The use of blockchain technology and AI is increasingly being discussed to fulfil compliance requirements and automate transfer pricing functions. The development of suitable technical concepts is necessary for this purpose. Even if these concepts are still in their infancy, their use in this area of transfer pricing is becoming noticeable.

1. Introduction

“Blockchain technology solves all problems”. This impression is partly gained by following current discussions on digitalization in tax law. Dominant topics in this context are the implementation of blockchain technology and artificial intelligence (AI). However, the digitalization of tax law using new technologies is much more far-reaching. For example, this includes the use of biometric identification, chatbots, robotics, and the automation of tax processes that can be achieved through process mining and robotic process automation.

Nevertheless, the introduction of blockchain concepts is desirable and intensively discussed in tax law. The implementation of blockchain technology and AI is interesting in tax law areas where a large volume of data is processed. This is the case in indirect taxation, like value added tax and customs, but also in transfer pricing.

Digitalization will have a strong impact on tax law in the future. Using transfer pricing as an example, it is therefore important to implement the automation of processes and to develop new concepts. This article is relevant for both scholars and practitioners. Blockchain technology can reduce transfer pricing disputes and documentation requirements for transfer pricing. The digitalization of the supply chain offers opportunities to standardize the calculation of transfer pricing.

In addition to blockchain technology, the use of AI is an important component in the digitalization of transfer pricing processes. This can lead to a reduction of the expenditure of resources and a higher legal certainty for companies and governments. If in-house transfer pricing processes are holistically digitalized and standardized, the automated auditing of transfer pricing can be carried out by tax authorities. Increased cooperation and intensive data exchange between tax administrations and taxpayers on equal terms is an international trend.

Blockchain technology is just one building block in securing trust in the processing and transmission of data. Governments and tax administrations should therefore introduce legal or administrative provisions enabling the verification of internal company data and consequently the auditing of transfer pricing.

However, there are not only advantages to be derived from the digitalization of internal company data through a blockchain. Under the theoretical concept of blockchain technology, data could be made more transparent, thus the enterprise internal data and trade secrets are in danger of becoming public. This article will describe existing technical concepts that can solve this problem.

Before blockchain systems are introduced in enterprise resource planning (ERP) systems and a transfer pricing calculation is added, it is necessary to consider various arguments. This article is intended as a starting point for further discussions.

2. Blockchain as a Relevant Technology for Transfer Pricing

2.1. Possible applications

Multinational enterprises (MNEs) often have a decentralized company structure, in which many internal company transactions between the various subsidiaries are carried out. On a technical level, different company servers with relevant transaction data in different data formats exist. Corporate units have to consolidate all data for analysis purposes. Van Rijmenam has analysed that large process-oriented organizations often try to transform their decentralized structure into a central one. However, the
decentralized blockchain technology is well suited for merging data and processes in a genuinely decentralized organization structure.\textsuperscript{7} Transfer pricing departments or transfer pricing consultants must merge this data to calculate the correct transfer price, according to the “arm’s length principle” and to have the necessary documentation available. If comprehensive standardized transaction data is available, the automation of transfer pricing processes can be more easily implemented.\textsuperscript{8} To automate a process, a strong process must first be available as a core element. If transfer pricing processes are well established, automation can also be implemented.\textsuperscript{9}

From an engineering point of view, a blockchain is a good way to avoid having to synchronize data from different internal ERP systems within the group. The data can be stored in a decentralized and standardized manner. A complete transformation of all ERP systems on a blockchain is a long-term goal, which is why interfaces from blockchain-based systems to other parallel existing systems of the subsidiaries must be established for a transitional period.\textsuperscript{10} The introduction of a blockchain in MNEs is also desirable if other ERP systems exist in parallel. A decentralized blockchain system can function as an interface and connect different systems and formats.\textsuperscript{11}

Transfer pricing departments often face the problem that information on relevant transfer pricing issues arises afterwards. This may require a correction of the tax return. It is therefore necessary to have all necessary information available as soon as possible. The correct collection of data and application of transfer pricing principles can be monitored in real time across all business units via a blockchain system.\textsuperscript{12}

A blockchain can also contribute to audit-proof archiving of transfer-pricing-relevant data. The mapping of intercompany data on the blockchain can reduce the expense of providing documents during a tax audit.\textsuperscript{13} This issue is particularly relevant because the OECD/G20 BEPS Project has introduced new documentation requirements in the framework of Country-by-Country (CbC) reporting. The transfer pricing documentation basically consists of a Local File, a Master File and a CbC report.\textsuperscript{14} The blockchain can contribute to a holistic view of all relevant transfer pricing data and thus facilitate the consolidation and automated generation of reports. By having complete data from the entire supply chain, the application of a profit split can also be carried out effectively. In the case of intercompany contracts, blockchain can also be used in tax audits to prove the actual performance or receipt of services. This can simplify tax audits by opening interfaces for tax authorities.\textsuperscript{15} Overall, the focus is on the transparent documentation and consolidation of transaction data between subsidiaries via a blockchain for transfer pricing purposes.

### 2.2. Blockchain technology

The key principle of blockchain is a decentralized ledger. The blockchain technology combines several already existing technologies. The technology should enable direct interaction between unknown parties without the need for trusted parties (peer-to-peer).\textsuperscript{16} The best-known example in this context is the cryptocurrency bitcoin.\textsuperscript{17} Trust is established through cryptographic encryption of data and a linking of different transactions to a chain. Trust in the integrity of the transmitted data is not provided by intermediaries, rather by a consensus mechanism. So-called miners in the system validate the action by solving a mathematical puzzle and then add the data to the chain. In the basic concept, a majority of the miners must support the authenticity of the information and are economically rewarded for their performance by the system. The data of the different blocks on the chain are connected to each other and cannot be deleted to maintain the integrity of the chain. In theory, any person (node) can enter information on a blockchain or validate information as a miner.\textsuperscript{18} This model is called a permissionless public blockchain, every node is entitled to read and write information on the blockchain. This means that theoretically all data entered on the blockchain is transparent for all participants. There are deviating models from this basic theoretical concept, which regulate the transparency of information, the admission of participants and the write/read rights. These are for example permissioned public blockchains or permissioned private blockchains.\textsuperscript{19}

Smart contracts are applications that run and are administered on a blockchain. A smart contract executes an action safely based on previously defined conditions. The automated processing of previously defined conditions is a core element of a smart contract. Sources of external information on the basis of which the contract is executed are called oracles.\textsuperscript{20} A problem in this context is that third parties can only have limited trust in the execution of a smart contract if the information comes from a source

7. M. van Rijmenam, The Organisation of Tomorrow – How AI, Blockchain, and Analytics Turn Your Business into a Data Organisation p. 100 (Routledge 2020).
11. X. Xu et al., The Blockchain as a Software Connector, p. 184 ff (33th Working IEEE/IFIP Conference on Software Architecture 2016).
13. Tönnissen & Teuteberg, supra n. 4, at pp. 1169 and 1175.
outside the system that is not consensus-based. Block- 
chain operating systems that offer a technical framework 
are for example Ethereum, Hyperledger Fabric, etc.

3. Necessary Design of Blockchain Models

3.1. Existing concepts

In the literature and in academia there is a discussion on 
how transfer pricing-relevant data should be recorded on 
the blockchain. Previously discussed blockchain con- 
cepts in the field of transfer pricing often use a permis- 
sioned private blockchain. The reasoning is to control 
transfer pricing data and to reduce transparency within 
the system. Furthermore, the writing and reading author- 
ization can be better controlled via smart contract monitor 
compliance with the permissible range of transfer 
prices in MNE transactions. One model, as proposed by Tön- 
nissen and Teuteberg, is to manage and merge intercom- 
pany contracts in a blockchain. The decentralized storage 
of contract data allows transfer pricing principles to be 
applied and documentation to be maintained for tax 
authorities.

Another model could be to advocate the digitalization of 
the entire supply chain or ERP systems on a blockchain. 
It is becoming apparent that supply chain management 
through a blockchain is not being promoted equally in 
all industries. For example, further progress has been 
made with models in healthcare systems and transport 
solutions. These concepts are initially detached from 
tax issues. However, if data on internal company trans- 
actions is entered on a blockchain anyway, it is advisable to 
use this subsequently for tax purposes, more precisely for 
transfer pricing purposes. In these concepts, subsidiaries 
have writing permission and can enter data on the block- 
chain. Tax authorities can act as nodes in the peer-to-peer 
network and have access to the transfer pricing documen- 
tation.

A complete recording of supply chain data by a 
blockchain offers the advantages that comprehensive data 
sets are available and transfer pricing-relevant facts such 
as functions, assets and risks are fully traceable.

3.2. Digitalization of transfer pricing processes

To ensure that a transfer price is determined based on the 
“arm’s length principle” and that the correct documenta- 
tion is maintained, the correct transfer pricing process

must be implemented on the blockchain system. The doc- 
umentation function and determination of transfer prices 
is performed by smart contracts. Beuther and Fettke 
identify four important functions:

- strategic transfer pricing (planning);
- transfer price calculation;
- transfer pricing reporting; and
- operational transfer pricing.

The priority must be the transfer pricing strategy, which 
identifies in particular intra-group transactions and func- 
tions of all corporate units in the value chain. The next 
step is to implement this strategy and to apply the MNE 
transfer pricing policy in accordance with the correct legal 
framework. Automated processes in this context can sim- 
plify transfer pricing with the help of AI. For example, 
identify comparable companies, functions, assets and 
risks, etc. more easily.

3.3. Using AI for transfer pricing calculation

The use of AI in the area of transfer pricing first requires 
the automation and standardization of processes. Older 
rule-based AI models could be useful to implement AI in 
transfer pricing. More recent AI concepts are data-based 
and work with machine learning and so-called artificial 
networks. On the basis of previously defined rules, 
a problem should be recognized and solved independently – 
such systems are called self-learning. If AI systems are 
used to determine transfer prices at arm’s length, in the 
author’s view, rule-based concepts for less complex trans- 
fer pricing cases should be used first so that the technol- 
ogy and applications can be tested. Three different kinds 
of assistance in transfer pricing by AI are identified by 
Heggmair and Makowsky:

- transaction data analysis;
- assistance in frequently asked questions; and
- review and support of necessary background infor- 
mation.

An AI approach combined with process management 
is useful to identify relevant patterns, relationships and 
rules in transfer price calculation. After a learning phase 
of AI from past processes, predictive processes can also 
be covered. One method for improvement of AI machine 
learning techniques takes place through so-called deep 
learning. In recent years, artificial machine learning has 
made great progress through neural networks and thus 
deep learning. This is especially due to the fact that com- 
puting capacities have been significantly expanded.

24. Tönnissen & Teuteberg, supra n. 4, at p. 1177.
27. Rodriguez, Ottini & Huibregtse, supra n. 14, at pp. 143-144.
29. Rao, supra n. 9, at p. 119.
30. Bilaney, supra n. 15, at p. 296.
32. Rao, supra n. 9, at p. 120.
AI and blockchain are not two competing technologies, but rather help each other or enable the technology to work better. Often there is not enough data available for AI to learn from past processes. To have a comprehensive data basis for teaching AI, it is necessary to monitor extensive, diverse and detailed processes. Using a blockchain, internal group transfer pricing data can be made available for AI training or analysis purposes without its content or business secrets becoming public. In addition, with AI, smart contracts can be tested before implementation, updated following legal changes and protected against cyber attacks. Smart contracts are dependent on external information; AI can provide this external data for the execution of smart contracts.36

Blockchain cryptographically encrypted transfer pricing data can be made available for AI analyses. This enables the creation of larger comparative databases of companies for transfer pricing calculation based on the “arm’s length principle”. In addition, AI programs can learn from the calculation made and adapt it to future transfer pricing cases. The providing of transfer pricing calculation data for AI programs can also be monetized by the providing companies. Sophisticated AI transfer pricing applications are thus available not only for MNEs but also for smaller companies.

Internationally, the first AI concepts for transfer pricing have already been introduced, for example in transfer pricing benchmarking37 or in the field of transfer pricing documentation and reporting.38

In summary, blockchain technology offers a suitable framework in which process data from the supply chain can be collected decentrally in a uniform format for evaluation purposes. Tools for determining the correct transfer price and providing documentation as well as reporting are only one of the advantages resulting from the complete digitalization of the supply chain. In this context, AI models can be used to successfully implement the automation and optimization of transfer pricing processes.

3.4. Technical solutions

The question arises how such a blockchain model can be implemented to digitalize the supply chain and to automate transfer pricing functions. There are several providers of blockchain platforms with different concepts, such as Ethereum, Hyperledger Fabric and Parity.39 When introducing blockchain models in companies, the risk of transparency is always identified by the entrepreneurs. For the validation of information in a blockchain, data transparency between validating actors is theoretically required, which does not guarantee data confidentiality.40

According to Wibowo and Sandikapura, two important questions must be addressed when selecting a blockchain platform: “Which parties can read and which parties can write the asset?”41 A large blockchain platform provider is Ethereum. Ethereum is a permissionless public blockchain, which means everyone can participate.42 Permissionless public blockchain concepts have a large number of nodes and rely on a computationally intensive transparent proof-of-work consensus mechanism to validate transactions. In contrast, permissioned blockchain systems (whether permissioned public or private blockchains) control who can access, read and write, and initiate transactions. For this reason, permissioned systems are more suitable for companies.43

Hyperledger Fabric is a blockchain platform that is considered to have great potential for corporate purposes in supply chain management. Hyperledger project combines several tools and blockchain platforms, which are developed and managed principally by the Linux Foundation. The platform of Hyperledger Fabric is supported by IBM.44 The design and validation of transactions is different from other blockchain systems. The advantage of Hyperledger Fabric is that in a supply chain only the necessary information is visible for selected parties involved in the blockchain system.

For example, only information relevant to transfer pricing could be shared. Tax authorities can also be involved in the system to monitor transfer pricing. This would not require extensive and confidential information to be disclosed. The basis for the calculation of transfer prices could be the transfer pricing-relevant transaction data from the supply chain, which are stored on the blockchain platform Hyperledger Fabric.

There are three phases to a transaction in Hyperledger fabric: Execution, ordering and validation.45 Smart contracts are called Chaincode in Hyperledger. Access to the Hyperledger Fabric system is controlled by a trusted Certificate Authority. In contrast to miners and peers in other blockchain systems, the nodes in the fabric are divided into Endorsers, Committers and Orderers.46 Endorsers serve as an interface between organizations. They execute Chaincodes and control the transaction. Orderers collect
and confirm the transactions and arrange the transactions in the correct order. In contrast to other blockchain systems, this approach increases the scalability of transactions. Committed check the data already verified by the Orderer and record it on the blockchain. Over the past years, Hyperledger Fabric has been continuously improved. The confidentiality of information is guaranteed by using only certain channels. Only previously defined peers can participate in a channel.

In summary, the blockchain platform Hyperledger Fabric can provide a suitable framework to digitalize the supply chain. Through a comprehensive digitalization of the supply chain, uniform and complete data are available, enabling automated transfer price calculation, documentation and reporting to be carried out using AI components.

4. Further Synergies: Automatic Auditing

4.1. Proposal for an automated compliance mechanism

The calculation of transfer prices as well as documentation and reporting ties up many resources. Transfer prices are often reviewed by tax authorities and adjustments must be made. This also leads to resource expenditure for tax administrations and governments in the control of transfer pricing. Transfer pricing can be misused to reduce the tax burden in high-tax countries and to shift the tax base to low-tax countries. In the event of transfer pricing adjustments, the participation of at least two jurisdictions often causes difficulties with a synchronous correction of the transfer prices in the respective countries. Several mechanisms, like mutual agreement procedures, exist internationally to ensure that a synchronized transfer pricing adjustment can be reached within the framework of intergovernmental understanding. However, these mechanisms are often time-consuming, do not promise any prospect of success and therefore pose risks for MNEs. The use of technology makes it possible to synchronize the exchange of information and verification of transfer prices between the various countries.

In such an idealized model, information for the automated determination of transfer prices is available through a completely digitalized supply chain, as described above. These processes can be made transparent to tax administrations. If countries agree in advance on the determination of transfer prices and participate technically in this system, a synchronous rejection or agreement to the transfer prices calculated by the MNE is possible. This is only facilitated technically by the complete and uniform recording of transfer pricing-relevant data in the supply chain through a blockchain.

In addition to the technical prerequisites, a legal framework must be established to provide companies with legal certainty. This requires an internationally binding form. A transposition is carried out in each participating country through a national implementation. Furthermore, a legal regulation should not be tailored to a specific application or technology. Access to relevant transfer pricing data can be provided by interfaces known as API (application programming interface).

4.2. Discussion

The introduction of an automated transfer pricing system is complex. Many challenges but also opportunities arise which have to be considered. In order for the system to be able to determine transfer prices, it is important that sufficient information is available and in particular that comparative data on the transaction is available from other companies. In some cases, these comparative data are not available, making it impossible to calculate transfer prices automatically. When MNEs digitalize their transfer pricing data from the supply chain, this data can be offered for sale anonymously, so that AI programs learn better, and comparative data is available for calculation. New business opportunities are created by offering AI transfer pricing tools on blockchain platforms such as Hyperledger Fabric. Automatic transfer pricing is therefore possible in less complex cases.

Opening up these systems to tax authorities and thus a more cooperative behaviour also offers the chance that transfer prices are automatically approved by tax authorities. As a result, the tax burden becomes more predictable and resources for companies are saved. Tax administrations could also use auditing tools more efficiently and risk-oriented in order to maintain tax base. Although an agreement with other countries on the transfer pricing in the above-mentioned system theoretically means that tax revenue is waived, a predictable tax administration and facilitated tax compliance by MNEs is a gain for the business location. In addition, the automated provision of anonymized data also provides a more coherent picture for tax administrations and networking with other systems is advisable.

Common concerns of taxpayers about the confidentiality of data and the validation of information by tax administrations in blockchain systems can be addressed by appropriate technical procedures. The confidentiality and validation of tax-relevant data in blockchain systems can be achieved by so-called zero-knowledge proofs. A node verifies the correctness of a generated signature without obtaining additional information. However,
problems arise in the realization of such systems because zero-knowledge proofs are very complex.\textsuperscript{56}

5. Summary

The digitalization of tax processes is progressing steadily. New technologies enable more intensive compliance and interaction between taxpayers and tax authorities than was previously possible.\textsuperscript{57} This is necessary at the same time because globalization and a more networked economy pose challenges to tax authorities. This leads to increasing compliance obligations, which have to be borne by companies and cause expenses. The example of transfer pricing illustrates these challenges and opportunities. The blockchain technology and AI are elements that enable the automation of transfer pricing processes. For a suitable implementation, it is necessary to collect relevant information of the supply chain through a blockchain. This makes it easier for companies to meet transfer pricing-relevant compliance requirements. At the same time, it also offers the opportunity for tax administrations to carry out transfer pricing auditing in real time or at least automatically.

In summary, blockchain technology may not offer a solution to all problems, but it can help to provide the chance to contribute to an evolution in tax law.


\textsuperscript{57} R. Doll & J. Walter, Digitalisierung der Finanzverwaltung und Steuerfunktion – Wohin geht die Reise?, beck digitax, pp. 2 (2020).