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International policy coordination for blockchain supply chains

Darcy W.E. Allen | Chris Berg | Sinclair Davidson | Mikayla Novak | Jason Potts

RMIT Blockchain Innovation Hub, RMIT University College of Business, Melbourne, Australia

Correspondence
Dr Darcy W.E. Allen, RMIT Blockchain Innovation Hub, Melbourne, Level 3, 440 Elizabeth Street, Melbourne, Australia.
Email: darcy.allen@rmit.edu.au

Abstract

From the adoption of the shipping container to coordinated trade liberalization, reductions in trade costs have propelled modern globalization. In this paper, we analyse the application of blockchain to reduce the trade costs of producing and coordinating trusted information along supply chains. Consumers, producers, and governments increasingly demand information about the quality, characteristics, and provenance of traded goods. Partially due to the risks of error and fraud, this information is costly to produce and to maintain between dispersed parties. Recent efforts have sought to overcome these costs—such as paperless trade agendas—through the application of new technologies. Our focus is on how blockchain technology can form a new decentralized economic infrastructure for supply chains by governing decentralized dynamic ledgers of information about goods as they move. We outline the potential economic consequences of blockchain supply chains before examining policy. Effective adoption faces a range of policy challenges including regulatory recognition and interoperability across jurisdictions. We propose a high-level policy forum in the Asia-Pacific region to coordinate issues such as open standards and regulatory compatibility.

KEYWORDS
blockchain, international policy coordination, institutional cryptoeconomics, supply chain governance, trade costs

1 | INTRODUCTION

Two innovations help explain the expansion in global trade from World War II until today: the standardized shipping container and global trade coordinating bodies.[1] The importance of both of these innovations comes through their reductions in trade costs: shipping containers reduced *transportation costs*, whereas global coordinating bodies reduced direct *regulatory costs*.[2] The effect was to make new markets possible, lengthen supply chains, alter trade patterns, and increase the diversity of goods. In this paper, we focus on the potential of blockchain technology to lower trade *information costs*. These are the costs of coordinating trusted information about the characteristics of goods for consumers, producers, and governments. When goods move, information about their provenance, ownership, and quality must also move with them. We examine how blockchain looks to reduce information costs by acting as new economic infrastructure before outlining the policy and regulatory challenges.

Our motivation to examine the blockchain supply chains stems from the increasing recognition of trade as an information cost problem. This focus on the information and regulatory costs of trade is demonstrated through recent efforts to develop single trade windows throughout the Asia-Pacific region. The 21 member-states of the Asia-Pacific Economic Cooperation (APEC) region have undertaken reform efforts over the last couple of decades to simplify international trade processes in the Pacific Rim. Notable among the reforms are the APEC paperless trade agenda, which broadly involves "trade taking place on the basis of electronic communications, including exchange of trade-related data and documents in electronic form" (Duval, Amandeep, & Utoktham, 2015, p. 108). A key element of paperless trade policy is the single window system (SWS), an electronic single-entry point for traders to comply with regulatory requirements of export and import in a more efficient manner (APEC, 2018b). Paperless trade has many potential benefits, including reduced cost of shipping goods, lower communications costs, lower paper handling charges, fewer errors and faster payment receipts, reduced trade finance charges, and lower inventories (Department of Foreign Affairs and Trade (DFAT) and Foreign Trade and Economic Cooperation (FTEC), 2001). Ultimately, paperless trade and SWS efforts are efforts to economize on the information costs of trade.

Although many technologies might be used to reduce information costs, our focus is on blockchain technology. Blockchain was invented less than one decade ago as a technology for creating the digital cash, bitcoin (Nakamoto, 2008). More broadly, blockchain enables the creation of distributed, immutable, and secure ledgers of information. Blockchains are a technology of governance of information and exchange (Davidson, De Filippi, & Potts, 2018). Blockchain

[1]The authors thank participants at the APEC Study Centres Consortium Conference (ASCCC), 14–15 May 2018, Papua New Guinea.

[2]For instance, Jacks, Meissner, and Novy (2008) found that falling trade costs explain "roughly 55 per cent of the pre-World War I trade boom and 33 per cent of the post-World War II trade boom" (p. 529).

may act as a governance structure for a secure and trusted source of information for consumers, firms, and governments about goods as they move along supply chains and across borders (Allen, Berg, & Markey-Towler, 2019). Indeed, numerous actors involved in international supply chain relations, as well as those with an interest in trade facilitation more generally, have suggested that blockchain (and other distributed ledger technologies) have the potential to advance trade facilitation agendas focussing upon cross-border paperless trading.

The Asia-Pacific region stands to capture a significant share of supply chain information cost savings resulting from blockchain adoption. Several cases indicate that blockchain could deliver sizeable reductions in the cost of trading goods and services in the region. For example, Suominen (2018) recounts that Korean multinational company Samsung, an entity with an extensive supply chain network, is using blockchain to facilitate the transportation of 488,000 tonnes of air cargo and over a million shipping containers annually. Following this, it has been suggested that the company has reduced its shipping costs by one fifth. Jurisdictions such as China have been proactive is using blockchain to facilitate trade finance, and have reported tentative, yet positive, results in terms of performance improvements with respect to ease of tracking transactional flows (Ganne, 2018). Australia has seen a number of efforts to use blockchain to track perishable goods such as agricultural products (e.g. AgriDigital, 2019).

Although blockchain technology is nascent, its application to supply chains will have to interact with governments as goods cross borders. Some of the issues this raises are familiar, having been seen in previous paperless trade agendas. We outline some of these policy challenges and ones unique to blockchain adoption, including government recognition of blockchain information, and technical and informational interoperability. We point to the need for regulatory coordination and adaptation in facilitating this entrepreneurial discovery process, including a high-level policy coordination forum in the Asia-Pacific region to develop open standards, propose new free trade agreements facilitated through blockchain, and encourage government regulatory recognition of blockchain-based information to comply with domestic regulations.

2 | TRADE AS AN INFORMATION COST PROBLEM

Trade costs are those costs incurred in addition to production costs (Petropoulou, 2005). Trade costs can be separated into three categories: transportation, regulatory, and information. The shipping container drove down the transportation costs of global trade. On 26 April 1956, a converted oil tanker, the *SS Ideal X*, set off from New Jersey to Houston, becoming the world's first successful container ship voyage (Levinson, 2016). In the decades to follow, the shipping container spurred a process of containerisation that was “one of the most important transportation revolutions in the twentieth century” (Hummels, 2007, p. 142). Prior to containerisation, the technologies of unloading and transporting cargo—such as wooden barrels and jars (see Twede, 2005)—have “hardly changed since the Phoenicians traded along the coast of the Mediterranean” (Bernhofen, El-Sahli, & Kneller, 2016, p. 38). International trade had been a dangerous, laborious, and inefficient process of packing and unpacking goods across modes of transport. Together with advances in other transportation technologies, such as air freight and the modernisation and development of trading ports, standardized shipping containers facilitated intermodal transportation networks that made transport cheaper.

Global and regional policy coordination bodies, such as the World Trade Organization (WTO), reduced trade regulatory costs. Formed in 1995 through the Marrakesh Agreement, the WTO emerged from the General Agreement on Tariffs and Trade (GATT). The GATT was partially motivated by the potential of multilateral reductions in the direct regulatory costs of trade following the raising of tariffs, import quotas, licencing requirements, and foreign exchange restrictions following World War I (see Irwin, 1995).[3] Coordinating reductions in trade barriers is necessary because each economy may be incentivized to strategically maintain their own trade barriers to protect domestic industries from international competition. International agreements align interests of governments to liberalize borders and embrace the benefits of globalization by acting as governance structures to reduce the transaction costs of negotiation (Goldstein, 2000). On many accounts, these efforts were remarkably successful, with the worldwide average of import tariffs dropping from 8.6% in 1960 to 3.2% in 1995 (Clemens & Williamson, 2004), with further reductions in regulatory trade costs since. Declining political trade costs made more mutually beneficial exchanges possible, spurring further globalization.[4]

The major type of costs facing supply chains today are not transportation or regulatory costs, but information costs. There are several reasons for this. First, information costs increase with the complexity, length, and volume of trade on supply chains. And second, as transportation and regulatory costs fall, the portion of information costs rises. Indeed, Anderson and Van Wincoop (2004) find that the costs of bringing goods across borders now exceed transportation costs. Information costs include the costs of enforcing contracts, searching for trading partners and information about the nature, characteristics, and provenance of goods as they move along supply chains. This information identifies goods and provides them with distinguishable economic value (Berg, Davidson, & Potts, 2019).

Global supply chain information remains trapped in manually administered and paper-based coordination between silos of firms and governments. Information flows are still often organized as transfers between separate organizations, despite efforts to use new information communication technologies such as the internet to digitize supply chain information (see Section 4). Each firm in a global supply chain passes off information relating to a tradeable good to each other one step at a time, holding that information until it can be passed to the next actor on the supply chain, and adding to that information as the nature of the good changes. Moving goods and their information along a supply chain can be remarkably complex, requiring hundreds of different actors, including exporters, importers, logistics companies, shippers, retailers, and governments. Maersk recently found that a shipment of refrigerated goods from East Africa to Europe went through over 30 different people and organizations, and involved more than 200 interactions and communications (IBM, 2017). This documentation includes cargo manifests, which outline characteristics of the cargo such as its size, bills of lading, which focus more specifically on ownership of the cargo, and trade finance documentation. The complexity of information coordination on supply chains is not only slow and potentially error-prone, but raises the potential of opportunistic behaviour and fraud. As in all economic environments, some individuals have the incentive to act opportunistically, providing false information about the nature of those goods.

Trusted supply chain information is important because it is demanded by consumers, producers, and governments. Particularly, for highly differentiated or perishable goods, consumers demand information not only about who produced the goods, but also other information such

[3]To be sure, there have been many other international institutions developed to overcome other forms of trade costs, such as the *Law Merchant*, which lowered the cost of contract enforcement. For example, see Milgrom, North, and Weingast (1990).

[4]These are of course not the only two drivers of global trade. For example, a further factor could be the rise of vertical specialization across countries (e.g., see Yi, 2003), which may magnify the benefits of tariff reductions as goods incur tariffs each time they cross borders.

as how that good was transported, its age, and its quality. Consumers are increasingly demanding information about the legitimacy of certifications of products such as fair trade and organic. The long-term impact of better information about goods is a de-commoditization of goods markets, where new markets of differentiated goods can be created (Allen et al., 2019). Governments also demand information to satisfy domestic regulations, such as biosecurity or ethical standards. These information cost challenges suggest the need for new governance structures and methods of information coordination for global supply chains to lower trade costs and usher in the next wave of globalization.

There are therefore potentially large economic benefits from economizing on information costs. Indeed, the World Economic Forum (2013, p. 4) concluded that there are "far more significant impediments to trade than tariffs." They found that reducing supply chain barriers to trade (not including tariffs) could increase global GDP by nearly 5% and global trade by 15%.[5] In the Asia-Pacific region specifically, a small number of studies have been undertaken to estimate the economic impacts associated with the simplification of international trade. A 2018 study by the United Nations indicates that cross-border paperless trade may increase exports by between US$36 billion and US$257 billion annually, depending upon the degree of region-wide implementation, as well as reduce the time required to export (United Nations (UN) and Economic and Social Commision for Asia and the Pacific (ESCAP), 2018). An earlier study estimated that substituting paperless for paper trade documentation with respect to intra-APEC merchandise trade could yield cost savings in the order of US$60 billion on an annual basis (Department of Foreign Affairs and Trade (DFAT) and Foreign Trade and Economic Cooperation (FTEC), 2001). The APEC Secretariat itself reports that APEC-region implementation of SWS and related initiatives has reduced export costs and time in recent years (APEC, 2018a). The notion that trade simplification can assist in the reduction of information costs is additionally supported by several individual-country case studies—including Japan, Republic of Korea, Singapore, and Thailand—referring to the transition towards paperless trade (APEC, 2011; Duval et al., 2015).

But how can we economize on information costs? From a new institutional economics perspective, the way information costs are economized is through different forms of governance (Coase, 1937; Ostrom, 1990; Williamson, 1985). We can use different forms of governance—such as firms, markets, and governments—to lower information costs in different ways and to differing effectiveness. For instance, we could vertically integrate an entire supply chain where all parties form a single hierarchical firm. In this example, trusted information may be more effectively administered through internal systems, but there are clear other costs relating to specialization. Alternatively, a supply chain might consist of a range of quasi-markets between different companies as goods move between them. Although this might have benefits in terms of incentive compatibility and efficiency, this organizational form might be more prone to monitoring costs and moral hazard. Each of these forms of economic organization economize on different elements of transaction costs in comparatively effective ways.

The potential governance solutions for the information costs of global trade ultimately depend on the technologies available and the capacity of entrepreneurs to apply those technologies. The internet, for instance, has been shown to increase international trade volumes by lowering information coordination costs (Freund & Weinhold, 2004). This has partly been due to its impact on the paperless trade agendas discussed earlier. Our focus is on blockchain technology and how it can form a new economic infrastructure for supply chain information governance. Blockchains

[5]The World Economic Forum (WEF) argue that reducing barriers to trade other than tariffs has a large impact because it eliminates resource waste rather than just reallocating resources.

may fundamentally shift the way current governance structures—such as firms and networks—govern supply chains to overcome information costs, opening up new institutional possibilities. Indeed, a 2018 study sponsored by the Cardano Foundation estimated that blockchain could expand world trade in goods by at least US$35 billion per annum (McWilliams, Niculescu-Marcu, & Cruz, 2018), whereas a World Economic Forum study suggests that blockchain usage could result more than US$1 trillion of new global trade over the next decade (WEF, 2018). In the following section, we turn to how such a blockchain-based infrastructure might work.

3 | SUPPLY CHAIN INFORMATION ON A BLOCKCHAIN

Blockchain is a new institutional governance technology for creating and maintaining distributed ledgers of information (Berg, 2017; Davidson et al., 2018; MacDonald, Allen, & Potts, 2016). First invented by Satoshi Nakamoto (2008) in its application of the cryptocurrency bitcoin, blockchain combines a number of existing technologies—including asymmetric cryptography, peer-to-peer networking, and append-only databases—to establish secure, distributed ledgers of information. The opportunity of blockchain is most visible from the understanding that much of a modern market economy consists of trusted relationships maintained through ledgers: citizenship, money, firms, and governments (Berg, Davidson, & Potts, 2018a; Casey & Vigna, 2018). Rather than ledgers of information being held within centralized hierarchies—such as governments or firms—blockchains enable decentralized ledger governance. Since its first application in cryptocurrencies, entrepreneurs have applied blockchain to many other ledgers including identity (Berg, Berg, Davidson & Potts, 2018) and voting (Allen, Berg, Lane, & Potts, 2018). Many nodes maintain the trusted state of a blockchain ledger through consensus protocols such as proof-of-work and proof-of-stake. Blockchain not only enables decentralized ledgers to be created, but incorporates incentive compatible mechanisms to maintain those ledgers through cooperation without the need for third party hierarchies. Given the information governance problems for global trade networks, can blockchains be used to lower the information costs better than current solutions?

Blockchain technology can track unique digital assets along supply chains, storing information about them as they pass between multiple parties. The information contained on the blockchain could include ownership data, time stamping, location data, and other product-specific data (e.g., see Abeyratne & Monfared, 2016). The information can be made available to producers, governments, and consumers to satisfy their information needs, and might help identify counterfeit goods (Hackius & Petersen, 2017; Kim & Laskowski, 2018). Blockchain may incentivize parties along a supply chain to provide the information "so that provenance can be evaluated even when no one party can claim ownership over all supply chain data" (Kim & Laskowski, 2018, p. 2). This is particularly important given that Alibaba estimates that global food fraud costs $40 billion per year (Zhao, 2018), leading to a wide range of issues of food safety.

There are a number of current trials of blockchain-based supply chains. IBM and Maersk are trialling blockchain for supply chains using a permissioned Hyperledger blockchain.[6] The trial involves a permissioned ledger where information about trade flows, financing, and contracts

[6]There are interesting governance questions relating to permissioned or permissionless blockchain applications. In a permissioned system, only selected users on the system can update the blockchain record. In a permissionless system any, node can contribute information. The former approach requires a level of centralisation to determine which individuals along a supply chain are authorized to upload information, whereas the latter approach may require further cryptoeconomic incentives to encourage the network towards consensus.

are updated and shared across the supply chain (IBM, 2018). There are also other pilots in specific areas, such as combatting illegal fishing.[7] Rather than the current system of generating supply chain information between hierarchical forms of governance, these examples demonstrate how blockchain potentially enables a secure, decentralized and transparent ledger of digital assets along a supply chain—a new economic infrastructure for supply chains.

Blockchain technology is being combined with complementary technologies such as the Internet of Things (IoT) and smart contracts. GPS and RFID sensors connected to vessels and containers are being used to upload information such as pressure, temperature, and location to immutable blockchains (Tian, 2016). The technological complementarities between blockchain and the IoT partially overcomes one of the primary challenges of blockchain supply chains, and indeed blockchain generally, the problem of the quality of data entered into a blockchain (Apte & Petrovsky, 2016). Through the use of smart contracts, blockchain has the potential to improve accountability between the various actors across the supply chain. Parties can also enter into automatically executing smart contracts (see Szabo, 1997). These smart contracts could perform many functions including automatically changing the ownership of goods, executing payments, or even compensation or insurance payments for a late delivery to compensate relevant parties (Staples et al., 2017). Blockchain supply chains are also likely to create more liquid and efficient data markets. Better trade data could be mined through artificial intelligence to recognize patterns, drive efficiencies, and identify fraud. In this way, supply chains may merge towards "demand chains" (Casey & Vigna, 2018; Casey & Wong, 2017).

The question of the dynamics and organization of blockchain-based supply chains remains open. As Petropoulou (2005) outlines, changes in information costs shifts in the organization of supply chains, including the importance of intermediaries in matching trades across unknown parties. This could open up entirely new forms of economic organization, such as v-form organizations (Allen et al., 2019; Berg, Davidson, & Potts, 2018b). Further, we expect the adoption of blockchain will vary by product, industry, and jurisdiction, and by the granularity and nature of information required. As Harris (1995) has outlined, information and communication needs—and therefore trade costs—are greater for differentiated goods, and trade volumes in these products are likely to be more sensitive to changes in the costs of information and communication. Blockchain is therefore expected to be applied to those goods with comparatively high information costs, such as perishable goods in agriculture (Tian, 2016), high-end manufacturing (Abeyratne & Monfared, 2016), and pharmaceuticals (Apte & Petrovsky, 2016; Mackey & Nayyar, 2017). The nature of these goods is that although their subjective value to the consumer may vary greatly given its provenance and attributes, that information is not always easily verifiable at the time of purchase.

Blockchain, however, is now only one decade old. And its application to supply chains is even younger. How exactly blockchain forms a new economic infrastructure to meet the information demands of supply chains is an entrepreneurial question. In the following section, we turn to some of the policy barriers to this entrepreneurial process. In particular, our focus is on interaction between blockchain supply chains and the regulatory requirements and barriers of territorial governments.

[7]See Provenance (2016). In the pilot, fishers were registered on the system, were tasked with sending SMS messages to create a digital asset of the tuna on the blockchain when it was caught, and that asset was subsequently updated along the entire supply chain.

4 | POLICY AND COORDINATION BARRIERS

A survey of experts in the logistics industry found that the two most common answers to the question "what are the likely barriers for blockchain adoption in the logistics industry?" are *regulatory uncertainty* and *different parties have to join forces* (Hackius & Petersen, 2017). In this section, we examine the role of government in the current entrepreneurial process of developing new blockchain trade infrastructure. How will blockchain supply chains interact with different regulatory states? What are the policy principles necessary to enable this new economic infrastructure to be built? We provide an overview of some of the policy and coordination barriers, helping to give direction to policymakers in the Asia-Pacific region.

The policy barriers of blockchain adoption fundamentally stem from the inherent nature of trade as inter-jurisdictional. Goods moving across borders must interact with a range of regulatory environments, complying with various rules. Therefore, solutions to supply chain information problems must not only take into account the relationship between producers and consumers—thereby providing more trusted information about provenance—but also how these solutions will satisfy regulatory obligations within different jurisdictions.

Scholars of the regulatory state have emphasized how the trade and market liberalization has been concomitant with the development of more regulatory controls around market exchange. The "regulatory state" is a paradigmatic shift in the structure of political economy that has seen regulation (typically governed by independent statutory authorities separated from the normal lines of democratic accountability) replace older models of state intervention such as direct ownership (Berg, 2008; Glaeser & Shleifer, 2003; Majone, 1996, 2011). The regulatory state has also opened new issues into the regulatory domain, such as intellectual property, rules of origin, and labour and environmental standards.

The development of the regulatory state has critical implications for our understanding of trade costs, and the barriers to implementing blockchain trade infrastructure. Heavier regulatory burdens require more information about compliance across a wider range of attributes. Imported goods are usually required to comply with domestic regulatory requirements about provenance and quality of goods. The result is greater demands for information across the entire supply chain. Further demands for information come from the creation of international institutions seeking regulatory harmonization. As the World Economic Forum (2013) outlined, one of the key barriers to supply chains is heterogeneity across jurisdictions "... and even among agencies within any one country. A lack of uniform customs rules, for example, makes it significantly more costly for a company to operate in multiple foreign markets." Global regulatory harmonization is information intensive. These information requirements are both at national borders—that is between states—and across jurisdictional boundaries—between multinational institutions, states, and subnational governments. As Casey and Wong (2017) note:

> *A complex array of regulations, maritime law, and commercial codes governs rights of ownership and possession along the world's shipping routes and their multiple jurisdictions. Marrying that old-world body of law, and the human-led institutions that manage it, with the digitally defined, dematerialized, automated and denationalized nature of blockchains and smart contracts will be difficult.*

This challenge of regulatory compliance and incompatibility extends beyond blockchain and can be seen in previous efforts of paperless trade agendas and trade digitization. There has been only partial progress among APEC-member countries towards practical implementation of paperless trading reforms. A comprehensive international audit has indicated that global trade facilitation progress remains uneven, with less developed countries (especially Pacific Island nations) enduring considerable difficulties developing infrastructure to facilitate the electronic flow of trade documentation (UN and ESCAP, 2017). It is noted in the same study that Southeast and East Asian countries (including APEC members) have achieved relatively high trade facilitation policy implementation rates, with an excess of 60% achievement rate in terms of trade facilitation across several measures (including paperless trade).[8]

Governments can be accommodative towards blockchain-based supply chains in many ways. The leading position taken by several countries in Asia and the Pacific, such as Australia, Japan, Singapore, and the United States, in imposing regulatory and fiscal policies in relation to blockchain could contribute towards a semblance of policy compatibility across countries. These countries have been assessed in recent studies to maintain policies of a blockchain-accommodative, "crypto-friendly" nature, motivated in part by perceiving blockchain innovation as a domestic economic development opportunity (Novak, 2018). For example, these countries have each adopted anti-money laundering (AML) and know your customer (KYC) regulatory standards, which is applicable to trade finance. The establishment of high-quality policy settings by crypto-friendly countries is suggested to encourage policy learning, and perhaps the emulation of similar policies by other jurisdictions in the region, in effect, inducing a diffusion of relatively-consistent policy responses to blockchain that is conducive to cross-border trade expansion.

There are several other regulatory issues that will create tension and should be addressed under the broad banner of crypto-friendliness. One of these is the legal recognition of blockchain-based information. Different governments have different requirements of how to comply with domestic regulations. Some of those requirements include the nature of how the information is provided (e.g., a particular form). This raises significant frictions around how governments recognize blockchain-based information about provenance as being sufficient to comply with domestic regulations. As Ganne (2018, p. 98) notes in relation to international efforts of classification, the way that information and contracts viewed as valid by customs and courts should seek to be technologically neutral. Governments should seek to be technologically neutral in how parties comply with domestic regulations. This neutrality also helps to ameliorate the issue of harmonization of requirements across different jurisdictions.

This problem of regulatory incompatibility also extends to the structure of data. Rather than just digitizing existing forms and processes—which has partially been the domain of previous paperless trade processes—blockchain enables new structures of data. This suggests that new forms of data contained within blockchains and other distributed ledger technologies will not necessarily satisfy regulatory requirements. Creating standards for data structures is necessary for several reasons, both from a technical perspective and from an information cost regulatory perspective. From a technical perspective, there are likely to be several different blockchain-platforms carrying supply chain information. The technical question is whether the data between different blockchains can interact. From an information perspective, standards are necessary in terms of data structure to comply with domestic requirements. This problem of standardization is common across many new technologies. We can see the need for standardization by looking at the modern shipping container and railway gauges, which

[8]On a closely related matter, international progress on paperless trade does not necessarily imply inter-country consistency on implementation, especially in the absence of tight coordination between policymakers to reduce trade information costs. As noted by the Australian Department of Home Affairs (2018, p. 5), more than 70 countries have developed and implemented SWS "but they vary considerably in their scope, complexity and sophistication."

experienced adoption challenges through the entrepreneurial discovery process. Due to network effects, differential standards and fixed costs in the adaptation of existing infrastructure, technologies such as the shipping container took decades to spread across the supply chain. Standards were required to ensure the same container sizes and construction, and set the boundaries within which entrepreneurs could test and trial new applications of this technology. Importantly, containerisation occurred faster in developed countries compared with developing nations—an important issue for development in the Asia-Pacific region. A similar dynamic is likely in the adoption of blockchain-based supply chains.

There may be a fruitful role of policymakers in the Asia-Pacific region, and beyond, to address the potential lack of blockchain interoperability through the development of commonly-agreed technical and information standards. In an international trade environment, the transition towards standard consistency, or at least mutual recognition of variant standards, towards blockchain may reduce costs associated with interpreting and processing data winnowed through different blockchain networks. It is in this context that moves within the Asia-Pacific to promulgate blockchain interoperability, and data exchange are of significance. Australia and several other APEC members, such as Canada, China, Japan, Malaysia, Thailand, and the United States, are progressing new blockchain standards through the International Organization for Standardization (ISO; Eyers, 2018). Some key activities currently undertaken through the ISO negotiations include permission model standards, smart contracting, and consistency in application programming interfaces (Das, 2016).

The development of blockchain standards can take two broad paths. Standards could either be open or closed. Closed standards risk being developed and defined by an early dominant player in the growing blockchain supply chain industry. If a few small parties are able to control the development of the standards, this will ultimately limit the entrepreneurial contestability of building this economic infrastructure. A preferred solution would be the creation of open standards that enable entrepreneurs to view the rules of the game within which blockchain solutions can be applied, and to enable the later interoperability of supply chain solutions.[9] Although it is not even clear yet what these standards will encompass, what is clear is that they must be international in scope, take into account differing jurisdictional environments, aimed to facilitate entrepreneurial discovery and be created with the input of a diverse number of stakeholders. Such policy entrepreneurship, however, must be coordinated.

We suggest that a process of coordination and policy entrepreneurship around blockchain-supply chains occur through a new high-level policy forum or governance body. The central roles of this body would be to develop open standards and commitments to regulatory recognition for the information governed on blockchain supply chains. Beyond existing international bodies (such as ISO mentioned above), such a new blockchain body might also assist with coordinating early-stage trials and special economic zones that are accommodative to blockchain-based supply chains. Indeed, these trials are necessary because the policy barriers themselves need to be discovered, rather than simply being negotiated away. That is, the role of the body would extend beyond setting technical standards to facilitating trials over the harmonization and recognition of blockchain-based data across various jurisdictions. The need for a dedicated blockchain

[9]For instance, as Levinson (2016, p. 137) outlines at length, in the case of the shipping container there was global coordination: "... the International Standards Organization (ISO), which then has thirty-seven nations as members, agreed to study containers ... The ISO project was meant to establish worldwide guidelines before firms made large financial commitments. Delegates from eleven countries, and observers from fifteen more, came to New York in September 1961 to start the process."

coordination body is also strengthened because blockchain is rapidly evolving—both the technology itself and the nature of the burgeoning industry—and this will necessitate fast-moving coordination. Further, the body's activities are likely to rely on a level of speciality and expertise around blockchain and other distributed ledger technologies across a wide range of potential applications, drawing on a range of different stakeholders from industry, government, and academia. Together, the nature of blockchain technology and the breadth of potential policy barriers and dynamics suggest the need for a high-level policy forum distinct from existing bodies.

5 | CONCLUDING REMARKS

Lowering trade costs expands the boundaries of mutually beneficial trade and propels the process of globalization. This process is critical in the process of Asia-Pacific economic development. Although the shipping container primarily economized on transportation costs, and bodies such as the GATT and APEC helped economize on direct regulatory costs, much of modern trade costs are now information costs. When physical goods are transported between parties and across borders, consumers, governments, and producers increasingly demand information about the characteristics of those goods. This information is costly to coordinate across multiple parties, particularly as supply chains become longer and more complex. New technologies can be used to lower trade costs, creating new forms of economic organization to produce, manage, and verify trade information.

In this paper, we examined the potential of blockchain technology—a new institutional governance technology for creating immutable, secure ledgers of information—to economize on the information costs of supply chains. Blockchain may not only make existing supply chains more efficient, but open up entirely new trading patterns and markets through governing deeper information about differentiated goods. The future of blockchain in supply chains will be propelled through a process of entrepreneurial discovery over several decades.

We then turned to a range of policy challenges that impact this entrepreneurial process of building new blockchain-based trade infrastructure. There are a range of problems that will face how blockchains interact with the regulatory state, including government recognition of data and transactions and technical and informational interoperability. We have identified the need for high-level international coordination between economies in the Asia-Pacific and globally. This forum would focus on connecting academia, industry, and government to discuss questions relating to open standards, the development of new trade agreements, and new trials for blockchain-based supply chains.

ORCID

Darcy W.E. Allen https://orcid.org/0000-0002-1466-5922
Chris Berg https://orcid.org/0000-0002-0856-7891
Sinclair Davidson https://orcid.org/0000-0003-4201-1077
Mikayla Novak https://orcid.org/0000-0002-9638-8825
Jason Potts https://orcid.org/0000-0003-1468-870X

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