Blockchain and payment systems: What are the benefits and costs?

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Abstract

The discussions of how blockchain technologies (blocktech) will disintermediate or transform the payments business continue. To date, the discussion has largely focused on the possibility that, in the near future, the technology could enable a nominally priced, frictionless value transfer process. An examination of the benefits and costs indicates that, at the current level of maturity of technology and legal frameworks, blocktech is not superior to existing mechanisms, except in certain niche circumstances. This, coupled with the lack of viral adoption characterising recent successful adaptations (eg Facebook), indicate that major breakthroughs are required before there is wide adoption of this new paradigm in payment systems.

Keywords: blockchain, blocktech, digital ledger, payment system, cryptocurrency, Bitcoin

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INTRODUCTION

Given that Bitcoin, the first blockchain technology (blocktech) originated as a payment system, it was inevitable that its initial success would lead to a rush of attempts to improve on its design and implementation in order to usher in the 'internet of value'.[1] This paper will examine: (1) the benefits and costs of Bitcoin — the first and still the most successful crypto-payment system; (2) the benefits and costs of Ripple — which has attempted to extend the paradigm to the interbank cross-border clearing space; (3) implications for cross-border correspondent banking; (4) implications for domestic payments; (5) whether any other (newer) blocktech solutions offer alternative approaches to improving cost to benefit ratio; and finally, (6) the legal aspects. A concluding appendix addresses cost elements

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in international payments. The paper does not discuss the experimentation conducted by central banks in the use of blockchain technologies, such as under the Canadian Jasper project.[2]

BITCOIN

Premised on distributed ledger technology (DLT), in 2009, Bitcoin introduced the blockchain — a database that put sequential records in a block, with each record cryptographically 'chained' to the next one, so as to be used like a ledger that can be shared and corroborated by any member of the Bitcoin community with internet access. Bitcoin was born out of a specific ambition — to create government-independent, censorship-resistant money.

Bitcoin is a closed system, where funds never move. As such, the transfer of ownership can happen as quickly as with any digital wallet (ie near real time). By way of illustration, it is similar to PayPal's internal processing: the money resides in PayPal's bank account, and when one PayPal user moves the money to another PayPal user, the money continues to reside in PayPal's bank account. Thus, there is no need for settlement, which allows PayPal to offer a real-time experience.

Bitcoin delivered a tremendous benefit to a community that needed censorship-resistant money — at a cost. To create an asset that cannot be directly controlled by a central authority, the creators of Bitcoin came up with an expensive way (proof of work) to transform electricity into a digital asset which can then be accessed/owned/transferred by anyone with internet access. To put those costs into context:

- University College London's (UCL) blockchain research centre has estimated that it costs US$400m a year to run a Bitcoin network.[3] According to Tomaso Aste, a professor of complexity sciences and director of the UCL's Centre for Blockchain Technologies, 'We can therefore conclude that the current cost for Bitcoin proof of work is large, wasteful, but necessary'.[4]
- The miner fee averages US$0.30–$1.00 per transaction.[5] Miner fees are roughly equivalent to the fees that a clearing and settlement mechanism would charge its banks — which vary from under US$0.01 for automated clearing house transactions to less than US$1 for a wire transfer.

As Bitcoin was the only solution to provide censorship-resistant money, costs did not matter. To expand beyond its original constituency, Bitcoin had to overcome its technical complexity — the difficulty of acquiring and using it in the general economy. To do this, an entire ecosystem sprung up, consisting of exchanges, wallets, payment processors, etc. This new layer added new costs (1.5–4 per cent — comparable to the credit card interchange[6]), while at the same time diluting the proposition of censorship resistance, as these entities are required to be regulated by competent authorities. This brought in all of the regulatory costs of the current, traditional banking ecosystem, such as know your customer, compliance, etc. These costs can be avoided (for a time[7]) by breaking the law. They can be absorbed into more profitable and riskier activities, such as those tied to the appreciation and volatility of Bitcoin. But hiding these costs does not make them any less real. Further, one must still account for the costs of establishing a strong legal foundation, as will be discussed in the section on legal aspects.

Thus, Bitcoin's fees and costs tend to be higher and it does not offer any compelling advantages in situations where fiat money suffices (ie the majority of the time). For example, fiat money:

- is just as fast — money transmitters such as Transferwise and Western Union already move money across borders rapidly and with certainty, while traditional banks and e-wallets move money instantly domestically;

- has much wider market access (ie the entire economy as opposed to the tiny slice of it);
- has proven, well understood processing and risk models (eg businesses do not need to worry that loss due to fraud is not covered or that their funds will be used to mutualise fraud losses in other accounts at the exchange[8]); and
- does not introduce tax issues — with Bitcoin, the holder has to account for price changes after asset liquidation (which includes making a payment).

RIPPLE

Three years after the introduction of Bitcoin (2012), Ripple began its journey. To improve on Bitcoin's cost–benefit profile, the Ripple Consensus Ledger was developed, which included several innovations, including:

- reduced processing costs obtained by replacing proof of work with a much more efficient consensus protocol and identifying alternative lower-cost sources of foreign exchange (FX) pricing;
- transfer speeds of under five seconds,[9] compared with might be days in a traditional correspondent banking process and 10–120 minutes for Bitcoin[10] (once the Ripple rule book[11] is finalised, transferred funds will be required to be available to the receiver in minutes, as is the case in domestic real-time payment systems); and
- a currency-agnostic protocol coupled with the appropriate business process to enable not only the carrying out of payments in Ripple's native currency but also in other digital as well as fiat currencies.

Although Ripple remains a popular (the third most traded) retail crypto-currency, what really makes it a good use case for the present paper is that Ripple (as a corporation) decided to avoid retail and instead to focus on the interbank clearing market for fiat currencies and, within that, to help banks perform cross-border transfers of such currencies faster and at a lower cost. The attraction of the segment is obvious. 'While cross-border payments account for less than 20 per cent of total payments volumes, they comprise about 40 per cent of global payments transactional revenues (ie transaction-related fees and float income), and generated US$300bn in global revenues in 2015'.[12]

So, consider the value case where Ripple proposes to reduce bank costs by 33 per cent (see Figure 1) by:

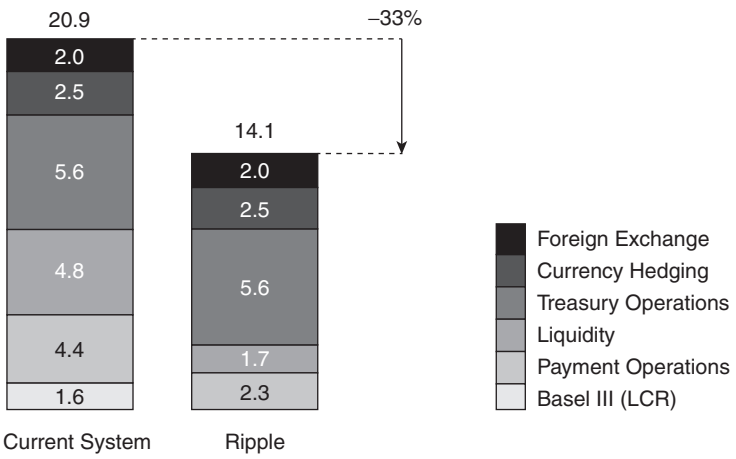


Figure 1: Potential cost reduction case

Source: Ripple (2016) 'The cost-cutting case for banks, the ROI of using Ripple and XRP for global interbank settlements', available at: https://ripple.com/files/xrp_cost_model_paper.pdf (accessed 8th September, 2017).

- reducing Nostro liquidity by 65 per cent by moving transactions across the ledger within the same day;
- reducing reconciliation costs by 48 per cent through the business process required by adherence to the rule book; and
- reducing BAL III (LCR) costs by 99 per cent through the use of real-time FX.

The merits of Ripple's analysis have not yet been validated in operational deployments; nevertheless, there are enough design details to observe that these improvements are not the result of using blockchain, or other unique features of crypto technology:

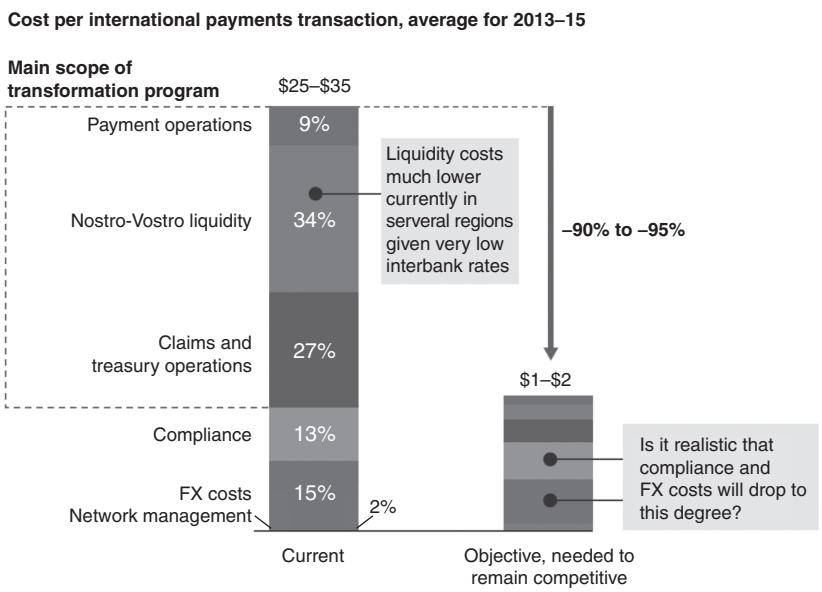
- Ripple has achieved immediate transmission between Ripple nodes by creating Interledger Protocol (now in open source). For an example of real-time distributed clearing without using consensus and related technologies, one can look to SWIFT in Australia's New Payments Platform. Both are in the very early stages, so no numbers are available to assess the relative merits of the two approaches.
- Ripple has achieved the traceability and immediate availability of funds to the receiver by requiring financial institutions that join its network to enhance their legacy infrastructure to enable this. The incumbent networks can impose the same conditions and some (eg SWIFT with GPI and Visa with Visa Direct initiatives) are already doing so (although to a significantly smaller degree).

The Ripple paper contains more ideas and more details that are beyond the scope of the present paper (particularly relating to the impact of the native currency, also called Ripples, on liquidity),[13] but they all fit into the above thesis — the technology advances created by Ripple do not materially change the cost–benefit proposition to banks; the new business and processing models that Ripple implements on top of its technology platform are driving the improvements.

POTENTIAL COST REDUCTIONS IN CROSS-BORDER CORRESPONDENT BANKING

In its 2016 paper, 'Digital transformation of correspondent banking' McKinsey states that 'To remain competitive, back-office costs for international payments will need to drop by 90 per cent to 95 per cent'[14] from the US$25–35 range to US$1–2 (see Figure 2).

Figure 2: Aspirational cost reduction opportunity



The appendix analyses the impact that crypto technology might have on the component costs and determines that, of the six components listed in Figure 2, two — claims and treasury operations and FX costs — do not lend themselves to blocktech solutions; and of the remaining four (which comprise 74 percent of the cost), blocktech is one of several possible solution vectors to cost reduction but by no means a clear leader.

One may therefore conclude that blocktech does not bring any unique advantages in this case, although for some components it ought to be as good as existing technologies.

IMPLICATIONS FOR DOMESTIC PAYMENTS

The potential for blockchain to transform payments is even smaller in the domestic context. As the number of steps is fewer and the steps themselves are simpler, the domestic process is far more efficient than the cross-border one. Equally, as there is significant competition in most domestic markets, the incumbent players have already achieved a high level of efficiency. Some blockchain players have claimed a ten-fold performance/cost advantage over legacy technologies, such as for real-time payments in the USA; however, there is, as yet, no empirical data from actual deployments to support this claim.

THE REST OF THE FIELD: OTHER (NEWER) BLOCKTECH SOLUTIONS

For the last few years, the predominant activity in payments has been around creating new coins. Arguably, the aim may be less about reducing costs and increasing the benefits of making payments and more about taking advantage of a new and largely unregulated funding mechanism — the initial coin offering (ICO) — while at the same time diversifying one's Bitcoin, Ripple and Ethereum holdings. From a technology perspective, none of them break new ground, although a number of different economic/settlement models have been proposed. For example, Humaniq (https://humaniq.co/) proposes a way to incentivise the use of its coin to make it attractive/useful to the 2 billion unbanked persons in the world. This may be crucial to the adoption of the new currency but does not change the cost–benefit profile established by Bitcoin in a material way.

In the wholesale payments infrastructure space, Ripple remains the front-runner by a wide margin. Although other blockchains, DLTs and crypto-tech solutions have been tested in proofs of concept, there is no evidence of them moving out of the experimental stage anytime soon.

LEGAL ASPECTS[15]

The operation of a DLT arrangement requires compliance with both technical and legal rules. The former consist of terms executed automatically by software and protocols so as to constitute 'smart contracts'. To be enforceable, such contracts must have a sound legal basis premised on the parties' consent and lack of any vitiating element such as unconscionability or material change of circumstances. Other than in relation to technical rules, legal rules can be divided into those dealing with governance and those dealing with regulation. For its part, governance is rule-making by the owners or participants with a view to safeguarding their own interests. In turn, regulation is rule-making, typically by an outside authority, with the view of representing the public interest. By consent, however, regulation may take place by means of contract or any other consensual organisational mechanism, in which case the line between governance and regulation may be blurred.

On the whole, existing legal rules governing payment clearing and settlement

have been drafted to accommodate the existing architecture of the system, and hence require adaptation to cover a DLT arrangement. By itself, this is a costly operation. The challenge, however, which is not to be conclusively resolved here, is to distinguish between those costs that once incurred will lead to a positive change and savings, and those that are effectively inherent in what will amount to a bad substitute to the traditional system. Moreover, in relation to a virtual currency of self-anchored value (that is, a privately issued digital currency hinging on cryptographic algorithms to control the creation of new units and facilitate payments whose value is not anchored in a specific asset such as a commodity or a fiat currency[16]) payable over a blockchain, such as Bitcoin, a preliminary legal question arises as to whether it is even 'money' in terms of being lawfully usable to discharge a debt, as well as to meet statutory requirements addressing 'money'. Taking into account the fluctuating value of a self-anchored currency, an additional challenge is how to provide for a legal framework facilitating price stability, eg by rebasing the amount of money, that is, adjusting the number of cryptocurrency units in every digital wallet.[17]

The decentralised basis of a DLT provides a challenge to governance, particularly in a permissionless DLT arrangement. It is a misconception to think of such arrangements as existing independent of human rule-making. This is so because technical rules must be produced and maintained. Unforeseen circumstances are unavoidable and the power of core developers may be in conflict with the will of the community. For permissioned DLT arrangements, governance is simpler because by definition there is a proprietor. Compared with both permissioned DLT arrangements as well as traditional payment systems, governance costs in permissionless DLT arrangements are bound to be higher because of the greater complexity of the technical arrangement, the sheer greater number of participants directly involved and the difficulty of getting a timely agreement. This can be seen from the drawn-out process and uncertainty in terms of responsibility and 'chain of command' involved in occurrences such as:

- scaling the size of the blocks in Bitcoin (so as to alleviate the fear that a backlog of transactions awaiting inclusion in a future blocks will clog up the Bitcoin network should blocks become consistently full);[18]
- the delays in addressing the known issues in Ethereum that led to the DAO exploit (under which a hacker exploited the design of the DAO and appropriated more or less US$50m worth of ether);[19,20] and
- the Ethereum flash crash (in which the value of the currency crashed within seconds from ~US$320 to as low as US$0.10 as a result of someone placing a multi-million-dollar sell order at market price).[21]

Regulatory legal considerations are numerous:

- There is a legal need to provide for the reliability and authoritativeness of the records on the distributed ledgers.
- Property rights in digital tokens representing physical assets as well as the liabilities and rights of parties transacting over them must be clearly defined and elaborated by law. As things stand now, there is not even a standard satisfactory definition as to what constitutes a digital asset, not to mention an elaboration of its relationship to the physical asset it represents.
- As new mechanisms (such as smart contracts) are created and adopted in payment and clearing systems, a satisfactory legal framework must be established to govern them at an equally rapid pace.
- A DLT arrangement generates new services and hence involves new players as intermediaries or otherwise providers of such services. This means licensing schemes, and possibly market conduct rules, including

those applicable to ICO (token sales), must be devised with a view to achieving, maintaining and improving both financial stability and protection of the public.

- To date, such arrangements have mirrored the existing structures — eg a Bitcoin Automated teller machine (ATM) parallels traditional ones, etc. However, it has not been validated that (or which) existing laws and rules apply, as is evident from the various treatments of virtual currencies — as property by the US Internal Revenue Service, a commodity by the US Commodity Futures Trading Commission, and as a currency (for VAT purposes) by the European Court of Justice.
- Settlement finality issues must be satisfactorily resolved. Settlement finality was defined to mean 'the legally defined moment at which the transfer of an asset or financial instrument, or the discharge of an obligation is irrevocable and unconditional and not susceptible to being unwound following the bankruptcy or insolvency of a participant'.[22] It is essential for the efficient operation of a payment clearing and settlement system. Indeed, blockchain systems are designed to prevent the 'double spending' of a 'coin' so as to ensure that payment will be carried out only with available funds. In a DLT arrangement, however, the process of settlement may not be short or even of an exact or predictable duration, and the point of finality may not be easily identifiable. In the proof-of-work model, the first updating instance merely signals the beginning of the process of ledger synchronisation leading to the achievement of consensus across the nodes. Hence, subsequent models (consensus, proof of stake) are being examined to address the technical considerations of, for example, defined service-level agreements to achieve final consensus.
- More complexity is introduced via delivery-versus-payment (DVP) and payment-versus-payment (PVP) systems. Furthermore, a DLT arrangement legal framework may neither provide for nor even address legal settlement finality. Indeed, settlement issues become even more complex when assets off the chain or off-chain transactions are considered.
- The payment systems must comply with secrecy, anti-money laundering and anti-terrorist financing requirements. All of these are more costly in the distributed (no governing jurisdiction) and permissionless (no identifiable responsible party) environments. In fact, decentralisation further challenges traditional methods of the enforcement of a judgment as well as of a security interest as, without the cooperation of the owner of an asset placed on the blockchain, the asset may not be accessible.
- Certain issues existing in relation to electronic funds transfers appear in a modified form in payment over a blockchain, such as mistaken as well as unauthorised payments. Unlike in a traditional payment system, there is no funds holder intermediating in the payment transaction, or in fact any accountable intermediary involved in the process of payment, which could potentially absorb losses and distribute the costs.
- Last and certainly not least, numerous questions arise regarding 'conflict of laws'. Such questions relate to jurisdiction as well as to the selection of law that will apply to private arrangements. This is particularly notable in light of the inherent ambiguities in pointing at the location of a contract/transaction, the blockchain and the money or monetary value itself.

Regulatory arrangements are partly set by the authorities and partly by contract or otherwise by industry autonomous bodies. Contractual or other private arrangements require negotiations and agreement — activities in which costs are incurred. Compliance with regulatory arrangements, of whatever source, is costly. Intuitively, the mere decentralised nature of the blockchain

arrangement, not to speak of its novelty as outlined above, is likely to increase compliance costs. Novelty and lack of precedents are certain sources of higher dispute resolution including litigation costs.[23]

Globalisation is enhanced by the cross-border scope of DLT in general and blockchain technology in particular. At the same time, globalisation has not caught up with its law-making. As such, there is a good chance that jurisdiction-by-jurisdiction law-making will be neither uniform nor even harmonious. The segmentation will increase disputes involving conflict of laws, as outlined above; therefore it is also bound to increase regulatory compliance costs. To meet the needs arising in such an environment, regulatory technology (RegTech) solutions are being offered with claims to achieving significant reduction in costs.[24,25] It may be too early to assess and quantify the value generated by such solutions.

At present, any claim to legal cost reduction in a blockchain environment remains unproven. Moreover, it seems that RegTech solutions will work equally well for traditional payment systems, so that any alleged competitive advantage they give to blockchain technological solutions remains tenuous. In the final analysis, legal costs will not be the dominant factor for blockchain technological solutions for payment and settlement systems. Issues raised in the course of globalisation, such as segmented regulation, also exist for traditional payment systems, and in each case are to be met by greater harmonisation of the law-making process. In the final analysis, once and wherever a strong business case is made for the adoption of blockchain technological solutions, the chance is that legal requirements designed to make adoption possible will be worked out whatever their cost may be. Stated otherwise, the existence of legal costs is unlikely to be a decisive factor in determining whether such solutions are to be adopted. The burden of legal costs may make a difference only in solutions with a marginal business case that do not have the margin to absorb even small variations.

CONCLUSION

Eight years have passed since the birth of Bitcoin in 2009. Overall, the impact on payments has been modest. Bitcoin created and still dominates the censorship-resistant payments niche, but has had very limited adoption beyond that, as neither benefits nor costs have been sufficiently compelling to outweigh the negatives and the adoption risk. The fact that when split into 'original' and 'higher-performance' versions, the Bitcoin price exceeded US$4,500 in August 2017, while appearing significant, does not alter that conclusion.

FinTechs have well-defined plans for improving efficiency through back-end innovation. For example, moving the Ethereum (the second most popular currency) ledger from proof-of-work to a much more efficient proof-of-stake is currently in the proof-of-concept stage. However, the gains in efficiency alone are unlikely to overcome the cost deficit as long as the solutions still have to rely on an ecosystem of parties to perform legal/regulatory due diligence (exchanges) and to mediate between fiat and crypto currencies.

Furthermore, although not a direct cost, the fact that the user experience is still very technical and does not rise to the level of the best mobile products (eg Pangea[26]) is definitely an area that must be improved if benefits are to be delivered to the masses.

Ripple's impact has been to cause the largest incumbent (SWIFT) to initiate Global Payment Innovation to materially improve its quality of processing. Once real-time domestic payment infrastructures begin to interoperate, this will likely result in costs falling closer to domestic levels.

To break out of its boutique status in payments, the blocktech industry has to

find a way to execute on two distinct fronts simultaneously:

- achieve a material reduction in infrastructure costs (say ten-fold); and
- deliver meaningful new benefits that can create viral network growth (something that Bitcoin — the most successful implementation to date — has failed to do).

What is more, it must do this quickly, as competitors are racing to the same goal and the window of opportunity is beginning to shrink.

References

(1) Bala, V. (2014) 'Lessons in innovation leadership: Chris Larsen', available at: http://www.nielsen.com/us/en/insights/news/2014/lessons-in-innovation-leadership-chris-larsen.html (accessed 24th June, 2017).

(2) See eg Chapman, J., Garratt, R., Hendry, S., McCormack, A., McMahon, W. (2017) 'Project Jasper: are distributed wholesale payment systems feasible yet?', available at: http://www.bankofcanada.ca/wp-content/uploads/2017/05/fsr-june-2017-chapman.pdf (accessed 24th June, 2017).

(3) Coindesk (2016) 'At $400 million a year, academic argues Bitcoin mining worth the cost', available at: http://www.coindesk.com/400-million-year-researcher-argues-Bitcoin-mining-worth-cost/ (accessed 24th June, 2017).

(4) *Ibid*.

(5) Voorhees, E. (2017) 'The true cost of Bitcoin transactions', available at: http://moneyandstate.com/the-true-cost-of-Bitcoin-transactions/ (accessed 24th June, 2017).

(6) Coinbase (2017) 'Coinbase pricing & fees disclosures', available at: https://support.coinbase.com/customer/portal/articles/2109597-buy-sell-bank-transfer-fees (accessed 24th June, 2017).

(7) Wikipedia (n.d.) 'Charlie Shrem', available at: https://en.wikipedia.org/wiki/Charlie_Shrem (accessed 24th June, 2017).

(8) Key, K. (2016) 'Bitfinex bail-in versus central bank bailouts', available at: https://news.Bitcoin.com/bitfinex-bail-in-central-bank-bailouts/ (accessed 24th June, 2017).

(9) Vias, M. (2017) 'Ripple consensus ledger can sustain 1000 transactions per second', available at: https://ripple.com/insights/ripple-consensus-ledger-can-sustain-1000-transactions-per-second-2/ (accessed 24th June, 2017).

(10) Bonneau, J. (2015) 'How long does it take for a Bitcoin transaction to be confirmed?', available at: https://coincenter.org/entry/how-long-does-it-take-for-a-Bitcoin-transaction-to-be-confirmed (accessed 24th June, 2017).

(11) Treacher, M. (2016) 'Announcing Ripple's global payments steering group', available at: https://ripple.com/insights/announcing-ripples-global-payments-steering-group/ (accessed 24th June, 2017).

(12) Niederkorn, M., Bruno, P., Istace, F. and Bansal, S. (2016) 'Digital transformation of correspondent banking, global payments 2016: strong fundamentals despite uncertain times', available at: https://www.smefinanceforum.org/sites/default/files/post/files/McKinsey_Global_Payments_Report_2016.pdf (accessed 24th June, 2017).

(13) Ripple (2016) 'The cost-cutting case for banks, The ROI of using Ripple and XRP for global interbank settlements', available at: https://ripple.com/files/xrp_cost_model_paper.pdf (accessed 24th June, 2017).

(14) Niederkorn *et al.*, ref. 12 above.

(15) Much of this section derives from UK Government Office for Science (2016) 'Distributed ledger technology: beyond block chain', available at: http://www.ameda.org.eg/files/gs-16-1-distributed-ledger-technology.pdf (accessed 10th September, 2017); Mills, D., Wang, K., Malone, B., Ravi, A., Marquardt, J., Chen, C., Badev, A., Brezinski, T., Fahy, L., Liao, K., Kargenian, V., Ellithorpe, M., Ng, W. and Baird, M. (2016) 'Distributed ledger technology in payment, clearing and settlement', available at: https://www.federalreserve.gov/econresdata/feds/2016/files/2016095pap.pdf (accessed 10th September, 2017); and Committee on Payments and Market Infrastructures (2017), 'Distributed ledger technology in payment, clearing and settlement: an analytical framework', available at: http://www.bis.org/cpmi/publ/d157.pdf (accessed 10th September, 2017).

(16) Geva, B. (2016) 'Disintermediating electronic payments: digital and virtual currencies', *Journal of International Banking Law and Regulation*, Vol. 31, No. 12, pp. 661–674.

(17) See Ametrano, F. M. (2016) 'Hayek money: the cryptocurrency price stability solution', available at: http://dx.doi.org/10.2139/ssrn.2425270, (accessed 26th June, 2017).

(18) Caffyn, G. (2015) 'What is the Bitcoin block size debate and why does it matter?', available at: http://www.coindesk.com/what-is-the-Bitcoin-block-size-debate-and-why-does-it-matter/ (accessed 26th June, 2017).

(19) Gelvez, M. (2016) 'Explaining the DAO exploit for beginners in solidity', available at: https://medium.com/@MyPaoG/explaining-the-dao-exploit-for-beginners-in-solidity-80ee84f0d470 (accessed 26th June, 2017).

(20) Leising, M. (2017) 'The ether thief', available at: https://www.bloomberg.com/features/2017-the-ether-thief/ (accessed 26th June, 2017).

(21) Tepper, F. (2017) 'Coinbase is reimbursing losses caused by the Ethereum flash crash', https://techcrunch.com/2017/06/24/coinbase-is-reimbursing-losses-caused-by-the-ethereum-flash-crash/ (accessed 26th June, 2017).

(22) Committee on Payments and Market Infrastructures, ref. 15 above.

(23) Higgins, S. (2017) 'Bitcoin mining fraud lawsuit moves forward in New Jersey', available at: http://www.coindesk.com/Bitcoin-mining-fraud-lawsuit-moves-forward-new-jersey/ (accessed 28th June, 2017).
(24) Willms, J. (2017) 'RegTech for Fintech may be the next "big thing" in the Bitcoin and blockchain space', available at: (accessed 24th June, 2017).
(25) Blaisdell, G. (2017) 'SEI exploring Blockchain with Coinfirm in their New Regtech incubator "Codify"', available at: http://www.prweb.com/releases/2017/04/prweb14269864.htm (accessed 24th June, 2017).
(26) Pangea (2017) 'Pangea wins best user experience and fastest transfer awards', available at: https://www.finder.com/pangea-winner-best-user-experience-money-transfer-award (accessed 24th June, 2017).

APPENDIX: ANALYSIS OF THE COST ELEMENTS OF INTERNATIONAL PAYMENTS

Category	*Category description*	*Analysis: Can crypto make a difference?*
Payment operations	Costs linked to reconciliations and investigations/exceptions items	*Crypto is one of several options under evaluation — but not a clear leader* Costs are linked to the business process that allows exceptions. Switching to a real-time, 'all or nothing' business process (such as Ripple or any modern real time payments infrastructure) will reduce the costs. The reduction will be driven by how quickly the industry (rather than any single player) adopts a real-time mindset. Although we have the technology to implement real-time FX settlement, there are no indications that the FX spot market is even contemplating to move in that direction in the near or mid-term, thus maintaining the disconnect (and the need for reconciliation) between the trade and the settlement.
Nostro-Vostro liquidity	Cost of trapped liquidity caused by the absence of systematic real-time reporting and the lack of trust (eg uncommitted lines) among correspondent banking partners	*Crypto is one of several options under evaluation — but not a clear leader* Multiple solutions exist for real-time reporting — and SWIFT Tracker would be a front-runner (because it is leveraging the established network). DLTs are being considered for the role but at present there is no evidence that they will shift the cost curve. Project Jasper, the latest experiment in Canada, did not find a benefit in a similar use case — of using DLT for settlement. Lack of trust cannot be solved by technology, although smoother operating process (see above) will help.
Claims and treasury operations	Complex interbank pricing rules create the need for manual invoicing, claims-handling and dispute management, requiring substantial manual effort	*Crypto has no role* The complexity of interbank pricing is independent of technology, although a smoother process again may influence the banks to simplify the rules. More likely, the competition from closed-loop infrastructure will drive that and process and technology improvements will support the process.
Fraud and compliance	Bad actors are allowed to enter the network, lack of information sharing leads to sub-optimal problem identification and decisioning	*Crypto is one of several options under evaluation — but not a clear leader* The whole area of access controls and better fraud, anti-money laundering detection is highly active, with AI and biometrics being frontrunners. In the area of information sharing, DLTs are being reviewed as one of several viable alternatives. It is worth noting that centralized sharing mechanisms (eg FS-ISAC) effectively and efficiently provided this capability for cyber security, demonstrating that existing centralised approaches are fit for purpose.
FX costs	The actual costs of doing FX	*Crypto has no role* Although many providers point to an increase in competition as a mechanism to drive down costs, given the size and liquidity of the FX market (over US$5tn trades per day), adding thinly traded currencies is likely to have no effect, or an opposite effect.
Network management	The need to negotiate and maintain the multitudes of bilateral agreements and large numbers of correspondent banking relationships	*Crypto is one of several options under evaluation — but not a clear leader* The de-risking drive is already causing banks to shrink the number of relationships. A smoother process will help. Equally, linking domestic immediate payment infrastructures and raising transaction limits will also significantly simplify network management, and we may get there soon.