conditions has been established. This section elaborates on what might be included in those transactional terms for the purposes of the NCM proposed here.

A Terms and conditions as code

Each market participant (that is, trading entities within each jurisdictional ETS) would be associated with, and gain access to, the distributed ledger through a participant jurisdiction and the individual entity's link with that jurisdiction's domestic register.[40] Each participant jurisdiction would be the operator of a domestic ETS and would thus (1) maintain a registry for that purpose, and (2) impose 'rules' on the participants within its own ETS. The rules that relate to transactions between and across ETSs in the networked market would themselves be part of an overarching code governing the terms and conditions of the contracts between counterparties. The rules of that code applicable to, and within, the distributed network would need to operate on two distinct levels, as set out in the following sub-sections 1 and 2.[41]

1 Rules governing jurisdictional participation and market operation

In order for the distributed network to create the framework for an emissions trading market that conforms with international (and national) climate change policy, certain fundamental rules and principles are of critical importance. These would include:

a) a condition that, in all transactions, **environmental integrity** be protected and preserved, that is, not compromised or reduced;[42] in other words, participation in the distributed market network must always contribute to a reduction in

[40] Some, such as international traders or market makers, may be associated with multiple jurisdictions; but in the context of any particular transaction, they will only be associated with one – the one where they have a registry account to or from which units will be moved for the purpose of that specific transaction.

[41] It is noted that participating jurisdictions would, at all times, retain jurisdictional control over the entities authorized by them to trade – including trading on the NCM. Hence, in the circumstance of incompatibility between the rules of a participating jurisdiction and the trading rules of the NCM, the entity would be obliged to follow the rules of its domestic jurisdiction. However, given the fact that jurisdictions, when opting to join, can decide the basis on which they authorize their entities to participate (e.g. any limits or boundaries that apply), the likelihood of such a situation of incompatibility, between rules of a jurisdiction and NCM trading rules, arising is considered remote.

[42] Such a rule is clearly necessary, and its enforcement a high priority, given the fact that international emissions trading, despite its potential advantages for environmental policy together with satisfying the demands of economic and business efficiency, is also subject to moral hazard.

greenhouse gas emissions for both jurisdictions with which the counterparties to a transaction are connected, and for the networked market overall;[43]

b) the application of the **supplementarity principle**,[44] dictating that not more than, say, 49% of the units held on a domestic ETS registry may be sourced from the international market (i.e., from sources outside the particular jurisdiction), although individual jurisdictions might be free to set limits even lower than this (which would then be enforced through smart contract code terms applicable to entities from that jurisdiction);
c) the requirement that any individual trading actor (in effect, a trading entity within a given participant jurisdiction's ETS) retain a **compliance reserve** of, say, 75% of its emissions-related obligations; it is noted that Parties in Annex B under the Kyoto Protocol had compliance reserve commitments under the rules for international emissions trading; (following a principle of economic/compliance risk management comparable with, for instance, the minimum capital deposits of banking institutions);
d) the application of an **automatic and immediate block** on all transactions involving entities from a jurisdiction, where that jurisdiction indicates an intention to withdraw from the distributed network;
e) the application by a jurisdiction of **national rules of acceptance/exclusion** prescribing conversion rate limits in regard to other jurisdictions with which it is willing to permit entities authorised by it to trade; for example, a refusal to permit transactions with a jurisdiction whose MV is below (or above) a specified level, or (whose MV) is outside a specified range;
f) upon a jurisdiction joining the distributed network, the **provision and maintenance of a surety** in respect of its contribution to joint network costs, to be forfeited, for instance, if the jurisdiction were to withdraw without proper notice; transaction rules would correspondingly block transactions by entities from any jurisdiction not providing an adequate surety;
g) the possibility of **jurisdictional adjustment of trading maxima or minima** under rules (b) and (c) (by respectively lowering or raising the figure) as they apply to a given jurisdiction's own compliance entities (i.e., traders within its own national ETS), for the purpose of managing domestic market activity; and

[43] Implementing this rule will have implications for how MV applies to transactions; so in terms of the smart contract terms and conditions, it can be parked as part of the MV component: e.g., the smart contract might operate to automatically block any transaction which, by application of the conversion rate, will result in a greater number of emission units than existed before the transaction: see also Macinante, fn.16 supra.

[44] The supplementarity principle as stated for the purposes of the Kyoto Protocol is that '… *the use of the mechanisms* [International Emissions Trading, CDM, JI] *shall be supplemental to domestic action and that domestic action shall thus constitute a significant effort made by each Party included in Annex I to meet its quantified emission limitation and reduction commitments under Article 3, Paragraph 1*.' (Article 1 Draft Decision -/CMP.1 (Mechanisms) contained in Decision 15/CP.7, Marrakech Accords). The 49% figure is proposed here for the purposes of indicating application of the principle in this context.

h) for those rules allowing for jurisdictions to make **adjustments** vis-à-vis trading activity of entities authorised by them (e.g., rules (b) and (c) above), an appropriate notification procedure would need to apply.

2 Examples of rules for transactions

Trading within the market established through the distributed network could be possible only where the individual actors (traders) face a minimum set of standardised rules or principles. These should include at least the following:

a) the seller must in fact hold **the trading units offered** for sale, evidenced by a registry/ledger entry;[45] this requirement might be satisfied by the seller's ability to convert the units offered into TUs;
b) the buyer must **hold the funds necessary** to complete the transaction, evidenced by bank records, automated bank confirmation, or deposit of the requisite amount into an account accessible to the seller on settlement;[46]
c) **automatic application of the conversion/discount rate** between the jurisdictions concerned applicable at the time of the transaction or, in the case of TUs as proposed here, conversion by the seller of its trading units into TUs (at the applicable rate), and, upon the price money being available/transferred, the conversion of the TUs into the buyer's domestic units (at the applicable rate) and the transfer of these to the buyer's account in its ETS registry; and
d) on settlement, as per (c), **updating of all copies of the ledger**.

3 Contracts as 'atomic' transactions

The smart contract would operate on the basis that, if any term or condition essential for such a transaction is not met, the transaction would not proceed. Thus, where all such requirements are not satisfied within some predetermined period (say, within 24 hours of the initiation of the transaction), the transaction would fail and lapse.

Essential terms and conditions would typically include the following information and specifications:

- name and jurisdiction of seller;
- domestic authorization, satisfactory KYC[47] and AML[48] checks on seller;
- name and jurisdiction of buyer;
- domestic authorization, satisfactory KYC and AML checks on buyer;
- certification or proof that the transaction is accepted as not negatively impacting upon environmental integrity;[49]

[45] In other words, there would be no scope for short-selling.
[46] An alternative would be that the smart contract would not permit the transfer of the transaction units from seller to buyer until the money was either available for or, in fact, had been transferred to the seller's bank account.
[47] Know-your-customer.
[48] Anti-money laundering.
[49] As noted earlier, most likely this would need to be part of the MV setting process.

- certification that the transaction would not cause the buyer's jurisdiction to breach the supplementarity principle (noting that either jurisdiction may have the level set lower than maximum applicable in the distributed system as a whole);
- certification that the transaction would not cause either the seller or the seller's jurisdiction to breach the compliance reserve (noting that the level may have been set higher than the minimum required for the distributed system as a whole);
- that the conversion rate is acceptable to the buyer's jurisdiction;
- that both jurisdictions have provided and maintain an acceptable surety in regard to their financial obligations towards the operation of the distributed network;
- confirmation that the seller holds and is entitled to sell the EEUs offered for sale;
- confirmation that buyer has funds to complete transaction; and
- the application of the correct conversion rate between jurisdictions or, for TUs, between each jurisdiction and a TU.

Once all such terms and conditions are satisfied, the transaction would proceed automatically and irreversibly.

B Permissioning[50]

The expression 'permissioning' is a term of art used in connection with the distinction between networks in DLT that are 'permissioned', as opposed to those that are 'permissionless'. The latter are open networks that anyone (individual, corporation, etc.) can join, relying on 'proof of work' tasks for the purpose of validating transactions to be added to the distributed ledger (or blockchain). Permissioned networks are usually privately owned, or at least set up by collaboration of parties, so that only trusted or vetted participants can participate in control and maintenance.[51]

The network proposed here in this conceptual model is a private (that is, exclusive), permissioned network. This means that only authorized entities[52] are able to participate. The primary requirement for being able to trade on the network is the existence of an authorization to trade in the domestic ETS of a jurisdiction that joins the network.

The *level* of permission - in effect, access to the ledger - granted to any entity would depend on the nature of its activity within the distributed market:

- entities with compliance obligations under the ETS (compliance entities), other authorised traders and market makers (not subject to compliance obligations)[53] should be able to access that part of the ledger relating to their own accounts and transactions;

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[50] See also the description set out in the Annexure.

[51] ASTRI Whitepaper On Distributed Ledger Technology (11 November 2016) Commissioned by Hong Kong Monetary Authority, http://www.hkma.gov.hk/media/eng/doc/key-functions/finanical-infrastructure/Whitepaper_On_Distributed_Ledger_Technology.pdf , accessed 12/01/17.

[52] The word 'entity' could conceivably include a 'natural person' if any jurisdiction authorizes natural persons to trade on its ETS.

[53] See Section VI, Part B, below.

- the administrative authority of a participating ETS would necessarily have access to its own registry, that is, it would have the competence to access all parts of the ledger that relate to accounts and transactions within its domestic ETS, but not necessarily to the entire ledger of the distributed market as a whole;
- depending on the level of international transparency considered appropriate by the managing body (or, where necessary, its participating jurisdictions), each jurisdiction's ETS registry administrator might be authorized to see also the composite ledger records for each of the other participant jurisdictions, but certain restrictions might be regarded as necessary, for example:
  - in regard to the entries relating to individual entities (of other jurisdictions), in particular because of data protection concerns; and
  - possibly even regarding access to the ledger as a whole, to information which, for a variety of reasons, may be considered nationally sensitive (for example, relating to or considered indicative of the strength of a national economy).[54]

The exact nature of the levels of access and/or restriction would need to be addressed in the final construction of a system such as that proposed here, and appropriate administrative and institutional arrangements would need to be established to accord with these.

C Irreversibility of transactions

As noted above, once the prerequisite terms and conditions are satisfied, a transaction would proceed automatically and irreversibly. If for any reason it were desirable or necessary to reverse a transaction (in effect, rescind an exchange contract), the scheme would need to incorporate appropriate steps (more or less analogous to the positive steps already set out, also taking appropriate account of any terms and conditions such as might need to apply to reversal) to be undertaken. In effect, the same transaction would take place, but in reverse order, noting especially, however, that the MVs and rates for conversion may have changed in the intervening period. If such were to be the case, then the reversal would not put the counterparties back into their original positions (that is, the transaction would not be annulled *ab initio*).

D Responsibilities and obligations of participants

All participants in the networked market (jurisdictional authorities, trading entities, etc.) would be expected to observe the rules of the system, and trading entities in particular to perform their obligations as counterparties to transactions. Central to this, the responsibilities and obligations of entities engaged in trading would include continuing compliance with the rules of the domestic ETS within which they are authorized operators.

The nature of the networked market contracts and the conditions applying to a jurisdiction which joins the network (all of which have been outlined above) necessarily imply that inter-ETS transactions embarked upon by entities operating within any of them would simply not

[54] Although, such a restriction would run counter to the objective of greater transparency, embodied in the Paris Agreement.

proceed unless the counterparties satisfied all terms and conditions and the constitutive requirements of the network. Scrutiny of the satisfaction of these rules and requirements would be essentially an automatic element of the structure and operation of the system, built into the DLT software.

In this sense, there would, in effect, be zero scope for non-compliance, or for breaches of networked contracts. That said, the satisfaction of a number of the pre-requisites of network activity does require continued observance of regulatory elements of national ETSs, including the meeting of environmental/emissions standards. That this would need continued enforcement by the responsible regulatory authorities within each national system (that is, each jurisdiction) ought to go without saying. Nevertheless, it should be stated here explicitly in order to avoid any impression that the establishment of the distributed market network would somehow obviate that continued need, as it would not do so.

VI Participants

The participants in any networked market, as proposed by this paper, are readily apparent: the administrators and registries of participating ETSs; the entities authorised to trade in those ETSs; any institutions necessary to the operation and management of the networked market. This section gives further brief consideration to them.

A ETS administrators and registries

The ETS administrators of participating jurisdictions would be non-trading actors within the network. The (national/jurisdictional) registries administered by them would themselves be part of the distributed ledger, to which they would have access for monitoring and verification of transactions involving counterparties authorized by them, and for examining data for audit and reporting purposes, possibly subject to any restrictions, as mentioned above.

B Entities with compliance obligations, traders and other market makers

Jurisdictions will authorize a range of entities under their domestic ETSs. As touched on earlier, these entities will include those that have compliance obligations placed on them under the scheme (referred to as “compliance entities”, to distinguish them from other entities authorised to trade under an ETS but which do not have such obligations); and entities that are participating for other commercial reasons (for example, on behalf of clients) and do not have specific compliance obligations under the ETS. This latter group may include banks and other financial institutions, traders and market makers looking for arbitrage opportunities. The system’s computer code for contracts would need to distinguish entities that were subject to compliance obligations under a jurisdiction’s ETS, and those that were not. The absence of specific compliance obligations on entities would mean that certain conditions, such as compliance reserve obligations, would not apply to them individually (although they might still be applicable on a jurisdictional basis).

C Institutions

As noted in Section IV, apart from a supervisory body with ultimate decision-making authority, and an institution for the purpose of determining the MVs of participant jurisdictions and conversion rates,[55] the network may not require any other formal 'institution' for governance purposes. This could be the case if it were agreed, for instance, that minimizing costs and administration was a key objective. The jurisdictions participating would then agree to the rules when joining, and these rules would themselves include provisions covering departure from the network and associated financing matters. Decisions needing to be made concerning the on-going operation of the network might be addressed by having a mechanism to convene a governing committee on an *ad hoc* basis, so that the jurisdictions participating at the relevant time could decide collectively (see also Section IV, part A).

Alternatively, participating jurisdictions might consider a standing body the more appropriate approach to on-going governance and operational management. There is any number of models in existing international bodies for how this might be structured and conduct its business. For example, there might be a standing secretariat, with a (rotating) presidency that would call together jurisdictional representatives for either regular periodic, or irregular meetings. This might also necessitate procedural rules. All of these elements would generate additional financing requirements for staff, premises, legal drafting and advice, financial management and accounting, and so on.

Nevertheless, one might expect that such additional costs (shared by the participating jurisdictions perhaps according to some formula, for instance, based on the volume of TUs traded) would be minimal in comparison with the value the distributed market could achieve. It is conceivable, also, that the addition of a standing body may well, in the long-term, save the participating jurisdictions from duplicated supervisory or controlling mechanisms within their own administrations, thereby lowering costs overall.

VII Legal, market and other issues

A Location of transactions for taxation and other legal purposes

Whether value-added tax (VAT) or a similar tax would apply to the international transfer of the mitigation value embedded in a mitigation outcome, would depend on the application of the VAT (or the equivalent) legislation in the participating jurisdictions. It is recognised that the levying of tax on transactions is a matter of domestic law. There are, no doubt, numerous questions that may arise regarding this, but not addressed for the purposes of this paper. The preferred position would be, however, for transactions to be treated consistently across all jurisdictions participating in the networked market. In this respect, it is posited that instruments representing mitigation outcomes should be treated as financial instruments in all participating jurisdictions and the international transfer of the mitigation value embodied in them treated as being exempt from VAT and similar taxes (for example, the Goods and Services Tax (GST) in Australia). Ultimately, however, this would always be a

[55] As flagged earlier, resolution of the nature, scope, formation, etc, of this body is not part of this paper.

matter for the jurisdictions concerned. For example, an EEU will be defined as a financial instrument in the EU from January 2018, however, a transaction for its transfer would still not be exempt from VAT within the EU.[56]

Where necessary in the context of market transactions themselves, it might well be feasible to make provision for meeting VAT (or any equivalent tax) obligations in the terms of the contract between the counterparties from those jurisdictions where such is levied, for example, so that it is automatically included if payable by the buyer, but levied by the seller's jurisdiction. Although this would add a layer of complexity to the transaction (and relevant computer code) it does not in itself present a major additional issue.

Another potentially significant aspect of transactions on the distributed network is the question of where the contract is made, for the purpose of determining the appropriate law of the contract in the event of a dispute between counterparties. It might be argued that the contract is made on the internet (so not in any jurisdiction), or that it is made in the place where the servers are located (although this will not really help, since the relevant servers would be either those facilitating operation of the internet, or the servers operating the ETS in the jurisdictions of the respective counterparties to the transaction).

An alternative approach might be to ask, at what point in time the contract is made. A transaction on the distributed network operates like a normal contract in the sense that the essential elements need to be present.[57] When these elements are present, the contract would be made. However, the point of the 'smart contract' is that all these elements would be established when there is satisfaction of the pre-requisite information and specifications, such as those listed in Section V, part A above, and at that point in time the contract should self-execute. To illustrate how this might proceed, the following is noted:

- As already observed in Section IV, part B above, in peer-to-peer transactions the counterparties would need a way to signify the EEUs that they wished to sell or to buy, thus pointing to the need for a listing platform. This might set out (a) the amount and (b) jurisdiction of the source of the EEUs concerned, as well as (c) prevailing conversion rates between EEUs of participating jurisdictions and the TU;
- A seller wishing to sell 'n' number of EEUs from its jurisdiction, might indicate at what conversion rate of TUs it would be willing to sell. As evidence that the offer is genuine,

[56] Directive 2014/65/EU defines 'financial instrument' to include emission allowances, consisting of any units recognised for compliance with requirements of Directive 2003/87/EC (Emissions Trading Scheme): Directive on Markets in Financial Instruments and amending Directives 2002/92/EC and 2011/61/EC ('MiFID II'), Annex I, Section C, paragraph (xi); however, this definition would probably not be sufficient to bring it within the scope of the existing financial services related exemptions in Article 135(1) of COUNCIL DIRECTIVE 2006/112/EC of 28 November 2006 on the common system of value added tax.

[57] This will be a question, to a degree, of whether the contract is being considered under common law or civil law traditions. For instance, essential common law elements are: offer; acceptance; consideration; the intention to create legal relations; and certainty, which, while similar, may not be identical to those required under a civil law jurisdiction.

it might be necessary for the seller to satisfy all the other pre-requisite elements, including making the EEUs in fact available for conversion into TUs;

- Similarly, a buyer wishing to buy 'm' number of TUs, might indicate at what conversion rate into its domestic EEUs it would be willing to buy. As evidence that this offer is genuine, it might be necessary for the buyer to satisfy all the other pre-requisite elements, including demonstrating immediate and non-revocable availability of the funds for the transaction;
- In either case, a potential counterparty wishing to accept the offer listed would need to indicate its interest. It would then have to provide the relevant pre-requisite information and satisfy the specifications (see Section V, part A) and, in doing so, it would signify its acceptance of the offer, and – in the context of smart contracts – also trigger automatic execution of the contract;
- In the event that all the relevant pre-requisite information is not provided and the specifications are not satisfied within some predetermined period (say, within 24 hours of the initiation of the transaction), the transaction would fail and lapse.
- If more than one potential counterparty indicated interest, the first to satisfy the relevant pre-requisite information and specifications requirements would be successful. The computer code of the system would need to be transparent in regard to the temporal ranking of both indications of interest and satisfactory completion of pre-requisites, especially in relation to resolving a possible coincidence of timing.

A mechanism along the lines outlined here would minimize potential for contractual disputes, by ensuring that the time of contracting would be contemporaneous with contract execution and, by virtue of the fulfilment of the pre-requisite conditions, execution effecting settlement. Publication of standard terms and conditions, outlining the process steps and the requirements placed on, and obligations of, counterparties to transactions, which those counterparties automatically accepted as terms of the agreement by proceeding with the transaction, would facilitate compliance and agreement, further removing the potential for dispute.[58]

B Dispute resolution mechanism and location

Despite measures to avoid disputes, there is always the potential for these to arise (a) between counterparties to transactions, or (b) between trading entities and the distributed network (that is, the participating jurisdictions collectively or, as they might be represented, a standing secretariat). Bearing in mind that counterparties to transactions will, frequently but not necessarily exclusively,[59] be from different jurisdictions, the issue of legal disputes

[58] E.g., the International Swaps and Derivatives Association Inc (ISDA) Master Agreement for over-the-counter (OTC) derivatives transactions is a comparable standard set of T&C for international financial transactions.
[59] There would be no reason why counterparties could not be from the same jurisdiction: in fact, by opting to join the distributed network, a jurisdiction would commit to domestic trading being implemented on the distributed ledger, as well as international trading, since the network would need to be able to track all transactions so as to maintain the ledger accurately.

between them in relation to a transaction raises the potential for questions of private international law to arise.

One way in which the system proposed in this model could respond is to provide for an alternative dispute resolution mechanism, such as arbitration.[60] This might apply both in regard to the terms on which jurisdictions agree to join the network, and to the standard terms and conditions, mentioned immediately above in sub-section A. An applicable law would still need to be specified for the purposes of any arbitration, and ultimately this would be a function of the jurisdictions participating in the network, in so far as would concern possible disputes between trading entities and the distributed network.

C Data privacy and commercial confidentiality

Data privacy and commercial confidentiality issues need to be balanced carefully against the objective of achieving greater transparency in the conduct of mitigation actions and disclosure of mitigation outcomes. The model proposed in this paper seeks to address these competing elements in terms of the permissioning rights in relation to the ledger.

By way of example, permissioning might operate such that:

- trading entities would be authorized to access that part of the ledger relating to their own accounts and transactions;
- the administrative authority of a participating ETS would necessarily have access to its own jurisdictional registry, that is, it would have the competence to access all parts of the ledger that relate to accounts and transactions in the domestic ETS;
- the administrative authority of a participating ETS might have access also to the composite ledger records for each of the other participant jurisdictions, but be restricted from the entries relating to individual entities (of other jurisdictions), but for reasons mentioned earlier this might also be restricted in various ways; and
- the managing body of the distributed network (such as it might be) would need capacity to review information on the distributed ledger for verification and audit purposes, and to collate such information for the purpose of reporting to the CMA (or any subsidiary supervisory body interposed by it).

D Liability and enforcement of obligations

The conceptual model proposed here does not include consideration of a liability regime, nor an enforcement mechanism, whether in respect of the commitments that jurisdictions undertake upon joining the distributed network, or in respect of the entities authorized by them to trade on the network. Rather, the objective of the model presented here is to leave as little scope as possible for liabilities to arise that would require enforcement, whether against a jurisdiction or a trading entity. As such, the concept seeks to achieve this through, amongst others, the following elements:

[60] For example, arbitration in the nearest neutral location (perhaps from a list of recognised locations such as London, Frankfurt, Hong Kong, Singapore, etc) to both counterparties and under the rules of one of the international bodies, such as the ICC, might be specified.

- publication of standard terms and conditions, outlining the necessary procedural steps and the requirements placed upon, and obligations of, counterparties to transactions;
- 'smart contract' mechanisms making the time of contracting contemporaneous with contract execution and, by virtue of the fulfilment of prerequisite conditions, execution being, in effect, settlement; and
- making participant jurisdictions aware of their commitments through transparent and binding rules, including the provision of a surety, established from the beginning, together with a clear process for governance and operational management of the distributed network on an on-going basis.

Should it become necessary to take action against a participant jurisdiction, recourse could be through forfeiture of the surety and either temporary or permanent exclusion from the network. However, it is noted that the focus, especially when considered in the context of the Paris Agreement, should be always on encouraging ever improving mitigation outcomes, specifically through the medium of the networked market, rather than on punishing defaults through exclusion.

In the case of trading entities, as noted earlier, the transaction mechanism should make non-performance or contract breach in fact difficult to realise: satisfaction of the pre-requisite information requirements and other specifications would be necessary before a contract could emerge and, immediately upon this occurrence, the contract would self-execute and automatically trigger settlement. If the pre-requisite information requirements and specifications are not satisfied in a limited timeframe (a period of 24 hours from initiation is suggested) then, as already set out, the proposed transaction would lapse.

Finally, a point that arises in the context of default by participants in the distributed network is that relating to cyber security. The description of DLT in the Annexure (below) briefly refers to the security measures such a distributed network might include. These could not account, however, for human error, which remains a risk for any such system. Jurisdictions and the entities they authorize to participate would need always to exercise due diligence in protecting and maintaining their security; they would, therefore, remain themselves liable for harm flowing from any failures in this respect and, consequently, be subject to any legal liability arising. Such a risk, although important, is not dealt with further in this paper.

E Regulatory implications

In proposing this model, it is recognised that a number of regulatory considerations will arise, particularly with respect the operation as a financial market. Many of the issues relating to regulating the application of distributed ledger technology proposed here are new and require detailed examination. This is beyond the scope and purpose of this short paper. Nevertheless, the existence of these issues, and need for them to be addressed, is acknowledged.

VIII Conclusion

As noted in the Introduction, this short paper proposes a specific conceptual model for the networking of emission trading schemes, built on the architecture of distributed ledger technology. The proposal is made while conscious of the increasing need for a plausible, more efficient and workable global scheme to facilitate actions by economic and state actors with a commitment (or subject at least to an obligation) to mitigate anthropogenic greenhouse gas emissions that may cause dangerous climate change.

The proposal in this paper does not assume international emissions trading alone is sufficient to achieve that aim. Rather it proceeds on the basis that emission trading is the mechanism of choice in an increasing number of diverse jurisdictions globally. The proposal set out here seeks to provide a bridge between those trading schemes. It does so in recognition of the complications presented by inevitable institutional and political hurdles in achieving a globally coordinated response. These include, in particular, the absence of any *binding* structure of governance on the international level (with the notable exception of the European Union).

The proposal puts forward the key elements of the underlying technology framework as a platform for the components of inter-jurisdictional emissions trading. This framework provides the backbone for enabling and effecting the essential transactions of a networked (cross-border) market and for the recording of such transactions and related accounting.

The discussion of the model in this paper has addressed, in particular:

- how a market, so constituted, might come into being;
- certain alternative possible transactional mechanisms, coming to the conclusion that whilst peer-to-peer trading effectuates the distributed ledger approach, the possibility of a central trading platform should not be excluded entirely;
- the institutional elements and requirements of digital infrastructure for such a construction;
- so-called ‘smart contracts’ as the key transactional component, in conjunction with the digital mechanisms, and the terms and conditions which would constitute the primary governing rules for the operation of such contracts in the networked market;
- the types and roles of potential participants in such a market; and
- some ambient and related legal, economic, and other concerns, and potential responses to these.

The purpose of proposing this particular conceptual model is to stimulate, as a matter of urgency, and to provide a starting point for, the discussion of the technical requirements for establishing such a market. This is done especially in the light of the commitments that a large number of states have undertaken under the Paris Agreement.

While acknowledging the work currently being undertaken by the Subsidiary Body for Scientific and Technological Advice (SBSTA) in relation to matters relating to Article 6 of the

Paris Agreement,[61] without some effective scheme such as that proposed here, there is a genuine risk that the ambition of the Paris Agreement will remain unfulfilled. The proposals should, though, be seen merely as an initial, tentative step in introducing such an approach and making a first assessment of its viability. They do not attempt to suggest its final determinative shape.

It is vitally important that, having committed to emissions markets as the mechanism of choice for responding to the demands posed by climate change, governments ensure that these markets in fact work to achieve meaningful and effective carbon pricing and to anchor this within standard national and international economic activity. The networking of carbon markets, while still only conceptual (as presented here), offers a practical and realizable answer to many of the barriers that may slow or impede meaningful and effective global carbon pricing for years or even decades. This is time that we cannot afford to lose in the implementation of global climate change policy. Applications of distributed ledger technology may themselves be still in their infancy, but an application of this technology to provide a networking of emissions trading schemes would seem to be a perfect fit and offer a vitally necessary mechanism for global environmental policy.

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[61] *"… SBSTA also noted that Parties engaged in a productive exchange of views on Article 6, paragraphs 2 and 3, of the Paris Agreement…"* paragraph 84, Report of the Subsidiary Body for Scientific and Technological Advice on its forty-fifth session, held in Marrakech from 7 to 15 November 2016, FCCC/SBSTA/2016/4 (31 January 2017). If this is the sum total to report on the progress made on this issue after twelve months, then things appear to be moving somewhat slowly.

Table of Abbreviations

AML	Anti-money laundering
CDM	Clean Development Mechanism
CMA	The Conference of Parties to the UN Framework Convention on Climate Change serving as the Meeting of Parties to the Paris Agreement
COP	Conference of Parties (to the UN Framework Convention on Climate Change)
COP21	Twenty-first Conference of Parties (to the UN Framework Convention on Climate Change)
DLT	Distributed ledger technology
EEU	Emission entitlement unit
EMIR	European Market Infrastructure Regulation
ETS	Emission trading scheme
EU	European Union
GHG	Greenhouse gas
GST	Goods and Services Tax
IMF	International Monetary Fund
IT	Information technology
ITMO	Internationally transferred mitigation outcome
JI	Joint Implementation
KYC	Know-your-customer
MOP	Meeting of Parties (to the Kyoto Protocol)
MV	Mitigation value
NCM	Networked carbon market
NDC	Nationally Determined Contribution
OTC	Over-the-counter
SBSTA	Subsidiary Body for Scientific and Technological Advice
TU	Transaction unit
UNFCCC	United Nations Framework Convention on Climate Change
VAT	Value Added Tax

ANNEXURE: **OVERVIEW OF DISTRIBUTED LEDGER TECHNOLOGY (DLT)**

The following explanatory background relies on a White Paper commissioned by the Hong Kong Monetary Authority:[62]

Ledgers have existed for thousands of years. Conventionally, they have been maintained by trusted centralised entities, for example, as in the case of customer accounts maintained by a bank. Today such centralised ledgers are maintained mostly on electronic databases.

DLT is a protocol for building a replicated and shared electronic ledger system, collectively maintained by the participants in that system or network, rather than by one central party. In a DLT system, each network participant constitutes a 'node' or, more exactly, the nodes comprise the individual participants' computers, each of which contains a complete set of transaction records (i.e., the ledger). Taken together, the nodes constitute and maintain the distributed ledger.

The ledger is organised as a chain of "blocks" of information – each block contains a collection of transactions. New transactions are collected to form a new block and are submitted for adding to the ledger. Hence a new block contains one or more new transactions. The adding of blocks (hence the building of the 'blockchain') means that the ledger grows cumulatively. Transaction information is thus exchanged between nodes and added as a new ledger entry to the computers of all participants. The ledger, so understood, is updated whenever a transaction takes place.

In the absence of a trusted central party, the updating in this way relies on a consensual process amongst the nodes. This so-called distributed consensus requires two processes to be carried through:

- '**validation'** of each transaction: certain nodes, so called 'validating nodes' (possibly, but not necessarily, all the nodes in a given system, depending on how the network has been established) perform a validation check of every transaction in the entire block of transactions to ensure that the contents of each transaction are legitimate; e.g., they must verify that the sender of a transaction is true owner of the asset being sold;
- '**broadcast and consensus**': when a validating node has validated one or more transactions and initiates the process of adding the transaction data to the ledger, it broadcasts information about this new block to other validating nodes. The validating nodes communicate amongst themselves and agree upon a common set of validated transactions to be added to ledger.

A DLT network may be established either as a "permissionless"[63] network, in other words, one which anyone is free to join, or as a "permissioned" network, one which is usually privately owned, or at least set up by a collaboration of parties, so that only trusted or

[62] Fn. 51 supra

[63] The expressions "permissioned", "permissionless", "permissioning" and so on, have become terms of art used in relation to elaboration of how DLT networks are set up and operate.

vetted participants can participate in control and maintenance. The network proposed in this paper would be permissioned and the role of 'validating node' probably confined to (the relatively restricted circle of) the jurisdictional administrative authorities of the participating ETSs.

The process for achieving the distributed consensus, described above, on a permissionless DLT network is called "mining" and is not considered further here, as the network proposed here is permissioned. The validation process on the permissioned network does not involve mining, which is a computationally and energy-intensive process. Rather, validating nodes simply check the validity of a transaction, ledgers are updated much faster, and more energy-efficiently (as compared to the process using mining). As each node holds a local copy of the ledger that should contain a complete set of transactions to date, each validating node just needs to check its own chain and record history in order to ensure the validity of the transaction.

The robustness of DLT in protecting the integrity of information is due, at the macro-level, to high-level design, and at the micro-level, to detailed technicalities and specific security arrangements. In addition, the high level of transparency and duplication or replication of records provides a certain buffer against fraud, hacking and other possible abuse or corruption.

At the macro level, the consensus process amongst validating nodes, described above, protects integrity; at the micro level, "hash" technology is applied. As noted, the distributed ledger is a chain of blocks in which the validated transactions are added sequentially to the ledger. The blocks in the chain are connected with electronic links built with what is called a "hash function", a one-way mathematical function that summarises a piece of data regardless of its size as a piece of unique, fixed-size, short data called its "hash value". Put another way, the hash function turns data into a trunk of random characters called "hash". Any alteration whatsoever to the data causes the hash value to change. It then becomes impossible to derive the original data from the hash. Any attempt to change the content of a block in the chain causes the value of its hash link to be changed as well. Thus, the link of a block in the blockchain is integrally tied to its content. This technological facet is a further barrier to abuse or corruption of network data.