Can Blockchains and Linked Data Advance Taxation?

Michał R. Hoffman
University of Southampton
M.R.Hoffman@soton.ac.uk

ABSTRACT

Permissioned distributed ledgers (permissioned blockchains) supporting smart contracts that automatically adjust accounts and coordinate records among multiple parties, present a valid platform opportunity for establishing a fully digital tax regime. We propose a permissioned blockchain-based system aimed at eliminating some of the losses that tax authorities globally are currently struggling with. These multi-billion flaws manifest themselves as the tax gap, or the inability to collect the full amount that is owed by a given entity to a particular authority. Illegitimate or inefficient tax operations could be prevented with a global suite of smart contracts deployed on top of a consortium distributed ledger with on-chain governance. We also introduce the vision for a VAT Invoice 2.0 modelled as a Linked Data document. A tax reference generated by a smart contract would allow anyone with the right permissions to immediately investigate the entire commercial chain for any taxable item on an ontology-based tax document.

KEYWORDS

blockchain, permissioned blockchains, tax ontologies, tax gap, VAT gap, smart contracts, on-chain governance, linked data

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1 INTRODUCTION

Distributed ledgers, also known as blockchains, provide decentralised, tamper-free registries of transactions among partners that distrust each other. Blockchain platforms keep permanent and unchangeable records of transactions between multiple parties, whilst also enabling those parties to run smart contracts, which can be thought of as self-executing agreements that do not need a centralised third party to verify [23].

In 2015, the World Economic Forum survey found that 73.1% respondents expected tax authorities globally to have begun collecting taxes via blockchain by the year 2023 [19]. As of today, global taxation systems lack operational efficiency when dealing with complex transactions, leading to loopholes that create billion-dollar losses every year [6]. These losses are generally suffered by nation states as opposed to corporate entities. Most consultancies have already launched research into how blockchains could improve the tax system [20] and potentially end VAT fraud altogether [13].

Although the use of distributed ledgers has been researched in many fields such as financial markets, banking and land registry services, its application in the fields of accounting, audit and taxation remains under-explored[7].

2 IS THE TAX SYSTEM BROKEN?

There are multiple inefficiencies in tax systems globally, but for the purpose of this paper, we shall focus on the *tax gap*, and some of the main factors contributing to it, such as tax avoidance or the issue of dishonest tax refund applications. The *tax gap,* [14] which most commonly manifests itself as the *VAT gap*, is the difference between the amount of tax (normally VAT) that is owed by taxable entities (normally corporations) to a particular tax authority (for example, Her Majesty's Revenue and Customs) and the amount that actually gets collected. What gets collected is typically much less than anticipated - in the United Kingdom, the tax gap is in the order of billions of pounds [18]. The official UK figure for the year 2017, as estimated by HM Revenue and Customs, is 34 billion pounds [21].

Tax avoidance is believed to be an important contributor to tax gaps around the world [9], as corporations have an incentive to manipulate their local books to gain a tax advantage globally. In the case of multinational corporations, it is particularly difficult to prove how a profit can be "created" in any particular country, given the complex flow of commercial internal and external transactions that cross borders, and the difficulty in coordinating the flow of information between different states' tax systems. Tax avoidance often involves contrived transactions that serve little purpose other than to generate a tax advantage. How much is lost to this practice is very difficult to measure [17]. Nevertheless, certain tax avoidance techniques have been receiving more research attention than others; in particular, BEPS (*base erosion and profit shifting* [8]), which is a strategy that exploits mismatches in tax rules to artificially transfer taxable profits to low tax locations where there is little actual economic activity.

As of 2018, there is still no global information system dedicated to managing the cross-border information flow in order to reliably check which economic activities have originated in which country[1]. There currently only exist local, or federated solutions to this problem, and those solutions typically operate on the basis of centralised data. In the European Union, for example, the VAT information exchange system (VIES) is a database solution to cross-border VAT inefficiencies. It is based around multiple centralised data centers that are linked through semiautomatic (frequently manual) data exchange processes [1]. These manual processes can cause

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many operational issues, for example, if more than two traders participate in a *chain transaction*[1] (eg. a baker in Austria buys flour in Poland, and uses it to bake cakes that are later sold in Germany), certain conditions must be checked in the home countries of all participating entities. The lack of transparency and the complexity of those manual processes could be alleviated by employing a globally-enabled permissioned blockchain to automate them. We explain our vision in more detail in the following sections.

3 THE CASE FOR BLOCKCHAINS IN TAXATION

One of the core advantages of a distributed ledger over a database is that it helps avoid replication errors [22] and delays when dealing with a huge number of parties. Blockchains are also superior for preventing forgeries and disabling unauthorised reversals of transactions.

Certain countries' tax authorities are currently exploring the use of blockchain technology to combat taxation fraud by tracing and matching data and improving reporting. The Danish Maritime Authority has launched a pilot project to register ships via a distributed ledger, to ensure the integrity of all relevant tax payments [3]. UK and Australian governments are already conducting comprehensive reviews to examine blockchain's potential for a range of government services[2].

3.1 Permissioned vs. Permissionless

In a "permissionless" distributed ledger such as the Ethereum platform, or the original blockchain underpinning Bitcoin, anyone can operate a node and participate in the chain through investing their CPU cycles. In our use case, the reliance on heavy computation to create trust is not just redundant (as tax authorities inherently possess trust which has been created in a legal albeit non-computational manner) but also prohibitively expensive. In a sophisticated blockchain use case like the one we describe in this paper, the advantage of the **permissioned** mode in terms of cost and throughput becomes tangible. In the permissioned model, the platform controls who is allowed to participate in the validation processes and in the protocol itself. Permissioned blockchains have a stronger notion of *identity* that can be managed by use of certificates. Furthermore, they allow grouping users according to a particular consortium, where trust is "transferred" from real-world trusted entities, such as government agencies and tax authorities.

3.2 Hyperledger: Fabric and Sawtooth

Hyperledger Fabric [3] is an implementation of a permissioned distributed ledger platform, running smart contracts, on top of a modular pluggable architecture. The distributed ledger of the fabric is run as a peer-to-peer protocol. The blockchain supports two kinds of peers: a validating peer responsible for running consensus and maintaining the ledger; and a non-validating peer that functions as a proxy to connect clients. Some key features of Fabric are:
- it is a permissioned blockchain with immediate finality;
- runs arbitrary smart contracts (called chaincode);
- user code becomes encapsulated in Docker containers;
- pluggable consensus protocol;
- supports certificate authorities (CAs) for identity management;
- supports transaction certificates;
- persistent state using a key-value store interface;
- an event framework that supports pre-defined and custom events;
- a client SDK (Node.js) to interface with the fabric;
- support for REST APIs and CLIs. Hyperledger Sawtooth[4] is much newer and was released at the time of writing this paper. It shares many capabilities with its Fabric predecessor, whilst also implementing the following:
- On-chain governance: smart contracts can be used to vote on blockchain configuration settings such as roles and permissions;
- Ethereum compatibility: solidity code can be deployed and executed on Sawtooth;
- Broader language support:smart contracts can be programmed in Go, JavaScript and Python.

4 THE "HOLY GRAIL" FOR TAX

For the taxation use case, a permissioned blockchain seems to be an essential requirement. Hyperledger Sawtooth, as outlined in the previous section, appears superior due to its on-chain governance features, that could be used to replicate real-world taxation governance structures and processes.

Managing bodies could use Sawtooth to ensure roles and permissions, ultimately setting up data access so that only participants that are party to a transaction can see sensitive details, a feature deemed necessary given the legal frameworks within which tax is assessed and collected. Smart contracts would be used to automatically synchronise data in real time between tax authorities in different countries.

This set-up is sometimes called a *consortium blockchain*. Vitalik Buterin, the creator of Ethereum, defines a consortium blockchain as "a hybrid between the low trust provided by public blockchains and the single highly-trusted entity model of private blockchains, whereas the latter can be more accurately described as a traditional centralised system with a degree of cryptographic auditability attached"[5]. The use of a modular system like Sawtooth would allow each country belonging to the global tax "consortium" to preserve their own taxation rules on the local level, whilst making it much easier to synchronise relevant tax information globally.

The authority and trust created outside of the networks ensures that participants trust what is committed to the ledger, whilst virtually all of the logistical issues associated with creating trust artificially (cost, speed, throughput and contract complexity) disappear.

In the case of the European Union, migrating from a central database, like VIES, to a consortium of multiple countries, running smart contracts on top of a permissioned blockchain, achieves the following beneficial outcomes:
1. Removing a single point of failure for the whole system.
2. Removing incentives for corruption by de-centralising power.
3. Avoiding replication errors and delays when dealing with a huge number of parties globally.
4. Preventing forgeries through the use of cryptography.

[1] https://www.pwc.com/sk/en/tax-services/value-added-tax/chain-transactions-and-vat.html
[2] https://www.gov.uk/government/news/distributed-ledger-technology-beyond-block-chain
[3] http://github.com/hyperledger/fabric
[4] http://hyperledger.org/projects/sawtooth

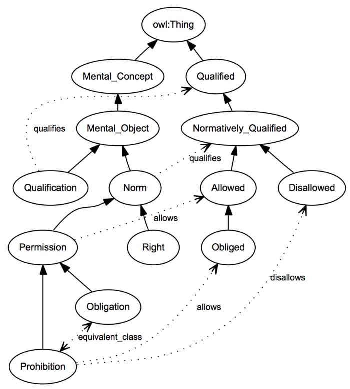

Figure 1: The LKIF core ontology[11] models important legal concepts

5. Disabling unauthorised reversals of transactions.
6. Providing a decentralised gateway for auditability.
7. Finally, assuming a modern robust legal framework that recognises blockchain data as belonging to a "universal jurisdiction" with its own visionary dispute resolution layer, the flow of confidential data between different jurisdictions would be much simplified.

Such a system would help close the tax gap through tackling BEPS, it could also help tackle many other ailments of the current tax regime. A good example would be chain transactions discussed earlier. Another example would be tackling an applicant's eligibility for a tax rebate. Illegitimate tax compensations are a challenge to trace. Although many countries globally have implemented double taxation treaties, these laws have not been matched with the right infrastructure to exchange information between tax authorities[12]. Authorities would benefit from a permissioned consortium blockchain to improve the data flow when managing duplicate cross-border claims.

4.1 Tax and Linked Data

The purpose of this section is to outline how a working solution would need to implement Linked Data principles to provide large scale integration of, and reasoning on, tax data. Ontologies (vocabularies) define the concepts and relationships of a particular domain [24]. They are useful for structuring and indexing information, and making data inter-operable[4]. Essentially, they help building knowledge and foster the understanding of the domain.

Modelling the tax code has historically posed a challenge to information scientists [16] due to the complexity of the domain, spanning countless industries across hundreds of countries worldwide. Nevertheless, there have been multiple ontologies proposed for describing various tax regimes around the globe. The earliest such effort can be found in the TAXMAN model by McCarty [15] in the 1970s.

Recently, a TKA (Tax Knowledge Adventure) ontology has been proposed [2], based around the 2007 LKIF Core ontology of basic legal concepts [11]. This ontology, a fragment of which we illustrate in Figure 1, models essential legal concepts such as the notion of *obligation* and *permission*.

In [10], Glaser proposes an ontology for decentralising technology infrastructure using blockchain systems. The framework provides cross-disciplinary researchers with an organised knowledge base and a common language describing the terms, concepts and their relationships within the blockchain domain.

By combining an LKIF-based tax ontology with a Glaser-based blockchain ontology, we could arrive in the future at a new type of vocabulary best suited for our use case.

4.2 The VAT Invoice 2.0

The invoice is the most essential tax document. We propose that every valid tax document be modelled as a Linked Data document, built using an ontology discussed in the previous subsection, and tagged with a digital identifier generated by a smart contract. The provenance, traceability and transparency of transactions is then achieved. Assuming the use of Hyperledger Sawtooth, set up as discussed above, we could generate a set of APIs that provide taxation support. A mobile phone connected to the Internet could be all that is needed to scan a tax document and quickly resolve the list of all transactions from the VAT Invoice 2.0. By using unique tax references, we could immediately investigate the entire commercial chain for any taxable item on a tax document.

The client could potentially reuse the open-source Hyperledger Explorer[5] which is a powerful blockchain module and one of the Hyperledger projects. Designed as a user-friendly Web application, the Explorer can view, invoke, deploy or query blocks, transactions and associated data, network information and transaction families.

This proposal could trivially solve the problem of falsified or mismatching VAT documents, which would provide value between customers and businesses. Using a smart contract, it would be easy to check whether the version of a VAT invoice presented by the customer and stored in his or her personal data store matches the version stored in the data store of the company who issued the original invoice.

This would also be the essential first step towards solving more complex tax anomalies such as BEPS or illegitimate refund claims. By combining the Vat Invoice 2.0 with provenance information about products and services, we would have a way of tracing where each product and service originated, and by using appropriate tax rules for each product and service, we could establish where profit was actually created, eg. by using a SPARQL query.

5 OPEN CHALLENGES

There exist a number of open challenges that need to be overcome in order to realise the vision for a distributed ledger tax regime:

5.1 Standards

The blockchain community is well aware of the fact that without interoperability and standards, it will be difficult for any solutions to truly gain traction within established industries. The rapid establishment of multiple consortiums to examine governance and standards in Blockchain development are evidence that efforts towards this goal are underway. ISO/TC 307 [6] is the official ISO code for the standardisation of distributed ledger technologies. There

[5] https://www.hyperledger.org/projects/explorer
[6] https://www.iso.org/committee/6266604.html

are currently 6 standards being discussed to normalise terminology, privacy, security, identity, reference architecture and ontology. These efforts are all in early stages.

5.2 Privacy

There is an inherent trade-off between privacy, which is required by many legal frameworks, and transparency, which is a design principle of distributed ledgers. In the context of European Union, the General Data Protection Regulation, issued in 2016, requires an in-depth investigation by legal experts on how it should apply to distributed ledgers. A better understanding is needed on what constitutes personal and personally identifiable information on a blockchain, and what protection mechanisms are required.

5.3 Reversibility and Dispute Resolution

By default, all transactions on blockchains are final, which is a desirable design principle, guaranteeing trust through non-repudiation. Nevertheless, mistakes are bound to happen when dealing with commercial transactions, disputes and refunds. A layer needs to be provided on top of distributed ledger data to manage conflicting edits, or when a party challenges an established record. This could be achieved, for example, through a simple protocol with the following rules:

1. Data cannot be deleted (by blockchain principle).
2. Data can only be inserted in a [Timestamp, Key, Value] format.
3. Data can only be inserted through an authorised open-source smart contract.
4. The inserting smart contract checks if an older value exists for the same key. If false, data is added. If true, a dispute resolution contract is called.
5. Data can only be retrieved through an authorised open-source smart contract.
6. The retrieval smart contract always returns the newest value for a particular key.

If implemented properly, a dispute resolution protocol could add value between businesses and governments by facilitating non-judicial conflict solving and offloading traditional legal systems.

6 CONCLUSION

Core attributes of blockchains point towards the significant potential for use in tax. We make our case that only permissioned blockchains such as Hyperledger Sawtooth are valid for this use case, as access is restricted to identifiable parties, and trust is bootstrapped from legally established authorities.

While distributed ledgers are not the cure-all for tax systems, they could be applied in a number of areas to reduce the administrative burden and collect tax at a lower cost, helping to narrow the tax gap and minimise fraud. Many governments and consultancies are already exploring this space. We argue that blockchains could add value between businesses, between businesses and consumers, and between businesses and governments. There is a need for experimentation as well as further research into the societal implications of blockchains and the changes brought by the use cases such as the one discussed in this paper.

There exist a couple of open problems that need to be solved in order to realise the vision for a distributed ledger tax regime and the VAT Invoice 2.0. Distributed ledger terminology, privacy, security, identity, reference architecture and ontology need to be standardised. More work is needed to understand what constitutes personal data and personally identifiable information on a blockchain, and protocols need to be developed for resolving disputes.

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