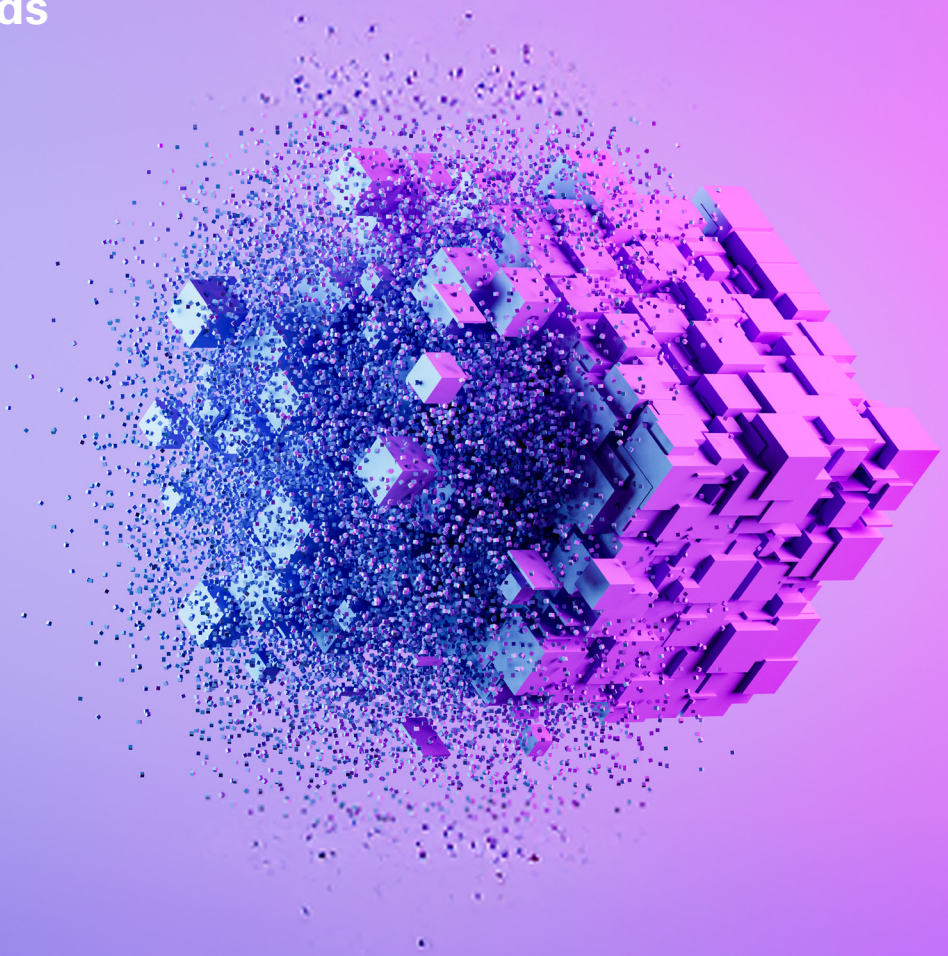
In cooperation with:

KFW

DLT-based capital market

An analysis of the degree of maturity based on KfW's first two blockchain-based digital bonds

February 2025



In collaboration with:

Boerse Stuttgart Digital

cashlink

DZ BANK Die Initiativbank

HAUCK AUFHÄUSER LAMPE

LBBW

Linklaters

METZLER

SCOPE Ratings

S&P Global Ratings

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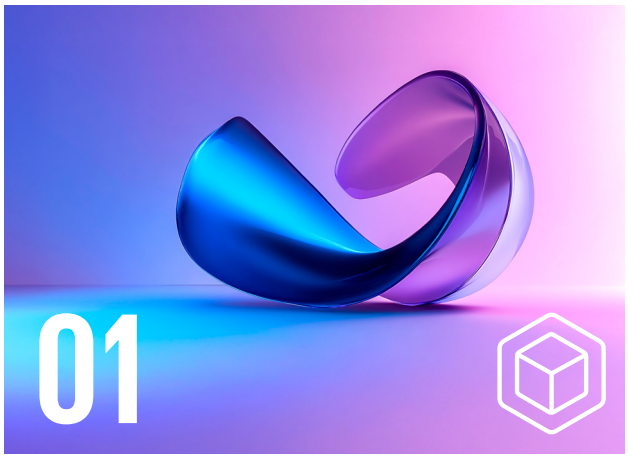

Digital capital market in Europe

KfW’s blockchain-based digital bonds

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Lessons learned

Maturity of the DLT-based capital market and outlook

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Authors

Boerse Stuttgart Digital

Sebastian Kraft
Executive Director

Dirk Kruwinnus
Group Strategy

cashlink

Rafael Kaaz
Head of Operations

Simon Censkowsky
Senior Manager, Business Strategic Business Development

Michael Chapman
Head of Tokenisation

Achim Linsenmaier
Managing Director, Vice Chairman of Global Public Sector (O&A)

DZ BANK
Die Initiativbank

Nils Christopeit
Product Manager Digital Custody

Nico Braun
SSA Syndicate

HAUCK AUFHÄUSER LAMPE

Kilian Brüll
Crypto Securities Product Manager

Dr. Miguel Vaz
Managing Director

KFW

Tim Meirer
Senior Manager, Capital Market Innovation

Bert Staufenbiel
Senior Manager, Digital Transformation

KPMG

Jens Siebert
Partner, Financial Services

Philipp Köhler-Brinkmann
Senior Manager, Financial Services

LBBW

Friederike Burckhardt
Digital Assets

Florian Rathgeber
Director, SSA Syndicate

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Linklaters

Dr. Christian Storck
Partner,
Global Head of Capital Markets

Sebastian Dey
Counsel,
Head of Digital Assets Germany

METZLER

Hendrik König
Head of Digital Assets Office

Christoph Hirth
Senior Advisor,
Corporate Solutions
EDCM Origination & Syndicate

SCOPE Ratings

Eiko Sievert
Senior Director & Lead Analyst

Alvise Lennkh-Yunus
Head of Sovereign & Public Sector

S&P Global Ratings

Dr. Mohamed Damak
Managing Director & Sector Lead,
Financial Institutions Ratings

Michael Stroschein
Director & Lead Analyst,
Sovereign & Int. Public Finance Ratings

Union Investment

Christoph Hock
Head of Tokenisation and Digital Assets

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Foreword

Against the backdrop of the current technological paradigm shift, which is characterised by the rapid development of new technologies such as distributed ledger technology (DLT) and artificial intelligence, it is crucial that Germany and the European Union actively engage with the development and expansion of an efficient market for digital assets – the DLT-based capital market. An efficient and integrated capital market is essential for Europe's competitiveness and sovereignty, which need to be strengthened in an increasingly digital world. The use of DLT – which also includes blockchain technology – offers great opportunities for European and international financial markets to process financial market transactions much more efficiently and securely.

Ensuring sustainable economic growth is a key objective of EU economic policy and technological progress and innovation play a decisive role in this. In order to position Germany and Europe as a global powerhouse for the „Web 3.0 age", it is of paramount importance that the legislator provides a secure legal framework in which innovative technologies for new fields of application can be tested and implemented. Mutual dialogue between market participants, regulatory institutions and interest groups is essential for identifying existing legal and technical hurdles at an early stage and to actively contribute to overcoming them.

The latest advances in digital technologies offer the opportunity to create an integrated European capital market for digital assets – in other words, a Digital Capital Markets Union. Thanks to progressive regulation, Germany and the EU are well positioned internationally to set up an ecosystem for digital assets. Further institutionalisation and greater scalability of DLT-based financial instruments are needed to not only maintain but build on this pioneering role. Above all, this will require even greater acceptance and consequently greater integration of new technologies into the existing processes of market participants.

It is therefore important to translate practical trials and lessons learned into scalable practice as quickly as possible, and to identify and resolve any outstanding regulatory issues, such as licensing, trading venues and central bank eligibility of DLT-based financial instruments, in a timely manner. The ability to act with speed is crucial. After all, Europe faces international competition from Asia, the Middle East, the UK and, above all, the US.

This analysis of KfW's first two blockchain-based digital bonds shows the current state of development of the DLT-based capital market and the concrete next steps needed to further advance the acceptance, integration and ultimately the scalability of the technology into financial market transactions. It is up to all of us to proactively utilise the opportunities presented by this technological change and secure the competitiveness and sovereignty of Germany and Europe in the long term.

Jens Siebert
Partner,
Financial Services
KPMG

Tim Armbruster
Group Treasurer,
KfW

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Executive Summary

In light of the present technological paradigm shift, it is vital that Germany and the European Union continue to actively engage with the **digital assets ecosystem** in order to sharpen their competitive edge and reinforce their clout in an increasingly digital world. In particular, the integration and use of distributed ledger technology (DLT) in the capital market, such as through the issuance of KfW's two blockchain-based digital bonds, offer considerable opportunities to increase efficiency and automate existing capital market processes. At the same time, these innovations pose new challenges that need to be addressed systematically. The main players involved in the transactions included **Bankhaus Metzler, Deutsche Bank, DZ BANK, LBBW, Union Investment, Boerse Stuttgart, Hauck Aufhäuser, Linklaters,** as well as **Cashlink and Deutsche Bundesbank**. The two bonds were rated by **Moody's Ratings, Scope Ratings** and **S&P Global Ratings**.

The analysis of the **current degree of maturity of the DLT-based capital market** in this paper is based on the insights gained by the stakeholders involved in relation to the first two blockchain-based digital bonds issued by KfW (MVP 1.0 and MVP 2.0). The Access, Service, Asset, Platform (ASAP) model of the International Monetary Fund (IMF), which enables a structured view of new emerging market infrastructures, serves as a basis and identifies key action items to further promote institutional acceptance and integration of DLT. Valuable insights were gained with regard to the **legal framework, technological implementations and practical challenges**. For instance, the settlement period for traditional bonds has already been significantly reduced through the use of DLT, and the combination of public and private blockchains has enabled efficient transaction processing. Moreover, the terms and conditions for both bonds were largely identical to those for conventional bonds issued as physical (global) certificates, supplemented by blockchain-specific requirements.

The insights gained from the first two KfW crypto securities issued in accordance with the German Electronic Securities Act (Gesetz über elektronische Wertpapiere, „eWpG") highlight, among other things, the need to continuously educate all stakeholders, to adapt legal frameworks and to develop standardised technical solutions in the interest of ensuring interoperability between different DLT systems. The development of a **liquid, hybrid and, in particular, scalable ecosystem** for DLT-based financial instruments is crucial for Europe's ability to compete in the global financial market going forward.

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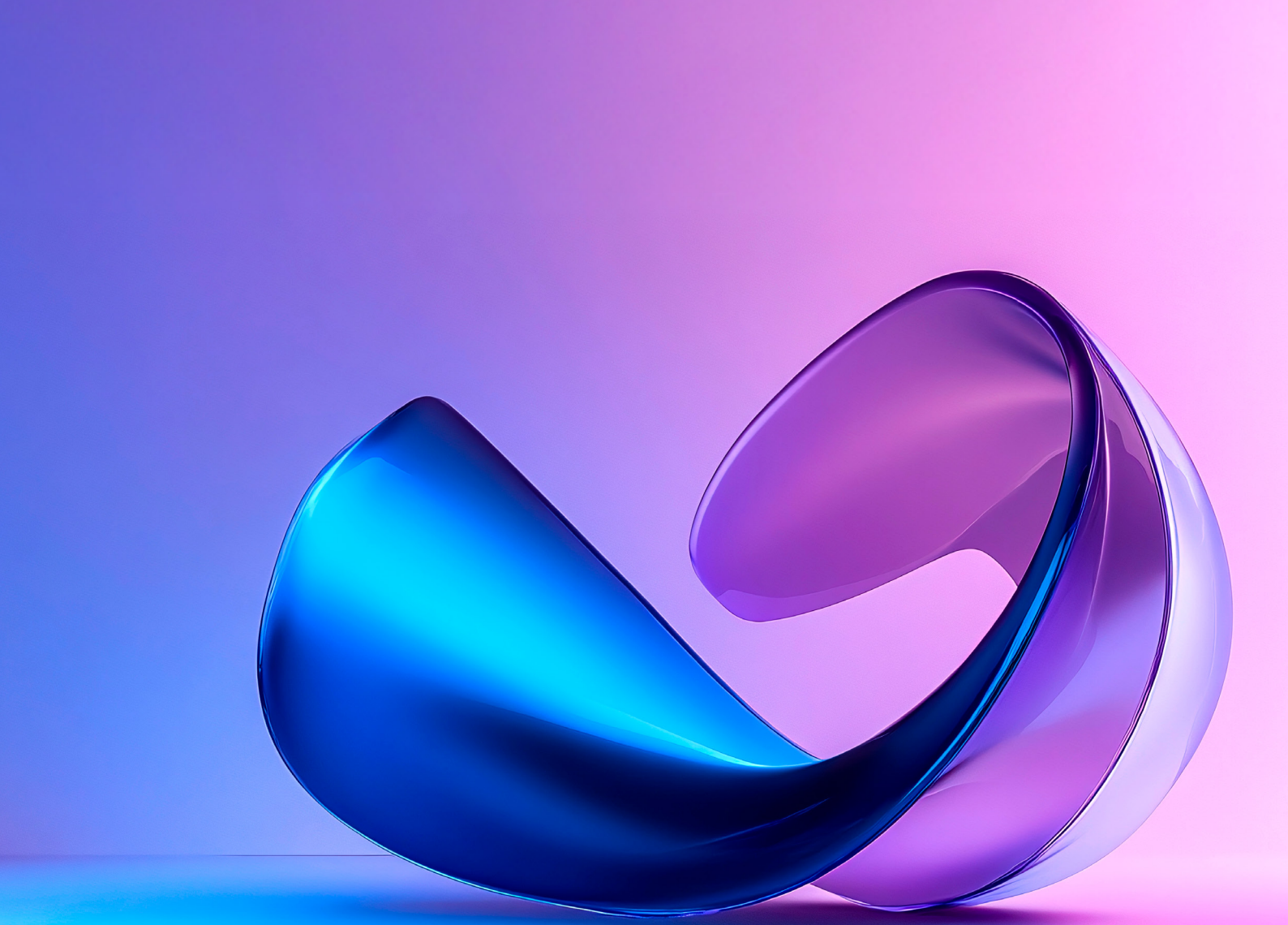

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Digital capital market in Europe

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1.1

Digitalisation of the capital market – overview in Europe

An efficient capital market is essential for the economy and key to efficiently allocating capital for investment. Today's capital markets are already based on **electronic trading**. But inadequate technical solutions for securities settlement have led to **complex market infrastructures** with a number of different players.

In 2015[1], the European Union (EU) resolved to introduce the Capital Markets Union (CMU), thereby taking another step towards a shared **single capital market** that is **competitive** in the global context, with the aim of strengthening the european financial market, better integrating capital markets and creating new opportunities for investors. Before the next step can be taken, there will have to be a comprehensive digital transformation of the capital market, in the process of which distributed ledger technology (DLT), in particular blockchain and securities tokenisation as well as digital identities, will potentially take a key role.

Market participants in Germany and the EU have recognised the transformational potential of DLT since the mid-2010s. Companies are coming under additional pressure to innovate, which is driven not only by technological change, but also demographic change and skilled labour shortages, known as the **war for talents**. DLT can act as an enabler of progress and competitiveness in this context and contribute to significant efficiency gains and process optimisations. A critical prerequisite for the use of new technologies in the capital market is that they are fully covered by an adequate regulatory and civil-law framework. The **DLT Pilot Regime** (Regulation (EU) No 2022/858) at EU level and the German Electronic Securities Act (Gesetz über elektronische Wertpapiere, „**eWpG**") in Germany create a legal framework that enables the issuance, trading and settlement of selected financial instruments using DLT in practice.

Distributed ledger technology (DLT) is the umbrella term for technologies that enable a decentralised distributed data register. In such a scenario, the register is distributed to several nodes in a network, which jointly validate and secure transactions without requiring the involvement of a central authority. Blockchain is a special form of DLT in which transaction data is stored in blocks that are cryptographically linked to each other. This blockchain creates an immutable history and guarantees the integrity of the system.

The digital representation of an asset on a DLT is generally referred to as a **token**. DLT-based digital assets, such as DLT-based digital securities, are also known as **assets on chain**. In addition to representing assets, DLT can also be used to represent cash (cash on chain) or the exchange of cash payments in digital form. It will only become possible to harness the benefits of DLT for the capital market with the joint representation of cash (payments) and assets on a (programmable) DLT-based infrastructure that uses **smart contracts**. This would enable automated, optimised processes without media discontinuity and reduce or eliminate existing inefficiencies in the current front-to-end process (such as data comparison effort and coupon payments).

Another essential factor for realising the potential of DLT is the introduction of **digital identities**, which allow secure and unique identification of market participants such as investors, issuers or payment service providers. Digital identities thus create the basis for a trusted infrastructure that complies with regulatory requirements, in which only authorised participants can access assets and payments.

As a central platform for integrating **central bank digital currencies** (CBDC), tokenised bank deposits and digital assets, the Bank for International Settlements (BIS) has proposed the introduction of a **unified ledger**[2]. This would allow the integration of

1 What is the capital markets union? – European Commission
2 III. Blueprint for the future monetary system: improving the old, enabling the new

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trading, settlement and custody functions and accelerate transaction settlement. BIS emphasises that, depending on the requirements of the respective jurisdictions, this concept could encompass multiple regional or application-specific ledgers. Data protection, cyber security, and the assessment of potential risks associated with DLT are central issues that must be addressed to build and maintain trust in these systems.

The implementation of a unified ledger as suggested by BIS requires a number of intermediate steps to deal with technical, legal and operational challenges. To this end, for example, **Project Agorá**[3] was launched in April 2024 to investigate how tokenised commercial bank deposits can be seamlessly integrated with tokenised central bank money for financial institutions in a public-private programmable financial platform.

In October 2024[5], Piero Cipollone, member of the Executive Board of the European Central Bank (ECB), spoke in connection with the establishment of a digital Capital Markets Union about a joint account ledger for Europe that could bring together tokenised versions of central bank money, commercial bank money and other digital assets on a joint programmable platform. **TARGET2-Securities** (T2S) could evolve into a DLT-based standardised financial market infrastructure for Europe. Smart contracts could automate and optimise front-to-end processes, especially in the areas of the primary and secondary market as well as lifecycle events. According to estimates, automation and smart contracts could reduce annual infrastructure operating costs on the global markets by around USD 15 to 20 billion[6].

Central bank digital currencies (CBDC) are increasingly gaining in importance. A total of 134 countries are now considering the development and implementation of CBDC.[4]

A distinction is made between two types, retail CBDC (rCBDC) and wholesale CBDC (wCBDC). rCBDC is the digital form of central bank money, which is to be made available for day-to-day payment transactions of the general public. It is an electronic version of cash issued by the central bank of a country.

By contrast, wCBDC is digital central bank money, which is used exclusively by financial institutions. The ECB also uses the term wholesale central bank money (wCeBM) in this context. Its purpose is to make transactions between banks, or between banks and the central bank, more efficient, more secure and faster. It is to be used mainly for wholesale payments in the interbank market and for trading in financial instruments, such as cash transfers, the settlement of securities transactions or money market transactions.

3 Private sector partners join Project Agorá
4 Central Bank Digital Currency (CBDC) Tracker
5 Towards a digital capital markets union
6 Impact of Distributed Ledger Technology in Global Capital Markets

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1.2 Legal framework in Europe and Germany

1.2.1 DLT Pilot Regime

Regulation (EU) 2022/858, known as DLT Pilot Regime, entered into force in 2023. It establishes an regulatory sandbox for the trading and settlement of financial instruments in the EU using DLT. It regulates the licensing and prudential supervision of **DLT market infrastructures**, for which the national competent authority is responsible. In Germany, this is the Federal Financial Supervisory Authority (BaFin). In addition, operators of the DLT market infrastructures have to comply with technical requirements, which are set out in the DLT Pilot Regime, in order to guarantee efficiency, transparency and security. With regard to usage and challenges, the DLT Pilot Regime provides a comprehensive overview of the practical possibilities and limits of the DLT market infrastructures and addresses unresolved practical issues. Financial instruments can be issued, transferred and stored using DLT, and this is intended to lead to greater settlement efficiency, more transparency and increased competition.

Another aspect of the DLT Pilot Regime is the market integration and long-term acceptance of DLT market infrastructures, which have to exist alongside traditional structures. These DLT market infrastructures comprise trading venues and settlement systems, although the DLT Pilot Regime has introduced for the first time a combined DLT trading and settlement system (**DLT TSS**). Before the DLT Pilot Regime was introduced, the combination of trading and settlement activities within one market infrastructure was not permitted under supervisory law. These infrastructures are aimed at lowering barriers to entry, offering space to innovative business models and improving market liquidity. The integration of DLT-based solutions into traditional market infrastructures gives rise particularly to **interoperability requirements** and poses technical challenges. The DLT Pilot Regime recognises the need for creating technical standards and interoperability solutions to enable seamless links between the different systems. National legislators retain their regulatory powers, especially for product-specific issues. The introduction of certain regulatory exemptions for DLT market infrastructures establishes a parallel regime for the use of DLT alongside existing regulation of the financial market.

In relation to the **front-to-end process**, DLT-based systems may potentially offer an alternative to central safe custody and process data and transactions directly in a **decentralised register**. **Smart contracts**

The **DLT Pilot Regime** is a regulatory framework of the European Union that allows companies to test DLT in a controlled environment and experiment with innovations in finance. The DLT Pilot Regime creates a simplified oversight framework for investment institutions, market operators and central securities depositories planning to trade in and settle selected financial instruments using DLT. With participation initially limited to a period of up to six years, it allows DLT-based market infrastructures such as trading and settlement platforms to be tested. The EU reserves the right to extend the period for the test environment. Approval of the DLT Pilot Regime means that participating companies have to meet certain technical and operational requirements. Participants can take different roles (DLT MTF, DLT SS or DLT TSS), for example as participants of financial services or market platforms for selected DLT-based financial instruments.

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play a critical role in this context as they enable settlement to be **automated** and **secured**, thus increasing **efficiency** and **transparency**.

The long-term market acceptance of the DLT Pilot Regime will depend to a significant extent on its successful integration into existing financial market infrastructures and a clear regulatory framework. The success of the Regime will also depend on how quickly and effectively technical and regulatory challenges can be overcome and licences granted.

Overall, the DLT Pilot Regime marks an important milestone in the modernisation and digitalisation of the financial market. It should, however, be noted that, since the Regulation entered into force in March 2023, only two market participants, CSD Prague and 21X, have been granted licences under the DLT Pilot Regime. It can, however, be assumed that further **licences** will be granted in the short and medium term.[7]

7 *First DLT Pilot Regime system gets green light: CSD Prague - Ledger Insights - blockchain for enterprise, 21X secures historic EU license to launch the first fully regulated blockchain-based trading venue - 21X*

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1.2.2
German Electronic Securities Act (Gesetz über elektronische Wertpapiere, „eWpG“)

Until the eWpG entered into force, securities in Germany were required to be securitised as **physical certificates**. This had an adverse impact on the innovation potential and attractiveness of Germany as a financial centre since other jurisdictions had already been allowing the electronic issuance of securities for many years. The aim of the eWpG, which was introduced in June 2021, is therefore to **strengthen Germany as a financial centre** without compromising the protection and the protection of investors and of the financial market. The option to issue **securities** represented by physical **certificates** has been retained.

Electronic securities are entered in an **electronic securities register** and have the same legal effect as securities represented by physical certificates. Electronic securities offer comprehensive **protection of property** as a result of the legal fiction of the eWpG that electronic securities are deemed to be „things“ pursuant to section 90 of the German Commercial Code (Bürgerliches Gesetzbuch, „BGB“). The fiction under the law of things used in the eWpG is not related to the Markets in Financial Instruments Directive II (**MiFID II**), which does **not require financial instruments to be securitised**.

Under the eWpG, there are two types of securities registers: **central registers** pursuant to **section 12 eWpG** and **crypto securities registers** pursuant to **section 16 eWpG**. The securities are registered pursuant to section 4 (4) eWpG; after filing and making the terms and conditions of issue available, registration requires that certain disclosures are made in the corresponding register. Amendments to the terms and conditions of issue are subject to strict rules.

Central register securities are issued by way of registration in a central register. The central register is managed by the registrar entity; for central register securities, the eWpG specifies for this role merely a **central depository for securities** or a **depository licensed for securities under the German Banking Act** (Kreditwesengesetz, „KWG“). Only the registrar entity is authorised to amend the central register, and only pursuant to the provisions of section 14 eWpG. Crypto securities are in turn issued by way of **registration in a decentralised, tamper-proof crypto securities register**. Detailed requirements for these types of registers are set out in the German Regulation on Requirements for Electronic Securities Registers (Verordnung über Anforderungen an elektronische Wertpapierregister, „eWpRV“). The

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crypto securities register is maintained by a **registrar entity** licensed under the KWG; this is the issuer itself or an entity that the issuer has specified. Pursuant to section 21 (1) eWpG, issuers of electronic securities are obliged to take technical and organisational measures to guarantee the integrity and authenticity of the securities. Moreover, section 10 eWpG requires them to ensure that electronic securities registers meet certain **publicity requirements** and grant access if there is a legitimate interest, in the same way as for central register securities.

Electronic securities registers are supervised by BaFin. The registrar entity's obligations include keeping a **log of access for inspection** and **requests for information**. For both forms of electronic securities register, the registrar entity is the addressee of the respective regulatory requirements. To replace a securities certificate by registering it in an electronic securities register, section 6 (4) eWpG always requires that explicit consent be obtained from the entitled party, unless it is to be replaced with a central register security with identical content and the requirements of section 6 (3) eWpG are met. In such a case, the certificate can be converted without the entitled party's consent. Moreover, dispositions of individually registered electronic securities always require registration or transfer in the register. If it has acted in good faith, the acquirer is to become the owner as soon as it has been entered in the register. The eWpG therefore marks an important step towards modernising the German financial market and keeping it competitive.

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1.3

Technological framework and the potential of programmable market infrastructures

The technological framework and the potential of DLT-based programmable market infrastructures offer a promising outlook for the future of the financial market. The combination of a **robust technological infrastructure, regulatory clarity** and **innovative projects** creates a solid basis for enhancing and implementing these technologies in the financial services sector.

Technological standards, such as **interoperability** between different DLT systems, and the integration of global standards, such as ISO 20022 for electronic data transfers between financial institutions, are of major importance here.[8] These standards ensure seamless communication and increased efficiency. It will be critical for the future development of DLT-based digital securities whether and how the different networks will be compatible and interoperable with each other. Chainlink's contribution, for example, is the Cross-Chain Interoperability Protocol (CCIP). CCIP allows the transfer of tokens and all types of data between different blockchains so that payments can be initiated on a destination blockchain and the associated status can be monitored on the source blockchain. Another important aspect in this context is token **standardisation**, which allows interoperability between the different networks to be increased further. Because of its regulatory compliance and the security aspect, it also ensures that trust in and acceptance of the technology are strengthened. Initiatives such as ERC standards[9], ISO guidelines and the Token Taxonomy Framework[10] play a key role in this context, too.

The introduction and scaling of DLT and DLT-based digital securities may entail considerable changes in the different stages of the lifecycle of securities. For instance, the time saved by using DLT will lead to prompter delivery of the security, reduce settlement risks and thus make the settlement process more efficient. All relevant information is stored on the DLT infrastructure or allocated directly to the asset, thus rendering paper-based securitisation redundant. **Automation through smart contracts** can make an additional contribution to increasing efficiency. In the secondary market, transaction costs can be reduced considerably by increasingly automating settlement through the use of smart contracts. This allows faster, more cost-effective transactions, which can increase market liquidity and efficiency. More automation means that in future processes will be able to facilitate 24/7 trading of DLT-based digital securities, i.e. trading around the clock on seven trading days a week, 365 days a year, if market participants embrace such an offering.

In clearing and settlement, the use of DLT will allow the settlement time to be reduced to **T+0**, where „T" represents the pricing day. Transactions will be cleared and settled faster and more securely as a result. Lifecycle events of securities, such as interest payments, redemptions and dividends, can be automated and therefore optimised with the use of smart contracts. This makes management and settlement more efficient, and this provides benefits for both issuers and investors.

8 ISO 20022 | ISO20022
9 What token standards are there?
10 Token Taxonomy Framework – IWA

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1.4

Ecosystem of providers and customers

New developments in the capital market, such as the use of DLT and the resulting enhancement of the **ecosystem**, require new, updated skills and functions. Functions that were previously treated strictly separately, such as trading and settlement, are brought together by the DLT Pilot Regime.

This is because, for multilateral trading of securities, the Central Securities Depository Regulation (CSDR) requires that they are recorded in book-entry form and deposited with a CSD. Before the introduction of the DLT Pilot Regime, neither **decentralised trading** nor decentralised settlement using DLT was possible.

The International Monetary Fund (IMF) has developed a conceptual model aimed at facilitating the understanding of DLT market infrastructures and cooperation by providing the required standardisation. The market requirements in the financial infrastructure landscape are examined in this process in order to enhance the interoperability and security of digital financial operations. The model, referred to as the **ASAP model** (Access, Service, Asset, Platform) has four layers.[11]

Published in February 2024, this theoretical concept is a structured framework that offers a clear and systematic method for assessing and designing business models, especially in the context of digital platforms and DLT. Later on, in the review of KfW's blockchain-based digital bonds, this conceptual framework is visited again and used to assess the **degree of maturity of the DLT-based capital market**.

The diagram shows the newly revised functions and their interconnections, with reference to the IMF's ASAP model, in the primary market ecosystem. The network participants regularly proceed through each of the levels shown in the diagram. This is presented in static form, depending on the network participants' primary orientation. The new roles and the executing market participants adopted from the existing ecosystem have to adapt to the new circumstances and requirements that **implementation of DLT-based digital securities in the finance industry** entails. With regard to the newly created functions, it is to be expected that new market players will increasingly emerge in the coming years. The new functions are in some cases subject to new legal requirements. The performance of these functions necessitates, among other requirements, licences for the provision of financial services such as crypto securities register maintenance or crypto custody. In addition, a number of practical trials are needed, such as KfW's first two blockchain-based digital bonds (MVP 1.0 and MVP 2.0), to analyse the degree of maturity of the emerging DLT-based capital market, obtain new insights and determine on this basis how the „new" ecosystem can gain scaling potential.

11 *ASAP: A Conceptual Model for Digital Asset Platforms*

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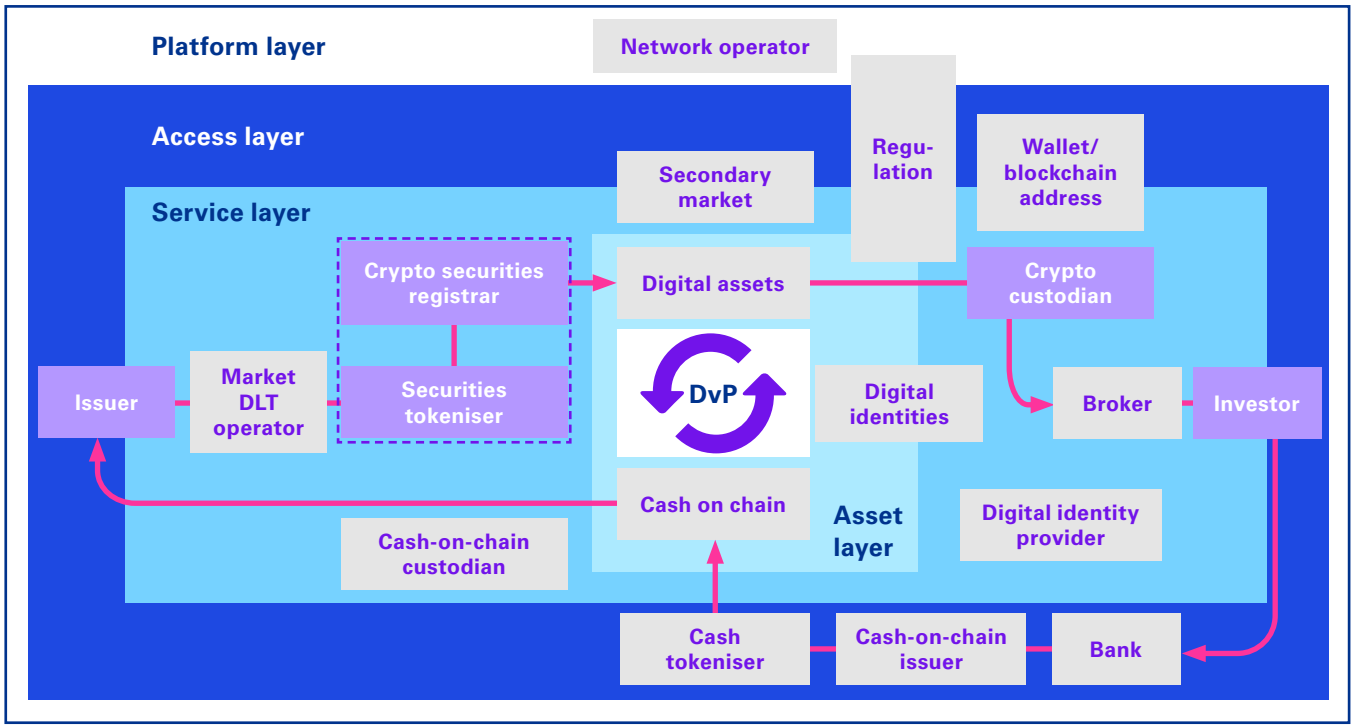
Figure 1:
Simplified digital securities ecosystem[12]



Source: Frankfurt School of Finance and Management, M. Vaz, 2021

Access: The Access layer contains functions and interfaces that enable clients such as users, applications, and other market components to engage with the underlying service, asset, and platform infrastructure layers.

Service: The Service layer covers functions that handle or utilize the financial assets deployed on the platform. Within a digital access platform (DAP), these functions, or their combinations, typically facilitate the implementation of financial services.

Asset: The Asset layer encompasses core functions that clearly define a digital security (issuance, transfer, redemption and possibly access control).

Platform: The Platform layer includes runtime capabilities supporting all the other layers' functions. In certain platform models, this layer is primarily used to implement the transfer of DLT-based digital securities from the next layer up. This is why it is occasionally referred to as the „settlement layer" (execution, storage, communication, consensus, identification, authentication and authorisation).

12 *2021, M. Vaz, „Certified Blockchain Expert" Lecture Notes, Frankfurt School of Finance and Management/Blocksize Capital based on the IMF's ASAP model*

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02

KfW's blockchain-based digital bonds

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2.1
Motivation and objectives

The motivation for issuing the first two blockchain-based digital bonds by KfW (MVP 1.0 and MVP 2.0) was driven by several major factors. Firstly, on international capital markets, KfW is one of the **largest issuers in the world**. At the same time, ongoing demographic change poses a challenge for maintaining the current process excellence. The resulting need to develop and implement digitalisation initiatives along the securities issuance process – if possible as part of a holistic system using **straight-through-processing** (STP) – will not least shift the focus towards the use and trialling of new technologies such as DLT. The ultimate aim is to secure the Bank's long-term competitiveness, efficiency and attractiveness as an employer.

KfW's specific choice of digitalisation and innovation initiatives is guided in particular by the existence of a legal and regulatory framework. The **eWpG** plays a key role in this context, as it has since 2021 provided the legal and regulatory foundation for issuing electronic securities, such as **crypto securities**, in Germany and therefore facilitated the use of new technologies such as DLT (leaning journey). Even though the first iterations of „new" products often fall short of providing a scalable solution ready for mass roll-out, the significance of the learning journey is that each stage of development („**MVP strategy**") will gradually shift the focus and achieve real, tangible progress in the scalability of individual aspects. The long-term objective is to develop an ecosystem within which scalable (financial) products can reach maturity.

Source: KfW Image Archive/Thorsten Futh, Germany, May 2016

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2.2

First blockchain-based digital bond (MVP 1.0)

KfW issued the first blockchain-based digital bond with the idea of embarking on a learning journey; it had three key aspects:

1. **Practical trial** of the relatively new legal and regulatory framework and technical implementation of issuing a crypto security in accordance with the eWpG
2. Gathering **feedback** from a group of market participants as broad as possible with a focus on investors „right from the start“
3. **Internal education** and **sharing lessons learned** with third parties

To implement these aspects, in particular for the priority area of investor focus, a syndicate of four banks was selected that holistically represents all **four pillars of the German banking landscape** and was therefore able to serve as a multiplier in the different areas. In the syndicate of banks, Deutsche Bank stands for large private and universal banks and DZ BANK represents the cooperative banking sector. In addition, LBBW is part of the Savings Bank Finance Group (Sparkassen-Finanzgruppe) and Bankhaus Metzler represents the private banks. Moreover, Union Investment joined the project as an anchor investor early on and stayed with the project over the entire development period. In addition, an **eight-week education and engagement phase** was slotted between the public announcement at the beginning of May 2024 and the issuance of the bond at the beginning of August 2024 to give potential investors as much time as possible for their investment decisions and to obtain relevant feedback. Traditional bond issuance only allows a few days for this step. To strengthen internal education and third-party participation in the insights gained, extensive **stakeholder management** was also conducted over the entire period of product development. This included, among other actions, the publication of key messages[13] after the successful first issuance as well as other internal and external communication measures intended to share insights from conference attendance and presentations.

2.2.1 Securities attributes, roles and stakeholders

Table 1:
Securities attributes of MVP 1.0

Securities attributes	Details
ISIN	DE000A383BJ9
Settlement	T+2 (where „T“ represents the pricing day)
Listing	No listing
Tradeability	Over the counter (OTC), market making by Deutsche Bank, DZ BANK and LBBW
Settlement on the payment side	Free of payment (FoP), Deutsche Bank as lead arranger
Underlying blockchain	Polygon (proof of stake (PoS)) via crypto securities registrar Cashlink

Source: KPMG in Germany, 2025

13 *KfW announces its first blockchain-based digital bond under the German Electronic Securities Act (eWpG) | KfW*

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Table 2:
Project setup for MVP 1.0

Role	Execution	Explanation
Issuer	KfW	
Bookrunners	Bankhaus Metzler Deutsche Bank DZ BANK LBBW	
Anchor investor and project support	Union Investment	
Selected investors[13]	Berliner Volksbank, DekaBank, LBBW, Solventis AG, Sparkasse Pforzheim Calw, WI Bank	
Custodian	DZ BANK	Collective registered holder at the highest level; further custody along the conventional custody chain (in-house collective custody)
Crypto securities registrar	Cashlink	Financial service in accordance with KWG requiring a licence from BaFin
Crypto custodian	Hauck Aufhäuser Digital Custody	Financial service in accordance with KWG requiring a licence from BaFin; secure custody of the private cryptographic key to the KfW blockchain address
Legal advisor of KfW	Linklaters	
Legal advisor of bookrunners	Hengeler Mueller	
Rating agencies and issuance rating	Moody's Ratings: Aaa/stable S&P Global Ratings: AAA/stable Scope Ratings: AAA/stable	

Source: KPMG in Germany, 2025

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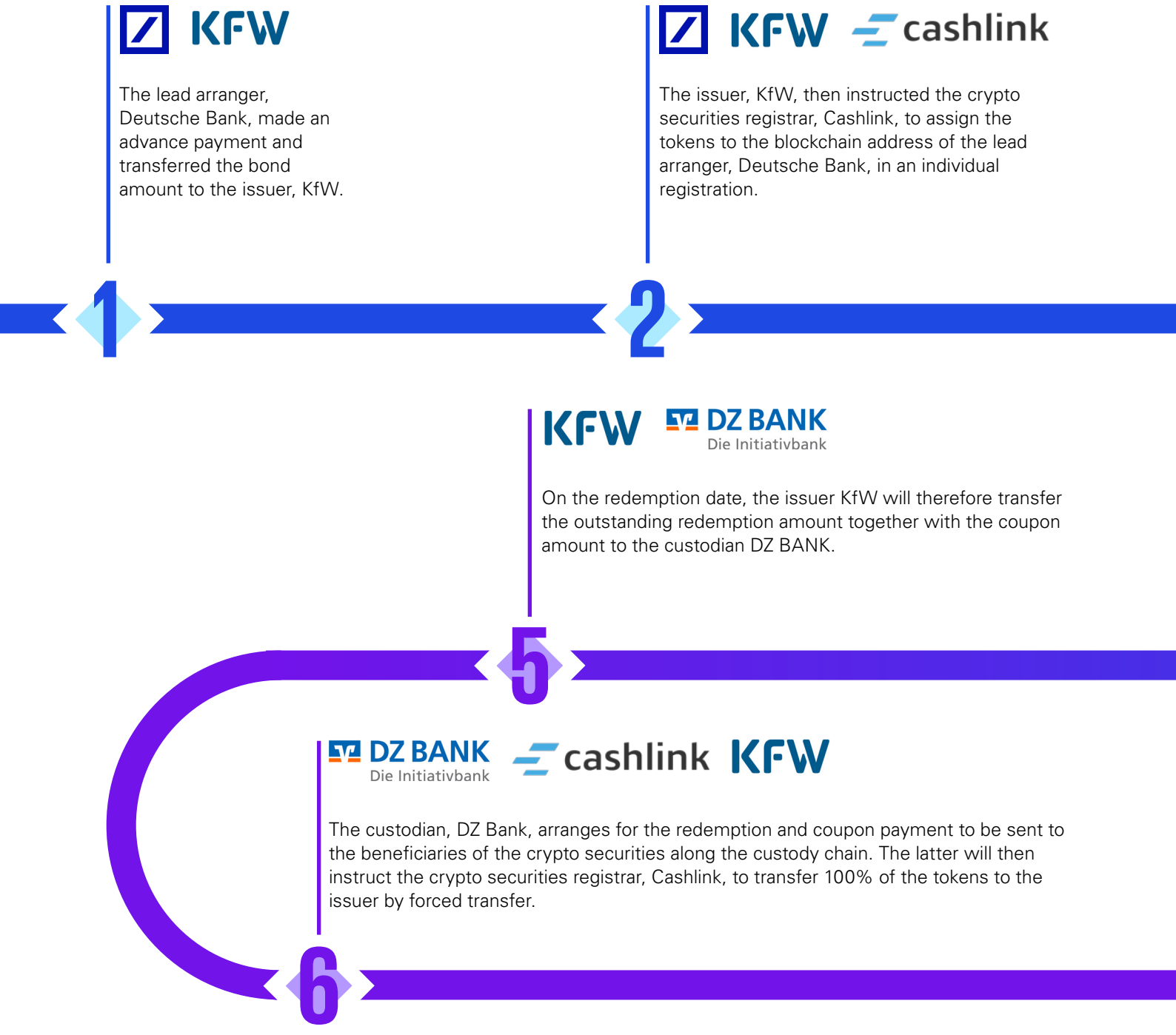
Figure 2:
MVP 1.0: Process description



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The crypto securities have come into existence in the legal sense upon entry of the lead arranger in the crypto securities register, together with the other details required for the crypto securities pursuant to section 17 eWpG, in the crypto securities register with a clear and directly recognisable reference to the issuance terms and conditions laid down. The lead arranger, Deutsche Bank, then instructed the crypto securities registrar, Cashlink, to transfer the tokens to the blockchain address of the custodian, DZ BANK, via forced transfer. Alongside this change of registration, the type of registration was changed from individual to collective registration.

3

The custodian, DZ BANK, holds 100% of the tokens in its blockchain address for the entire term of the bond and acts as the collective registered holder at the highest level. The custody of the tokens or crypto securities and thus the mediation of the legal position takes place off-chain and along the conventional custody chain.

4

After receipt of the tokens on the blockchain address of the issuer KfW, it will instruct the crypto securities registrar Cashlink to burn the tokens.

7

Primary market settlement

Redemption

Source: KPMG in Germany, 2025

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2.3
Second blockchain-based digital bond (MVP 2.0)

The learning journey when the second blockchain-based digital bond was issued had two major focal points: trial of the use of DLT-based central bank money during the **ECB exploration phase** using Deutsche Bundesbank's Trigger Solution as well as gathering additional practical experience in the handling of crypto securities. As the focus areas of the learning journey had changed, the project partner setup was adjusted accordingly, with some parts of it becoming leaner while others were expanded.

In April 2023, the ECB announced plans to explore solutions for the settlement of wholesale financial transactions recorded on DLT platforms. During the **ECB exploration phase** to trial new technologies for the settlement of DLT-based financial market transactions in central bank money, eligible market participants and eligible market DLT operators were given the opportunity, from May to November 2024, to test the interoperability solution(s) of their choice offered by the Eurosystem. The tests, which involved a total of 60 market participants, comprised trials with actual settlement in „real" central bank money and experiments with simulated settlement (mock money) in a test environment. The Bundesbank had provided the Trigger Solution, the TIPS Hash-Link solution came from the Banca d'Italia, and the Banque de France had developed DL3S, a DLT infrastructure in which simulated transactions could be executed. All three options were available during the exploration phase.

2.3.1
Securities attributes, roles and stakeholders

Table 3:
Securities attributes of MVP 2.0

Securities attributes	Details
ISIN	DE000A383P06
Settlement	T+1 (where „T" represents the pricing day)
Listing	No listing
Tradeability	Over the counter (OTC), market making by DekaBank, DZ BANK and LBBW
Settlement on the payment side	Delivery versus payment (DvP) via the Deutsche Bundesbank's Trigger Solution as part of the ECB exploration phase, Cashlink as market DLT operator, use of Hashed Timelock Contracts (HTLCs)
Underlying blockchains	Hyperledger Fabric via Deutsche Bundesbank and Polygon (PoS) via crypto securities registrar Cashlink

Source: KPMG in Germany, 2025

14 Eurosystem exploratory work on settlement in central bank money using new technologies: first batch of experiments successfully completed by the Banque de France with DL3S extended functionalities on automated wholesale payments | Banque de France

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Table 4:
Project setup for MVP 2.0

Rolle	Ausführend	Erläuterung
Issuer	KfW	
Bookrunner	DZ BANK	
Investors	DekaBank DZ BANK Union Investment	
Custodian	DZ BANK	Collective registered holder at the highest level; further custody along the conventional custody chain (in-house collective custody)
Crypto securities registrar	Cashlink	Financial service in accordance with KWG requiring a licence from BaFin
Crypto custodian	Boerse Stuttgart Digital Custody	Financial service in accordance with KWG requiring a licence from BaFin; secure custody of the private cryptographic key to the KfW blockchain address
Market DLT operator	Cashlink	Entity responsible and liable to market participants for the activities taking place on the platform, including but not limited to securities delivery in the context of DvP settlement[15]
Legal advisor of KfW	Linklaters	
Rating agencies and issuance rating	Moody's Ratings: P-1 S&P Global Ratings: A-1+ Scope Ratings: S-1+	

Source: KPMG in Germany, 2025

15 Call for Expression of Interest

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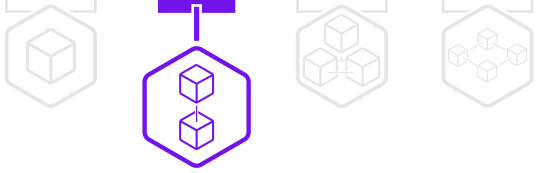

Figure 3:
Process description MVP 2.0

KfW cashlink

On the settlement day, the issuer KfW created its secret and the secret hash and instructed the crypto securities registrar Cashlink to assign the tokens to the KfW blockchain address.

cashlink DZ BANK Die Initiativbank

The bookrunner DZ BANK then approved the payment instruction and the bond amount was transferred by direct debit from the DZ BANK account at the Bundesbank to the Bundesbank interim account.

cashlink DZ BANK Die Initiativbank

The market DLT operator Cashlink created the payment instruction on the trigger solution using the secret hash transmitted by the issuer KfW. The market DLT operator Cashlink then provided the HTLC smart contract with the issue parameters, including the secret hash, on the asset chain and transferred the tokens from the blockchain address of the issuer KfW to the HTLC smart contract. The market DLT operator Cashlink notified the bookrunner DZ BANK about the existence of the payment instruction for approval on the trigger solution.

cashlink DZ BANK Die Initiativbank

The market DLT operator Cashlink created the payment instruction on the trigger solution using the secret hash. The market DLT operator Cashlink then provided the HTLC smart contract with the redemption parameters, including the secret hash, on the asset chain and transferred the tokens from the blockchain address of the custodian DZ BANK to the HTLC smart contract in accordance with the instruction from the custodian DZ BANK.

cashlink KfW

The market DLT operator Cashlink notified the issuer KfW about the existence of the payment instruction for approval on the trigger solution. The issuer KfW approved the payment instruction and the redemption amount, including the coupon, was transferred by direct debit from the KfW account at the Bundesbank to the Bundesbank interim account.

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Primary market settlement

Redemption

KFW

The issuer KfW has now been automatically notified that the payment has the status „Payment Locked“ on the trigger solution. The issuer KfW called up the HTLC transfer function of the trigger solution and subsequently disclosed its secret in the trigger solution. Entering the secret released the payment block and the issuer KfW received the credit for the bond amount in its Bundesbank account.

4

cashlink

DZ BANK Die Initiativbank

The market DLT operator Cashlink received notification via the trigger solution that the payment was successfully executed and also gained access to the KfW secret. Furthermore, the market DLT operator Cashlink used the KfW secret to release the tokens from the HTLC smart contract so that the tokens could be transferred to the blockchain address of the bookrunner DZ BANK.

5

DZ BANK Die Initiativbank cashlink KFW

On the redemption date, the custodian DZ BANK created its secret and the secret hash and instructed the crypto securities registrar Cashlink to transfer the tokens to the issuer KfW.

6

DZ BANK Die Initiativbank

The custodian DZ BANK received notification that the payment had the status „Payment Locked“ on the trigger solution. The custodian DZ BANK called up the HTLC transfer function of the trigger solution and disclosed its secret in the trigger solution. The entry of the secret released the payment block, and the custodian DZ BANK received the credit of the redemption amount, including the coupon, in its Bundesbank account.

9

cashlink KFW

The market DLT operator Cashlink received notification via the trigger solution that the payment was successfully executed and also gained access to the DZ BANK secret. The market DLT operator Cashlink used the DZ BANK secret to release the tokens from the HTLC smart contract so that the tokens could be transferred to the blockchain address of the issuer KfW. After receipt of the tokens on the blockchain address of the issuer KfW, it instructed the crypto securities registrar Cashlink to burn the tokens.

10

Source: KPMG in Germany, 2025

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03

Lessons learned

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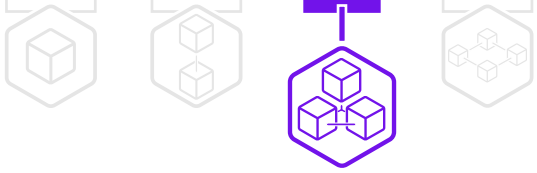

3.1
Issuer perspective

The insights gained by KfW in its role as issuer break down into aspects relevant across issuances and issuance-specific aspects.

The eWpG provides a functioning framework for the issuance of crypto securities. On the other hand, some provisions of the **eWpG** have not or hardly been tested in practice, which is due in particular to the relatively recent adoption of the Act as well as to the associated changes to the technical infrastructure as a result of using DLT. This includes, for example, the possibility to replace crypto securities with certificate-based securities pursuant to section 6 (2) eWpG.

Project partner roles such as **crypto securities registering** and qualified **crypto custody** are new financial services governed by the KWG; they require a BaFin licence to be performed.

In the context of crypto securities, the traditional **function of central securities depository** is divided into up to three fields of activity, which can theoretically be assigned to three different service providers. However, this increases the effort required for coordination and agreement according to the project partner roles required:

- **Custody function:** Performed in both issuances by DZ BANK as collective registered holder at the highest level
- **Clearing function:** Not applicable in MVP 1.0 because free of payment, in MVP 2.0 performed by Cashlink using the Trigger Solution of Deutsche Bundesbank in its function of market DLT operator
- **Provision of technical infrastructure** for mapping the crypto security: performed in both issuances by Cashlink in its function of crypto securities registrar

By using DLT in the issuance process, the **settlement period** could be reduced from T+5 for traditional bonds to **T+2** in MVP 1.0 and to **T+1** in MVP 2.0 (where „T“ represents the pricing day).

Especially against the backdrop of increasing **market dynamics**, the education of internal and third-party stakeholders about the use of DLT in the issuance process in general and about crypto securities under the eWpG in particular is essential and will remain so in the future.

For KfW, the disintermediation of bookrunners is not expedient for a number of reasons.

For example the high funding volumes make the **underwriting function** particularly important. In addition, the know-your-customer (KYC) requirements (for far more than 800 investors) would exceed KfW's capacities.

The following specific insights were gained from **MVP 1.0**: the four members of the bookrunner syndicate spoke to over **110 investors** in the course of the eight-week education and engagement period and gathered valuable feedback in the process:

- The current lack of **central bank eligibility** and the fact that the bond cannot be included in ratios such as the liquidity coverage ratio (LCR) and high-quality liquid assets (HQLA) mean that, in our view, there is not yet a level playing field for crypto securities when compared with traditional securities (as well as central register securities).
- Even though the market making activities of the bookrunners ensure OTC tradeability of the bond in principle, **secondary market liquidity** of blockchain-based digital securities is still limited when compared to traditional securities (as well as central register securities).

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- Investors have to perform – in some cases time-consuming – new product processes (NPP) to achieve **internal readiness** (cost-benefit analysis).

MVP 2.0 also delivered specific insights:

- Technical **delivery-versus-payment** (DvP) settlement that is traceable step by step, in under three minutes and without a central securities depository (CSD), was successfully trialled both during primary market settlement and on redemption.

- The **mix of educational, legal and technical work** changed significantly between the two issuances, not least because of the changed focal point of the learning journey and the retention of most of the project partner setup: MVP 1.0: approx. 40 percent/50 percent/10 percent compared with MVP 2.0: approx. 10 percent/10 percent/80 percent (order indicates breakdown of the mix into educational share/legal share/technical share).

> *The issuance of our first crypto security is another important milestone on our digital learning journey. From the outset, our aim was to involve as many market participants as possible in the transaction in order to collectively learn new things and test the innovation facilitated by the legislator through the German Electronic Securities Act (eWpG) together with our banking partners, our anchor investor Union Investment and other interested investors. The healthy level of participation shows the investors' keen interest in the digitalisation of capital market transactions. We now want to use this potential to identify scaling options for our refinancing activities.*
>
> **Tim Armbruster,**
> **Group Treasurer, KfW**

Source: KfW Image Archive/Rüdiger Nehmzow, Germany, 2014

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3.2
Bookrunner perspective

In their respective roles as **bookrunners**, Bankhaus Metzler, Deutsche Bank, DZ BANK and LBBW gained the following insights from their involvement in KfW's two blockchain-based digital bonds:

Preparatory and marketing phase: A preparatory phase of several weeks and an eight-week marketing phase were useful to clarify the background of the transaction internally and externally, as happened in the case of MVP 1.0. For as long as the majority of investors have not completed an NPP for DLT-based digital securities, a longer marketing phase allows participation in the primary market transaction while at the same time enabling investors to make the necessary decisions and preparations. However, eight weeks, as in this case, are not enough for many firms. Since the joint lead managers (JLMs) engage in market making, there is an option to acquire securities in the secondary market at a later date. A lead time of three months, for example, is considered more appropriate. Several investors complain in their feedback that there are only few relevant benefits compared to investments in traditionally issued bonds at the present time. Participation in the issuance of DLT-based digital securities is mainly driven by the expectation that the technology will gain in relevance in the future and experience in this technology is already being gathered. Other factors deterring investors from participating are firstly the absence of a **repo transaction market**, secondly the greater effort required for onboarding special **safe custody solutions**, since custodian banks rarely offer custody for crypto securities, and thirdly the current lack of ECB eligibility. In addition, investors are unsure whether the eWpG allows the collective registration of multiple custodians at the highest level in the register.

Qualification of market participants: The selective education of all involved parties, especially sales staff and investors, is of great importance. The video series[16] was useful, although feedback from internal and external participants indicated that the videos were too long and the information was not provided in text format for reference, which made it considerably more difficult to distribute the information within the firms. The **information memorandum** was very positively received by some institutional investors because it simplified the NPP. The contents of the information memorandum and liability risks that may potentially arise were, however, the subject of controversial debates to start with. Broad-based education on this subject will continue to be essential. What made the project complex was the need to address the different target groups in suitable ways and to offer a mix of formats with different levels of detail. There is interest in the technology in the market, combined with the question of when the firm itself should start to take action. Even if it was decided not to make an investment in the case in question, the educational efforts were a driver of the digitalisation of the financial centre.

Efficient investor involvement: Keeping the maturity of the issuances as short as possible was the right decision in order not to exclude any investors due to the **economic component**. Pricing on the basis of a traditional reference bond plus a mark-up was also the correct decision, as this meant that no investors were discouraged by the pricing and the independence of market movements could thus be maintained. As soon as crypto securities become more mainstream and the disadvantages and barriers to investment are eliminated, we expect that the pricing of crypto securities will be adjusted.

Early involvement of JLMs: The early involvement of the JLMs was a mutual enrichment that allowed the parties to consider the arising issues holistically. To keep the potential need for coordination at a reasonable level and allow effective action to be taken, strategic decisions on size, composition and requirements were to be taken in advance. The general idea was to formulate a **catalogue of requirements** for the JLMs before the system went live (market making, custody for third parties etc.), combined with an obligation to meet those requirements.

16 *Tokenisierteanleihe.de*

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3.3

Investor perspective

Union Investment (UI) in its role as **anchor investor** and project facilitator breaks the insights it has gained into several segments.

Collaboration of the stakeholders involved: In the token economy in general and in the development of a digital Capital Markets Union with assets-on-chain and cash-on-chain at its core, close collaboration among all financial market participants is a necessity. They include in particular regulatory authorities, central banks, finance ministries as well as issuers, investors, banks, law firms, data providers, trading venues, custodians and registrars – from both the traditional finance industry and the financial technology segment (fintechs).

Analysis of the features of the individual bond: Since there is no market standard yet, all features of the DLT-based digital securities must be considered in detail. The Minimum Requirements for the Risk Management of Asset Management Companies (Mindestanforderungen an das Risikomanagement von Kapitalverwaltungsgesellschaften – KAMaRisk) provide the basis for asset management companies. As part of a „concept for the use of crypto securities and crypto fund units in securities investment funds, taking account of the requirements of section 9 of KAMaRisk (activities in new products or in new markets)“ and a resulting checklist, the following process and test steps were taken internally at UI, including a review of counterpart (issuer or syndicate of banks), ratio of the UI transaction volume to the whole issue volume, group of investors, investing funds of UI, settlement via fiat money or wCBDC, settlement cycle, pricing in combination with customer benefits, issue rating and tradeability.

Review of DLT-based risks: New opportunities associated with DLT-based digital securities are balanced by new potential risks, which asset management companies have to review in detail and on a case-by-case basis as part of their fiduciary function. This includes in particular an analysis of the underlying blockchain itself (governance, anti-money laundering, permissioned as opposed to permissionless technology) as well as a due diligence investigation of crypto securities registrar (in particular a review of smart contracts used) and custodian of crypto securities (in particular management of the private cryptographic keys and on-chain as opposed to off-chain accounting). Responsibility for potential liability risks must be clearly agreed in a contract with the custodian. Financial market stability will ultimately have to be safeguarded as a precious commodity. The delivery of added value and the generation of benefits for investors have ultimate priority.

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3.4
Custodian perspective

DZ BANK in its role as **custodian** in the form of collective registered holder at the highest level breaks down its lessons learned into two areas.

Legal assessment: In practice, sales of crypto securities to bank customers via banks requires the registration of a custodian authorised to conduct custody business with collective registration pursuant to section 8 (1) no 1 eWpG, because otherwise each investor will have to be **individually registered** and the investor will therefore have to arrange their own safe custody and administration of the crypto securities. In contrast, collective registration of one or more custodians „at the highest level" allows them to provide safe custody services and similar custody chains in the same way as in the conventional securities business. This is what investors want (all the investor's securities are in the same safe custody account) and it entails simplified regulatory treatment, as known requirements (such as BaFin's minimum requirements for the custody business) „only" have to be modified to make them appropriate for crypto assets. Against this backdrop, the issuance process of KfW's first blockchain-based digital bond (MVP 1.0), with its two parts – „individual registration for the bookrunner first" and „then change from individual to **collective registration** with a custodian in favour of the investors" –, included the unnecessary step of individual registration, which in the worst case may lead to additional errors and costs. As was done for KfW's second blockchain-based digital bond (MVP 2.0), the issuer should therefore directly specify a custodian in collective registration.

Pursuant to section 8 (1) eWpG, the collective custodian is registered as a holder of electronic securities at the issuer's request. The custodian manages the collective registration on a fiduciary basis for the entitled parties pursuant to section 9 (2) eWpG. The collective custodian could therefore be selected from the investor side, but is registered at the issuer's request. Moreover, in the conventional securities business, as **Issuer Central Securities Depositories (CSDs)**, collective custodians of the issuer are attributed to the issuer side. This creates legal uncertainty as to whether – and what – responsibility the issuer assumes for collective safe custody and the collective custodian, what should be disclosed in this regard in the issuance information memorandum, and which party instructs the collective custodian (issuer or bookrunner).

Since there is no standard yet for the safe custody and administration of crypto securities, the **„Special terms and conditions for securities transactions"**, which have been customary in the industry for the existing safe custody business in Germany, are not entirely suitable. The rules for safe custody and administration – depending on the crypto security issuance – therefore have to be adapted to the custody business of the collective custodian on a case-by-case basis, and the custodian has to agree these rules with all its own direct customers or investors and with all custodian banks connected to the custodian. In turn, the custodian banks have to mirror these rules in the arrangements with their own customers or investors so that the same rules apply along the relevant investor custody chain. In KfW's first transaction (MVP 1.0), this step took considerable time and coordination effort. In practice, crypto securities would therefore benefit greatly from a consistent standard for common custody services, supplementing the „Special terms and conditions for securities transactions", since this would eliminate the need for **bilateral custody agreements tailored to each individual case** in the custody chain in favour of a master agreement that applies in principle to all crypto securities.

Functional considerations: In the context of KfW's two blockchain-based digital bonds, DZ BANK was able to gain valuable insights into the role and requirements of a custodian under the eWpG. For example, the custodian made sure that the crypto securities issued met regulatory requirements and the accompanying **digital infrastructure** operated stably. The custody platform reliably performed its core functions in relation to the safe custody and administration of the crypto securities and enabled transparent documentation and **compliance with regulatory standards.**

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There is room for improvement in the **integration of the custody platform** with existing payment, trading and booking systems. In the current setup, data between the respective systems is in some cases still exchanged manually or via stand-alone interfaces, and this increases the time and effort. Given the relatively small number of transactions, this does not cause a problem. However, as the solution is scaled up, seamless connections with existing systems will further reduce processing time and effort while simplifying compliance and reporting requirements at the same time. To drive further automation, it is advisable to have a basic set of standards that can continuously be enhanced.

Security plays a key role, including in the safe custody of crypto securities. The use of blockchain technology demonstrates that continuous monitoring, practised transparency and the implementation of advanced encryption technologies are excellent tools for ensuring the security of the assets. It will be necessary for the future to **deal extensively with data protection issues**. Requirements that are right for widespread use will have to be formulated in this process. The flexibility and programmability of a secured blockchain should yield possible technical solutions. To meet the requirements of the German Money Laundering Act (Geldwäschegesetz, „GwG") and the KYC process, the use of public blockchains allows transactions to be examined with enhanced compliance and reporting tools.

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3.5 Crypto securities registrar perspective

Cashlink, in its role of **crypto securities registrar** as well as **market DLT operator** in MVP 2.0, made the following key findings.

Technical mapping of the delivery versus payment (DvP) process: In terms of technology, the DvP settlement was successfully mapped using the HTLC protocol on the trigger chain, also referred to as Trigger Solution, and the asset chain (Polygon). This solution facilitated the simultaneous handling of securities and cash flows.

Use of the Trigger Solution and HTLC protocol

The Trigger Solution combined with a **hashed timelock contract** (HTLC) served as bridge between conventional financial systems and the world of blockchain. HTLC technology, which has its origins in decentralised finance (DeFi) has also proved effective in the area of conventional finance. It allows transactions to be settled securely and transparently by using the following mechanisms:

1. A **secret** is created and published in the form of a **hash**.
2. This hash serves as a **lock** on the money and asset side.
3. The transaction is executed only once the associated **secret** that opens the lock is **disclosed**.
4. A **time limit** provides additional security by cancelling the transaction automatically if the conditions are not met.

Implementation of HTLC on the asset chain

For running the DvP process, an **HTLC smart contract** is provided on the asset chain; it uses the same secret as the HTLC on the trigger chain. This dual structure enables coordinated execution on both sides. HTLC is configured on the asset chain in such a way that it allows tokens to be issued only if the correct secret is disclosed. The trigger chain controls the payment process and uses the same secret in order to guarantee the money transfer to the seller. **Synchronisation** ensures that token transfer and payment can only be made if both parties have met their obligations. This reduces risks and improves settlement efficiency.

The technical integration of the HTLC protocol and Trigger Solution unlocks far-reaching opportunities for the financial market:

Increased efficiency: Automation and direct settlement help to accelerate processes.

Minimised risk: Thanks to synchronised execution, settlement and counterparty risks are significantly reduced.

Flexible use: The solution is independent of the type of payment medium used (e.g. fiat money, digital assets) and can be used in different market environments.

This innovative solution demonstrates how blockchain technologies can **merge** with existing financial infrastructures to facilitate a new generation of secure, efficient financial transactions.

Asset chain orchestration: The technical orchestration of the asset chain in the context of the DvP process uses an infrastructure that combines the public Polygon blockchain and the private Hyperledger chain. This innovative combination allows users to take advantage of both worlds – the openness of a permissionless blockchain and the control of permissioned infrastructure.

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Use of Polygon and Hyperledger

The asset chain is based on the scalable, cost-effective and transparent **Polygon blockchain**. Tokenised assets are securely managed and the decentralised structure guarantees high reliability. The open infrastructure enables future use cases and the integration of additional protocols or smart contracts. The Bundesbank's Trigger Solution, which has been realised with **Hyperledger Fabric**, operates as a private-permissioned blockchain. It provides a controlled, restricted-access and secure environment of payment settlement. This ensures a high level of compliance and data protection, which is critical, especially in the conventional financial sector.

Function of the HTLC protocol in the cross-chain setup: The HTLC protocol has been shown to be effective as a key orchestration function. Although Polygon and Hyperledger are fundamentally different blockchain architectures, the HTLC protocol worked smoothly between the chains, facilitated by the consistent use of a shared secret and hash, which ensures trusted interaction across chain boundaries.

On-chain availability and transaction data security: Another key aspect of the orchestration was the on-chain availability of the transaction data. The fact that they were available on both the asset chain and the trigger chain offered a number of advantages:

Transparency: All participants had access to the relevant data at all times, adding considerably to transaction transparency.

Security: The use of blockchain technology guarantees the immutability and integrity of the data, thus ruling out manipulation.

Automation potential: End-to-end availability of the transaction data creates the basis for further-reaching process automation.

In summary, asset chain orchestration on the basis of Polygon and Hyperledger shows how different blockchain architectures can be combined successfully to harness the strengths of both technologies. The seamless integration of the **HTLC protocol** and the on-chain availability of the transaction data offer significant potential for further enhancing the efficiency and security of financial transactions.

Simultaneous settlement on the money side: Simultaneous settlement on the money side as part of the DvP process was realised with the Bundesbank's Trigger Solution. This infrastructure enables efficient and secure settlement of the cash flows in the TARGET2 system.

Use of the trigger chain via API and user interface

The Trigger Solution, which is based on Hyperledger Fabric technology, could be accessed via both a user-friendly web-based **user interface (UI)** and an **application programming interface (API)**. This flexibility allowed the players involved to execute and monitor transactions according to their technical requirements or preferences. The API facilitated integration into existing IT systems and automated settlement. The user interface provided an intuitive platform for manually tracking and controlling the transactions.

Live transaction tracking

The API and the user interface enabled participants to track settlement in **real time**. They were able to follow the progress of the payment process in all phases, which was an advantage particularly for time-critical transactions. This **live monitoring** contributed considerably to making the process transparent and secure.

Money transfer via TARGET2 in a matter of seconds

Once the previously specified secret had been entered, the money transfer was initiated by the **trigger chain** and executed via the European **TARGET2** payment settlement system within a matter of seconds. This process guaranteed fast, reliable payment, which was processed simultaneously with the token transfer on the asset chain.

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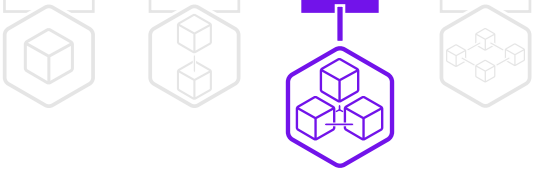

Effective use of the HTLC protocol on the Hyperledger chain

The **HTLC protocol** was successfully used on the **Hyperledger-based trigger chain**. It secured synchronisation between the payment on the trigger chain and the token transfer on the asset chain. A special feature is that the HTLC protocol does not transfer any tokens on the trigger chain, but controls the TARGET2 payment. If the transaction is successful, the agreed payment is triggered (executed).

Simultaneous settlement on the money side demonstrated how DLT-based technologies, such as Bundesbank's Trigger Solution, can work efficiently with established payment systems such as TARGET2. Live tracking, fast payment settlement and the option to use the **cross-chain** function of the HTLC protocol provide a high level of security and automation potential for future financial transactions.

A financial milestone

The implementation of real **DvP settlement**, in which both the tokenised asset transfer and the payment were processed simultaneously, is a breakthrough in the digitalisation of financial transactions. The possibility to realise such a secure and transparent transaction on the blockchain highlights the **technological maturity** of the solutions deployed and sets standards.

Trigger solution complements eWpG-based infrastructure

The Bundesbank's trigger solution perfectly complements the technical infrastructure on the basis of the German Electronic Securities Act (Gesetz über elektronische Wertpapiere, „eWpG") and the use of digital assets. The Trigger Solution closes a critical gap for the **seamless integration of money and securities transactions**.

Functioning orchestration and automation potential

Thanks to the HTLC protocol, the orchestration of the DvP process between the asset chain (Polygon) and the trigger chain (Hyperledger) went smoothly. This coordination demonstrates that it is possible to achieve a high level of **automation** and **synchronisation** of transactions in different blockchain environments; it provides an excellent foundation for further optimising the whole transaction process and to automate it in its entirety. Real-time synchronisation enables significant reductions in settlement times.

Conclusion

MVP 2.0 has shown how **blockchain technology** and **regulatory innovations** can work together to raise the digital capital market to a new level. The Bundesbank's trigger chain allowed not only a real DvP process to be settled securely and efficiently, but also holds the potential to digitalise and accelerate future transaction processes on a comprehensive scale. This project is a significant step towards a fully integrated and automated digital financial market.

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3.6
Crypto custodian perspective

As part of their activities as **crypto custodians** with an existing crypto custodian licence under the KWG in the context of the blockchain-based digital bonds, Boerse Stuttgart Digital Custody and Hauck Aufhäuser Digital Custody have, among other things, gained the following insights and identified the following aspects:

As custodians of crypto assets regulated in Germany, they can use existing processes and technologies to provide services, including in the context of crypto securities. One example is the securing of private keys for KfW's two blockchain-based digital bonds. The adoption of the **German Financial Market Digitalisation Act** (Finanzmarktdigitalisierungsgesetz, „FinMaDiG") in 2024 also guarantees the **regulatory security** of future use cases for crypto custodians.

The facts around securing described in the KWG could possibly be interpreted to mean that a crypto custodian cannot directly operationalise the private key for creating a signature for a transfer without a custodian banking licence. In this interpretation, it would be necessary to transfer the **private cryptographic key** to the **end customer**. In practice, this is often not feasible for the following reasons: First, surrendering the cryptographic key would compromise the confidentiality of the key as, from that moment, it can no longer be deemed confidential and therefore adversely affects the security of the assets. Second, customers often lack the necessary technical infrastructure to receive and store the keys securely, and as a result the protection requirements cannot be met. Third, customers would have to obtain their own gas tokens for transaction fees and make sure that they are used, which creates an additional technical and operational barrier. These challenges are driving the search for specialised service providers such as crypto custodians that can perform the secure administration of the cryptographic keys.

On-chain accounting by means of segregated addresses creates a high level of transparency and monitoring options, provided the issuance takes place on publicly accessible blockchain technology. In this context, the developments in the Basel Committee with regard to capital requirements for the use of public blockchains should be monitored. A solution for DLT-based central bank money could not be tested in MVP 1.0. But in the context of KfW's second blockchain-based bond, the Bundesbank's Trigger Solution was trialled; it acts as a bridge between DLT-based systems and TARGET2 and thus facilitates settlement in central bank money.

No market standards for crypto custodian services for securing private cryptographic keys in the context of crypto securities have established themselves to date. There is, moreover, no consensus in the market as yet regarding the mechanisms for operationalisation, liability, rights and obligations of surrender, and security mechanisms.

While token standards such as ERC-20 have established themselves, there are no standardised approaches to dealing with private cryptographic keys or best practices for operationalising them in the context of transfers.

In summary, KfW's two blockchain-based digital bonds demonstrate that **crypto custody services** still face challenges of a legal as well as a technical nature. The creation of standards that meet legal and operational requirements is an essential step for accelerating and reinforcing ways to highlight the advantages of crypto securities. Recommendations for enhancement include the development of clear legal requirements for crypto custodians that can be enforced in practice within the framework of the eWpG as well as the promotion of **best practices** and technological solutions to optimise transaction processing.

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The **crypto custody business** is a financial service that relates to the safe custody, administration and securing of crypto assets and private or third-party cryptographic keys. Until the end of 2024, the term „crypto custodian“ (Kryptoverwahrer) was used to refer to custodians of crypto securities. Since the German Financial Market Digitalisation Act (Finanzmarktdigitalisierungsgesetz, „FinMaDiG“) entered into force, this term no longer necessarily applies. Institutions authorised by the end of 2024 pursuant to the German Banking Act (Kreditwesengesetz, „KWG“) to provide crypto custody were allowed to store cryptographic keys that enable control of the crypto securities (in particular transactions involving them). This authorisation is now being converted into an authorisation under the Markets in Crypto-Assets Regulation (MiCAR) for crypto assets and into the new authorisation category of „qualifying custody business“. However, institutions that undergo the authorisation procedure under MiCAR are not automatically granted this authorisation.

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3.7

Regulation and legal documentation perspective

Linklaters gained the following insight and identified the following aspects in providing **legal advice** to KfW on its two blockchain-based digital bonds:

In terms of regulation, the issuance of the two KfW bonds showed that the **eWpG** is suitable for issuing securities under German law, even **without certificates**, in a **legally secure framework**. However, some of the provisions of the eWpG relating to collective registered holders were revealed to be imprecise. For instance, the question was raised as to whether there could be more than one collective registered holder per issue. Clarification within the Act would be useful, given that multiple collective registered holders would provide a considerable boost to the sale of crypto securities in practice.

As regards **contract drafting**, the issuance of the two KfW bonds showed that boilerplates for conventional bonds can be largely adopted in the terms and conditions of issue and in issue and purchase agreements. Moreover, the blockchain-specific provisions and necessary adjustments are manageable and can easily be incorporated into the existing boilerplates for traditional bonds.

The **rules and regulations of the registrar entity and the crypto custodian** (if required) are uncharted territory from the point of view of an issuer. This applies in particular to the incorporation of technical processes and risks from a legal standpoint. For instance, the processes for issuance and redemption of the bonds are descriptive in the registrar entity's rules at present due to the newness of the products. The level of detail is expected to decrease in future. The rules of the crypto custodians show that, in some cases, the custody of private cryptographic keys that serve to hold or dispose of crypto securities for others imposes different requirements than the custody, management or safeguarding of crypto assets such as Bitcoin.

There is an increasing focus on the **capital charge** of crypto assets in the international financial market due to the entry into force of specific requirements such as the Capital Requirements Regulation III (CRR III). While the **SCO60 standard of the Basel Framework**, which is due to become effective as of 1 January 2026, has been dealing with this issue since December 2022, the EU legislature has committed in its latest revision package under the CRR III to setting specific benchmarks by mid-2025 for special regulatory treatment of crypto asset exposures with a view to international standards. In the meantime, transitional provisions initially apply within the scope of the CRR, which are to be substantiated by the Regulatory Technical Standards (RTS) currently still being drafted by the European Banking Authority (EBA). The level of differentiation required in the classification of crypto assets remains unclear in light of the findings of the Basel Committee thus far. For example, it is not yet clear how important the DLT underlying a product will be and how the associated risks should be adequately addressed in order not to require a **risk weight of up to 1,250%** and thus a capital charge up to the full amount. This decision now requires the European legislature to create the basis for the capital charge and regulatory treatment of crypto assets and thus also future technical innovations in the financial sector, and in so doing to take a further key step towards a digital capital market.

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3.8

Rating agencies perspective

Moody's Ratings, Scope Ratings and S&P Global Ratings have provided **credit ratings** for the two blockchain-based digital bonds of KfW, and ascertained the following in the process:

No distinction was made between ratings for DLT-based digital securities and traditional securities. The issuer's **redemption promise** underlying the rated blockchain-based digital bonds of KfW is the same as that for a conventional security. The Federal Republic of Germany provides an explicit, unconditional, unlimited, statutory, direct and irrevocable guarantee for the obligations of KfW, which gives creditors direct recourse in the event that the bank cannot settle its obligations. The obligations of the issuer of the rated digital bonds have the same **seniority** as traditional liabilities. Similar legal mechanisms were used to safeguard investor rights. This meant the same rating criteria were applied – for the type of issuer and the instrument – as for conventional securities to assess the quality of the underlying redemption promise of a rated DLT-based digital security.

However, new and developing structural details required an in-depth and issue-specific analysis. The use of new technologies in digital bonds must not lead to additional risks for investors if they are to achieve the same rating level as their traditional counterparts. The structural characteristics of MVP 1.0 and MVP 2.0, such as the underlying blockchain, the parties involved and the mechanisms used to settle payments during the lifecycle of the security, required a specific analysis of any potential new risks compared with traditional settlement. The counterparty risk in the transaction was effectively addressed by means of a **replacement mechanism** for the crypto securities registrar and a **third party audit** of the smart contracts (smart contract audit). As market maturity increases, specific norms may develop or some structural elements may be repeated. The use of a controlled environment to settle payments under the bonds has increased trust in the settlement mechanism. An important analytical consideration in evaluating DLT-based digital securities is whether payments are made on-chain or off-chain, and in what form. Whereas crypto currencies are volatile as a denomination of the bonds or a payment medium and may lead to difficulties in assessing creditworthiness, stablecoins bear the inherent risk of unpegging. Payment settlement in a controlled and secure environment, on-chain via wCBDC, or – as with MVP 2.0 – by using a DLT-based central bank money solution, such as the Bundesbank's Trigger Solution, to synchronise payment, limited risks for investors to the extent that the rating was comparable with analogue bonds. The solution also profited from the standing of the institutions involved.

The analysis of a **backup plan** also plays a key role. The question as to how investors are paid out if the platform used for the issuance and administration of DLT-based digital securities does not work as planned was an important analytical consideration. The risk was mitigated by the existence of a business continuity plan, which is activated immediately should a platform fail. In some cases, the bond administration is relocated and the redemption initiated in the traditional settlement form. The solution via the backup plan was also facilitated by a sufficiently small number of parties involved in these test phases.

Thus far, DLT-based digital securities have generally been lacking **liquidity**. Intermediaries are still testing their platforms and the participation of investors on these platforms is not yet sufficiently broad. Increasing maturity will enable the sector to achieve better scalability through shared use of private-permissioned blockchains of various partners, or by using **cross-chain communication technologies**. This may also alleviate the associated risks or mitigate them further by using public blockchains.

Initial bond issuances such as KfW's MVP 2.0, which allow settlement of DLT-based financial transactions in **central bank money** in the ECB exploration phase, are of key importance. They will be decisive in demonstrating scalability and establishing industry standards. Broad-scale acceptance will depend, not least, on the maturity of the blockchain technology, cross-border regulation standards and the creation of robust secondary markets.

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04

Maturity of the DLT-based capital market and outlook

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4.1

Market maturity in the status quo based on the ASAP model

The global financial market is facing an important upgrade to the realm of **synchronised markets and programmable market infrastructures**. Tokenisation has proven its general potential, but currently primarily constitutes „islands of harmony" within an „ocean of diversity". Various initiatives have tried to solve the problem of interoperability, but without sufficient success. One of the main reasons is the lack of trust anchors as regards standardisation within the ecosystem, and economies of scale of shared networks that have yet to be realised. In order to unleash the full potential of programmable market infrastructures, there need to be synchronised markets that are supported by uniform standards and a trusted framework.

To enable classification, the **current market maturity** of DLT-based digital securities will be explained and indicated based on the diagram below. This is focussed on German jurisdiction. The diagram refers to both the IMF's **ASAP model** and the **front-to-end process**, and shows the respective level of maturity in the process by means of colour-coding. The basis is formed by the knowledge gained from the two blockchain-based digital bonds of KfW.

The **access layer** contains functions and interfaces that enable customers and users, applications and other market components to connect with the underlying service, asset and platform infrastructure levels. This layer comprises functions that enable presentation, translation and formatting of data, processing by customers, management of credentials and data exchange.

The front-to-end process of the two KfW blockchain-based digital bonds had a limited scope with regard to the access layer. This meant that regarding the issuances some access points could be implemented via the respective blockchain addresses, the Trigger Solution or interfaces. Moreover, the main part of the infrastructure was with crypto securities registrar Cashlink, as a one-stop shop, without a direct node or access for the issuer KfW. The basis forms an **electronic instruction** to Cashlink, meaning that an IT interface between Cashlink and KfW need not be programmed. The access to DLT is therefore provided indirectly via the crypto securities registrar. There was no systemic instruction, with existing roles and services being used instead. With time to market in mind, use of IT resources at the issuer is avoided as far as possible in order to ensure a minimally-invasive process for KfW's IT and system infrastructure. It should also be noted that there is still scaling potential particularly with respect to the secondary market and lifecycle events. However, it can be assumed that the competent national authorities will issue more licences for trading platforms and market infrastructures in the short and medium term as part of the DLT Pilot Regime, which will require standardisation and uniform processing of the access layer and its data.

The blockchain-based digital bonds of KfW enabled many services to be identified in the **service layer** that are ready to be implemented, such as asset transfer and custody of DLT-based digital securities following trading on the primary market. The service layer comprises functions that manage or use the financial assets provided on the platform. Within the ecosystem or financial market infrastructure, these functions, or combinations thereof, typically facilitate the implementation of financial services. In other words, this is the application layer at which financial services are provided. Some closed networks (private-permissioned DLT networks) with a large number of participants, such as those at Goldman Sachs and JP Morgan, may be viewed as advanced in their development. They already offer a wide range of services such as asset transfer, collateralisation, swaps and lending. The unexploited potential lies in the fact that there is no framework for standardisation of services at this level. A framework of this type

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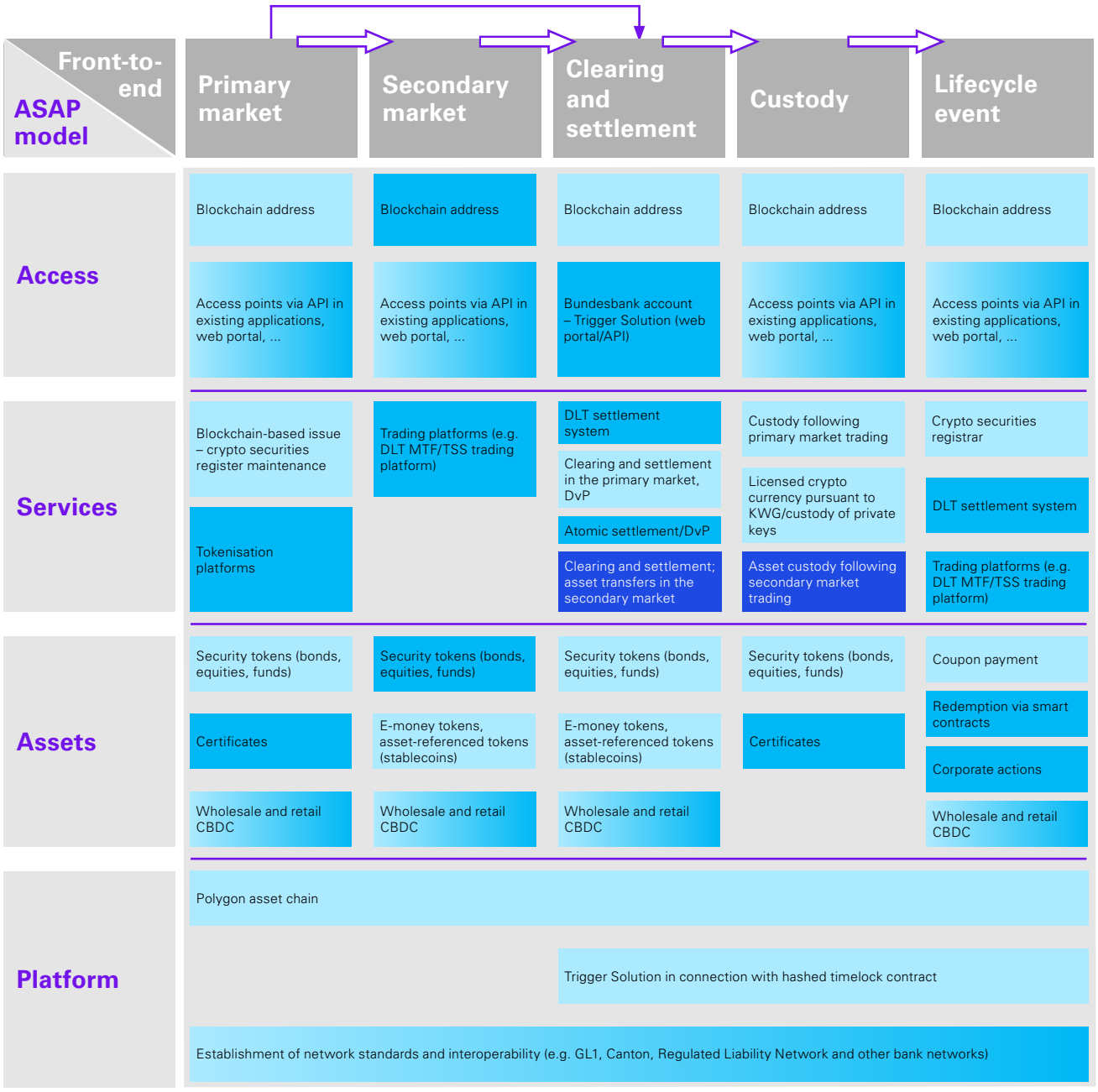
Figure 4:
Degree of maturity of the DLT-based capital market



Quelle: KPMG in Deutschland, 2025

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could help to standardise various service implementations and protocols, which has **great potential for standardisation**. There is a need for standardisation in other areas too – in future also in connection with cash and cash on chain solutions.

The **asset layer** focuses on functions that define the financial asset, representing the condition, issuance, transfer, redemption and potentially access control of financial assets. There are many tokenised assets; blockchain-based digital bonds are relevant in relation to the front-to-end process for MVP 1.0 and MVP 2.0. The cash on chain payment side, on the other hand, is not currently available as a scalable solution at the productive level. The ECB exploration phase in 2024 showed that DLT-based central bank money enables provision of the money side of a transaction in tokenised form for direct use in DLT networks. Moreover, **interoperability solutions** also showed the possibility of connecting the benefits of DLT networks with settlement in existing payment systems. This can be used successfully for all payment events in the lifecycle of a security. The long-term goal must be to implement both the security side (assets on chain) and the payment side of the transaction (cash on chain) in the form of DLT-compatible central bank money in the capital market. The general trend is continual growth in solutions for regulated DLT-based digital securities. This is supported, among other things, by the rising number of crypto security issuances in Germany and the additional possible DLT market infrastructures through the DLT Pilot Regime, which also permit alternatives to cash settlement in DvP. Switzerland offers a look to the future. Many banks in Switzerland have introduced tokenisation services, and financial market infrastructure providers such as SIX Digital Exchange (SDX) offer multilateral neutral issuance, trading and settlement of bonds and other financial instruments which were either issued in native form on the blockchain or were subsequently tokenised.

The **platform layer** implements the transfer of assets from the previous layer and therefore contains logistics for execution, storage, communication, consensus, identification, authentication and authorisation (e.g. Ethereum or Canton). There are a large number of underlying platforms on which the front-to-end process of a securities issuance can be carried out. These can mainly be broken down into public-permissionless and private-permissioned blockchains. Polygon (PoS), a public-permissionless blockchain, was used in the context of the two KfW blockchain-based digital bonds. The connection between the security and payment sides (exchange of information) was ensured in the context of MVP 2.0 through use of the Bundesbank's Trigger Solution (a private-permissioned DLT system) during the ECB exploration phase. The different consensus mechanisms used are another means of diversification. The limited **interoperability** that still exists between the platforms is a challenge to be surmounted. Blockchain bridges are currently the only link, although they are sometimes associated with risks. However, efforts to improve interoperability are under way at various levels. In order to overcome these challenges, networks and platforms should, for instance, use existing global principles for FMIs[17] and requirements for digital asset networks such as IOSCO, BCBS, and FATF[18] for orientation.

The innovation race at platform level has led to an explosive increase in sometimes unique and incompatible architectures, without any incentives for service providers to agree on a standard. As regards the IMF ASAP model, the key to effectively improving interoperability can primarily be found in the **standardisation** of the asset and service layers, which was also evident in the two blockchain-based digital bonds of KfW.

17 *Bank for International Settlements; Principles for financial market infrastructures*
18 *IOSCO; FR11/23 Policy Recommendations for Crypto and Digital Asset Markets(iosco.org)*

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4.2

Conclusion and outlook

The issuance of the two blockchain-based digital bonds of KfW along with the lessons learned and the publications and models involved show that there has been **significant progress** in the development of a DLT-based capital market in the international context in recent years. As a well-known frequent issuer, KfW with the issuance of MVP 1.0 und MVP 2.0 can take the role of a trail-blazer, helping to clarify relevant issues promptly; its pilot projects will be available as orientation aids for further institutionalisation in the **geopolitical tech race**. It is also evident in the traditional capital market that central infrastructure providers and banks, for instance, are investing in the expansion and reorientation of their digital security issuing, trading and post-trading systems and are increasingly using new technologies such as DLT to do so.

However, this should not detract from the fact that the DLT-based capital market is currently in a relatively early stage of development and therefore has limited **scalability**. This is because many market participants, including issuers, investors, (central) banks, infrastructure providers and others, are all necessarily undergoing iterative and incremental development in the new ecosystem. The projects carried out to date represent isolated solutions at present, as the interoperability required to link them together and enable **exchange of information** is still lacking in various areas. The degree to which future scaling potential can be realised depends heavily on external factors, such as the availability of DLT-based central bank money and an increase in the secondary market liquidity of DLT-based digital securities, which can potentially be expanded through increasing adoption of the DLT Pilot Regime.

Nevertheless, the **milestones and developments** achieved to date deserve recognition. These include the entry into force of the eWpG in June 2021, the ECB exploration phase involving 64 market participants in 2024, and the fact that more than 150 crypto securities had been issued under the eWpG by the end of January 2025.[19]

In order for the ecosystem for DLT-based digital securities to become sufficiently scalable, this must, crucially, also be the intention of the institutions creating the framework. Initiatives such as the ECB exploration phase and the development and entry into force of the DLT Pilot Regime are indicators in this regard. DLT-based central bank money is an **essential component**, without which DvP settlement in central bank money is not possible. The DLT Pilot Regime provides the opportunity for significant progress in the secondary market liquidity of DLT-based digital securities. Increasing adoption in the short term, and long-term prospects of use in the market, ideally without maturity and volume limits, will be key. Creating a level playing field for DLT-based digital securities and traditional securities, such as by enabling central bank eligibility and access to the repo market, increases the attractiveness for investors and issuers.

Moreover, a **hybrid setup** in cooperation with current central securities depositories is worth consideration as an opportunity for incremental transition to dematerialised issuance in order to increase liquidity in trading in the short term.

The DLT-based capital market and the related ecosystem for DLT-based digital securities are currently highly fragmented in relative terms, particularly in the areas of „legal and regulatory frameworks“, „tokenisation platforms/providers“ and

19 BaFin – Crypto securities register at the Federal Financial Supervisory Authority pursuant to section 20 (3) eWpG

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„standardisation of networks“. This limits its scalability. **Efforts to harmonise** in these areas in particular could be a significant factor in increasing scalability, as has also been seen in the latest discussions on a regulated network as a financial market infrastructure. The use of a shared DLT-based financial market infrastructure would eliminate the need for transactional messaging, reduce the associated inefficiencies and significantly improve interoperability. The design and implementation of **specific use cases** will still play an important role to enable the product and feature spectrum in the ecosystem for DLT-based digital securities to be enhanced and expanded on an ongoing basis.

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Table 5:
Lessons learned

Perspective	Lessons learned
Issuer	• The **eWpG** (German Electronic Securities Act) provides a legally secure framework for the issuance of crypto securities. • The use of **DLT** shortens the settlement period from T+2 (MVP 1.0) to **T+1** (MVP 2.0). • A technical **delivery-versus-payment** (DvP) system without a central securities depository was successfully trialled.
Bookrunner	• A lead time and marketing phase of at least **three months** is necessary. • Investors often participate to gain **experience with the technology** given the lack of advantages over conventional bonds. • There are **challenges** stemming from the lack of repo markets, special custody requirements and a missing of ECB eligibility.
Investors	• Close **collaboration** between all stakeholders is essential to the development of a digital capital markets union. • **There are no market standards;** all bond features must be scrutinised individually. • **DLT-based risks** (governance, money laundering, due diligence for registrars/custodians) must be analysed in detail.
Custodian	• **Collective registration** in accordance with Section 8 eWpG reduces errors and costs. • A lack of standards increases the **coordination effort**. • **Integration** of custody platforms with payment, trading and booking systems is necessary.
Crypto securities registrar	• A successful **DvP process** was carried out with HTLC protocol on the asset chain (Polygon) and the trigger chain (Hyperledger Fabric). • Orchestration of **public-permissionless blockchain** (Polygon) and **private-permissioned blockchain** (Hyperledger Fabric) results in transparency and control. • **On-chain data availability** increases transparency and automation potential.
Crypto custodian	• Existing **processes and technologies** can be adapted for crypto securities (e.g. securing private keys). • **On-chain accounting** through segregated addresses offers transparency and monitoring options. • There is a lack of standards for securing **private cryptographic keys**.

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Table 5:
Lessons learned

Perspective	Lessons learned
Regulation and legal documentation	• The **eWpG** is suitable for legally compliant securities issuances, but some provisions remain vague. • **Legal documentation** for conventional bonds can be largely adopted, and adjustments for blockchain provisions are manageable. • New regulations such as CRR III and SCO60 standards pose challenges for the **capital requirement** of crypto assets.
Rating agencies	• Ratings for blockchain-based digital and conventional bonds **do not differ** as long as there are no additional risks for investors. • Structural features of blockchain-based digital bonds require an **issuance-specific analysis**. • **Backup plans** are essential to ensure investor confidence.

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List of figures and tables

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Abkürzungsverzeichnis

API	Application programming interface
ASAP	Access, service, asset, platform
BaFin	Bundesanstalt für Finanzdienstleistungsaufsicht (Federal Financial Supervisory Authority)
BGB	Bürgerliches Gesetzbuch (German Civil Code)
BIS	Bank for International Settlements
CBDC	Central Bank Digital Currency
CCIP	Cross-Chain Interoperability Protocol
CMU	Capital Markets Union
CRR III	Capital Requirements Regulation III
CSD	Central securities depository
CSDR	Central Securities Depositories Regulation
DAP	Digital asset platform
DeFi	Decentralised finance
DLT	Distributed ledger technology
DLT MTF	DLT multilateral trading facility
DLT SS	DLT settlement system
DLT TSS	DLT trading and settlement system
DvP	Delivery versus payment
DZ BANK	Deutsche Zentral-Genossenschaftsbank
EBA	European Banking Authority
EU	European Union
eWpG	Gesetz über elektronische Wertpapiere (German Electronic Securities Act)
eWpRV	Elektronische Wertpapierregisterverordnung (German Regulation on Requirements for Electronic Securities Registers)
ECB	European Central Bank
FinmadiG	Finanzmarktdigitalisierungsgesetz (German Financial Market Digitalisation Act)
FinTech	Financial technology
FOP	Free of payment
GwG	Geldwäschegesetz (German Money Laundering Act)
HQLA	High-quality liquid assets
HTLC	Hashed timelock contract
IMF	International Monetary Fund
JLM	Joint lead manager
KAMaRisk	Mindestanforderungen an das Risikomanagement von Kapitalverwaltungsgesellschaften (Minimum requirements for the risk management of asset management companies)
KfW	KfW Group
KWG	Kreditwesengesetz (German Banking Act)
KWPRF	Crypto securities registrar
KYC	Know your customer
LBBW	Landesbank Baden-Württemberg
LCR	Liquidity coverage ratio
MiFID II	Markets in Financial Instruments Directive II
MVP	Minimum viable product
NFT	Non-fungible token
NPP	New product process
OTC	Over the counter
PoS	Proof of stake
rCBDC	Retail Central Bank Digital Currency
Repo	Repurchase agreement
RTS	Regulatory technical standards
S&P	Standard & Poor's
SDX	SIX Digital Exchange
STP	Straight-through processing
T2S	TARGET2-Securities
UI	Union Investment
wCBDC	Wholesale Central Bank Digital Currency
wCeBM	Wholesale Central Bank Money

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Glossary

Term	Definition/explanation
Blockchain	A **blockchain** is a specialised technology to store data in decentralised networks that are not controlled by a central entity. The data is stored as blocks, which are added one after another, with each block linked to the previous one. These blocks are shared across the nodes in a computer network. The use of cryptography ensures that the sequence of the blocks remains unchanged and any manipulation is immediately identifiable. A consensus mechanism guarantees that all participants in the network have the same current status of the blockchain. Transactions such as payments in crypto currencies can be verified securely and transparently without a central authority using blockchains.
Blockchain address	A **blockchain address** is a unique alphanumeric code or sequence of characters that represents a destination or location in a blockchain network. This is mathematically generated from the public key by means of a one-way function called hashing.
Burning	**Burning** in the context of DLT refers to the process of permanently removing a specific number of digital assets from circulation. This generally involves sending the tokens in question to an address to which nobody has access, not even the original owner. This burn address is often an empty or inaccessible smart contract, which means that the removed tokens cannot be restored or used again.
DLT	**Distributed ledger technology** refers to database systems that allow simultaneous verification and storage of data in peer-to-peer networks. This technology does not have a central administrator or a centralised database, instead the computers within the network communicate by using various consensus mechanisms to verify, confirm, cryptographically link and store new transactions in a decentralised manner.
DLT MTF	A **DLT MTF** is a multilateral trading facility for DLT securities. The regulated activity of a DLT MTF is subject to the same rules as already apply to the operators of multilateral trading facilities. However, unlike a traditional MTF trading platform, a DLT MTF is not subject to agency obligations within the meaning of the MiFID II directive. By contrast, a DLT MTF can provide interested investors – both retail and institutional – with direct access to its trading facility.
DLT SS	The regulated activity of a **DLT SS** is basically the same as that of a conventional securities settlement system within the meaning of the CSDR. These settlement systems currently are a core function of a central securities depository, which is not permitted to be provided by any other entity. Consequently, operation of a DLT SS is open to authorised central securities depositories within the meaning of the CSDR only. However, the DLT Pilot Regime defines a number of exceptions for the DLT SS from existing rules, as they conflict with the use of distributed ledgers and are not necessary for DLT-based digital securities. For instance, DLT-based digital securities are no longer required to be recorded in book-entry form, and the (cash) settlement may also take place using e-money tokens.

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Term	Definition/explanation
DLT TSS	The **DLT TSS** combines the activities of a trading system (DLT MTF) with those of a settlement system (DLT SS). The DLT Pilot Regime therefore enables trading and settlement of DLT-based digital securities through a single source. Both investment firms with authorisation to operate an MTF and central securities depositories are permitted to operate a DLT TSS.
Forced transfer	A **forced transfer** is a blockchain transaction not initiated using the private cryptographic key of the registered owner, but by the registrar via a mechanism in the smart contract.
HTLC	A **hashed timelock contract** is a protocol used in blockchain networks for secure exchange of crypto currencies and data. The exchange functions on various blockchains, and combines two key functions – the hash function and a time limit. The sender of an HTLC generates a cryptographic hash based on a secret key (password), which is saved in an HTLC smart contract and is visible as encrypted information for the recipient. The secret key must be published in order to decrypt the hash and trigger the transaction. This is the only way to fulfil the contract and execute the blockchain transaction. The HTLC also has a time limit; if the secret key is not correctly published by the deadline, the payment will not be made.
Crypto asset	According to the definition in section 1 (11) sentences 4 and 5 KWG, a **crypto asset** is the digital representation of value that is not issued or guaranteed by a central bank or public authority and does not possess the legal status of currency or money, but is accepted by natural or legal persons as a means of exchange or payment by virtue of an agreement or actual practice or is used for investment purposes and which can be transferred, stored and traded electronically.
Crypto security	A **crypto security** is an electronic security entered in a crypto securities register and thus a subtype of electronic security (section 4 (3) eWpG). Crypto securities can be issued as an aggregate issuance via a collective registration or via individual registration. Following the issuance, i.e. entry of the details required for the crypto security pursuant to section 17 eWpG in the crypto securities register with a clear and directly recognisable reference to the issuance terms and conditions laid down (section 4 (4) eWpG), the issuer must have the entry of the crypto security in the crypto securities register published in the Bundesanzeiger and must notify the supervisory authority of this publication without delay.
Minimum viable product (MVP)	A **minimum viable product** is a product development concept with the aim of releasing an initial version of a product on the market with few but key features. The objective of any MVP is to test the basic functions of a product at the earliest stage and gain valuable feedback from users. This enables iterative further development addressing the actual needs of the target group instead of making assumptions about market needs.

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Term	Definition/explanation
Minting	**Minting** refers to the process of creating and issuing digital assets. Minting is a blockchain transaction that requires validation. The validators verify the existence and accuracy of the set security features.
Native	In a general context, **native** describes something that originally or naturally exists in a certain context or system without the need for an external source or intervention. It often describes something natural or original, and is frequently used to indicate that something was created or exists directly in a specific environment.
Crypto-graphic key (private and public)	**Cryptographic keys** are fundamental elements of cryptography used to secure information. They are essentially large, randomly generated numbers used in cryptographic algorithms to encrypt and decrypt data. The *private key* is the secret part of the key pair in asymmetrical cryptography. It should be stored securely and secretly by the owner or their representative. A *public key* is also part of an asymmetrical encryption system. It is publicly accessible and can be used by anyone, for example to check whether data comes from a certain private key. The blockchain address is derived from the public key.
Secret	A **secret** is a secret value or key used in various cryptographic applications. In many systems, particularly in the world of blockchains and crypto, authenticator secrets are private cryptographic keys known to the owner only. These are often used to encrypt data, sign transactions and authenticate users. An authenticator secret is therefore a key to security and privacy as it protects the identity and integrity of information.
Secret hash	A **secret hash** is the output of a hash function used with respect to secure input. The hashing process involves sending the secure input through a mathematical function that generates a fixed value (hash), regardless of the length of the original input. The hash serves as a fingerprint for the input and enables the data to be verified without revealing the actual content. Hashes are frequently used in blockchain systems to ensure that only the owner of the input has access to specific information or transactions. The hash can be made publicly available without any secret data being revealed.

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Term	Definition/explanation
Smart contract	A **smart contract** is a self-executing program that automates the actions required in a DLT transaction. Once completed, the transactions are trackable and irreversible. The best way to envision a smart contract is to think of a vending machine – when you insert the correct amount of money and push the button for the item you want, the program (the smart contract) activates the machine to dispense your chosen item.
Straight-through processing (STP)	**Straight-through processing** is an automated financial process in which the transaction is processed as far as possible from beginning to end without manual intervention. The aim of STP is to optimise the flow of financial transactions by minimising operational risks, thereby improving processing efficiency and reducing susceptibility to errors.
Token standards	**Token standards** are essentially a set of rules, protocols, and specifications that delineate how digital tokens should behave and interact within a given blockchain environment. These standards play a fundamental role in shaping the functionality and behaviour of tokens, providing a framework that ensures uniformity, compatibility, and ease of integration across various blockchain applications.
Transfer	**Transfer** within the meaning of section 4 (8) eWpG means replacing the holder of an electronic security registered in the electronic securities register with a new holder. In the context of redeeming a bond, this means replacing the holder of an electronic security registered in the electronic securities register with the issuer.
Wallet	A **wallet** is an application to generate, manage, store or use private and public cryptographic keys.

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Contact

KPMG AG Wirtschaftsprüfungsgesellschaft

Jens Siebert
Partner,
Financial Services
M +49 170 2427-442
jenssiebert@kpmg.com

Philipp Köhler-Brinkmann
Senior Manager,
Financial Services
M +49 160 92800-957
pkoehlerbrinkmann@kpmg.com

Tim Meirer
Senior Manager,
Capital Market Innovation
M +49 174 6818-551
tim.meirer@kfw.de

Bert Staufenbiel
Senior Manager,
Digital Transformation
M +49 162 7876-728
bert.staufenbiel@kfw.de

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