TRUST FOOD

Co-funded by the European Union

“Advanced Digital Skills on Blockchain for Trusted Food Supply Chains”

Project: 101100804 — TRUSTFOOD

DIGITAL-2022-TRAINING-02-SHORT-COURSES

Deliverable: 3.4

Educational Design of Pilot Studies

Work Package 3

Responsible Partner: UNIC

This project has received funding from the European Union’s Digital Europe Programme under Grant Agreement N° 101100804

D3.4: Educational Design of pilot studies

Issued by:	University of Nicosia (UNIC)
Issue date:	18 April 2024
Due date:	30 June 2024
Work Package Leader:	University of Nicosia (UNIC)

Start date of project: 01 January 2023 **Duration:** 36 months

Document History

Version	Date	Changes
0.1	18/4/2024	D3.4 Table of Contents (ToC) and Initial work distribution
0.2	15/5/2024	Contributions in Section 1, 4 and 5
0.3	17/5/2024	Contributions in Section 2, 3
0.4	22/05/2024	Fine-tune Sections 4
0.5	23/05/2024	Fine-tune Sections 5, Include Appendices
0.6	31/05/2024	Include Executive Summary, Conclusions
0.7	31/05/2024	Pre-final version ready for review
0.8	10/06/2024	Internal review by INSME with comments to be addressed
0.9	10/06/2024	Reviewers' comments addressed in all sections
0.10	14/06/2024	Quality Review
1.0	21/06/2024	Final version ready for submission

Dissemination Level

PU	Public	**X**
PP	Restricted to other programme participants (including the EC Services)	

RE	Restricted to a group specified by the consortium (including the EC Services)	
CO	Confidential, only for members of the consortium (including the EC)	

Main authors	
Name	**Organisation**
Evgenia Kapassa, Marianna Charalambous, Andreas Delladetsimas, George Giaglis	UNIC
Leonid Khatskevych, Eugen Merzlyakov, Roman Kravchenko	482.solutions
Pien Schouten, Pieternel Luning	WU
Dimitrios Tsolis, Christina Korovila	REZOS
Sotirios Karetsos & Konstantinos Demestichas	AUA
Tomislav Knežević, Krešimir Ivić	AFC
Dimitris Botsis	UNI LUX
Maria Poulimenou	UBITECH
Aleksandra Kocet	Green Point
Filippo Grassi	INSME
Viorelia Rosca	ATC
Laura Uturytė and Giedrius Bagušinskas.	LITMEA

Quality reviewers	
Name	**Organisation**
Filippo Grassi	INSME
Anastasia Vlachou	REZOS

TRUST FOOD

Table of Contents

Contents

List of Figures

List of Tables

Executive Summary

The present deliverable (D3.4), titled “Educational Design of Pilot Studies” focuses on the educational design of the TRUSTFOOD short courses, a key component of the TRUSTFOOD project. It presents an overview of the educational methodology implemented in the development of 140 short courses aimed at enhancing blockchain technology education within the agrifood sector.

The deliverable comprises several key sections, starting with an **Introduction** that outlines the project's scope. The **Educational Design and Methodology** section details the methodology employed in the development and implementation of the “Educational Design of Pilot Studies” under Task T3.4, which was a collaborative, iterative process aimed at developing the courses. The **Development of Case Studies and Scenarios** section, describes the creation of various scenarios and case studies targeting different groups.

A significant part of the deliverable is dedicated to the **Educational Content Development** which outlines the development of the actual educational materials, including slide decks, case studies, formative and summative assessment, which will be uploaded into the TRUSTFOOD Software Training System, as will be documented in (D4.3 and D4.4). Initially, 20 courses covering a wide range of blockchain topics within the agrifood sector were created in English and then translated into six additional languages: Greek, Italian, Romanian, Lithuanian, Slovenian, and Ukrainian. This extensive translation effort resulted in a total of 140 courses, ensuring broad accessibility and dissemination of blockchain knowledge in the food supply chain.

The **Design of Creative Approaches** section explores the creative approaches for the TRUSTFOOD educational ecosystem, aiming to deliver content in ways that are both innovative and effective at engaging diverse target groups. The deliverable concludes with a synthesis of the key findings and insights garnered from the development of the TRUSTFOOD educational content.

The educational design and the successful development of 140 short courses underscore the project’s potential to significantly enhance the understanding and implementation of blockchain in the agrifood sector. By participating in these well-structured and accessible training courses, stakeholders in the agrifood sector will be better equipped to leverage blockchain technology to improve traceability, transparency, and trust throughout the food supply chain.

1. Introduction

TRUSTFOOD was launched with the aim of designing and implementing Blockchain courses, tailored to re-skill and up-skill employees and job seekers in the agri-food sector. The project seeks to foster the development of advanced digital skills of people among the labour force, prioritizing small and medium-sized enterprises (SMEs), as well as job seekers. This will be achieved by offering them access to specialized training courses that align with the most recent advancements in Blockchain technology, particularly its comprehensive applications within the food supply chain. The courses will be designed with a strong emphasis on practical knowledge about Blockchain and its relevance to the FSC. Additionally, the courses will be practical and will provide specific knowledge about key digital technologies of Blockchain and their applications to the food supply chain sector.

The TRUSTFOOD project - which started in January 2023 and will run until December 2025 - is made up of a consortium of 14 partners plus one affiliated entity from the European Union (EU) and Ukraine: REZOS BRANDS SA (coordinator), Agricultural University of Athens, University of Nicosia/Institute For the Future (IFF), Wageningen University & Research, Uni Systems LUX, 482.solutions, UBITECH, INSME – The International Network for Small and Medium Enterprises, ITC – Innovation Technology Cluster, Lithuanian Food Exporters Association (LitMEA), Kyiv Academic University, DIH AgriFood Croatia, Green Point – short food supply chain and Smart Agro Hub, and AgroTransilvania Cluster (ATC) plus UniSystems EL.

Deliverable 3.4 (D3.4), titled "Educational Design of pilot studies", focuses on the educational design of the TRUSTFOOD short courses. The main objectives of D3.4 is to explain how the educational content of courses was produced and provide some insights into the methodology and creative approaches utilized by the consortium. It's worth mentioning that the methodology followed the sub-tasks of Task 3.4 (*Educational Design of pilot studies*) of WP3 (*TRUSTFOOD Learning Ecosystem*):

- *T3.4.1: Design of Scenarios and Case Studies:* Training scenarios and case studies were created to identify different groups that would be interested in blockchain technologies, focusing on trust in food chains and traceability.
- *T3.4.2: Production of Educational Content:* Educational content, including interactive approaches was produced and translated into six languages of the consortium.
- *T3.4.3: Design of Creative Approaches:* Creative approaches such as games and videos were taken into consideration when creating the courses. These methods aim to engage target groups effectively and innovatively.

Within the scope of Task 3.4, the consortium achieved some significant milestones:

- The preparation of 20 courses covering a wide range of blockchain topics within the agri-food sector, in English.
- The translation of these 20 courses into the following languages: Greek, Italian, Romanian, Lithuanian, Slovenian, Ukrainian.
- The production of 140 courses in total.

These courses are crucial for disseminating blockchain knowledge in the food supply chain, ensuring that the agri-food labor force is well-equipped with the necessary skills to leverage blockchain technology for improved traceability, transparency, and trust within the sector. The implementation of blockchain technology in the food supply chain can revolutionize the way information is shared and managed, providing a secure and immutable ledger of transactions that enhances the credibility and reliability of data across the entire supply chain.

By participating in these short training courses, employees and job seekers in the agri-food sector will gain a deep understanding of how blockchain can be applied to various aspects of the food supply chain. The courses cover key blockchain concepts, practical applications, and real-world case studies, empowering participants with the knowledge and skills to implement and manage blockchain solutions effectively.

Moreover, the TRUSTFOOD project places a strong emphasis on the needs of small and medium-sized enterprises (SMEs), which often lack the resources to invest in cutting-edge technology and training. By providing accessible blockchain education, TRUSTFOOD aims to level the playing field, enabling SMEs to compete more effectively in the global market and enhance their operational efficiency and product quality.

The educational content produced under WP3, and as demonstrated in this deliverable, addresses the lack of knowledge about blockchain in the TRUSTFOOD project. By focusing on the unique challenges and practical applications of blockchain technology in the food supply chain, the courses aim to fill the knowledge gap and equip participants with the skills needed to implement and manage blockchain solutions effectively. By providing to the labor force advanced blockchain skills, TRUSTFOOD is contributing to the broader goal of enhancing food security, sustainability, and economic growth within the European Union and beyond.

2. Educational Design and Methodology

The methodology employed in the development and implementation of the "Educational Design of Pilot Studies" under Task T3.4 was a collaborative and iterative process aimed at creating an effective educational ecosystem. Task 3.4 and its outcomes was built upon the foundational work completed in Task T3.2 and reported in D3.2: TRUSTFOOD Learning Ecosystem, ensuring continuity and coherence throughout the project's educational framework. Figure 1 below, outlines the flow of the educational design and development methodology.

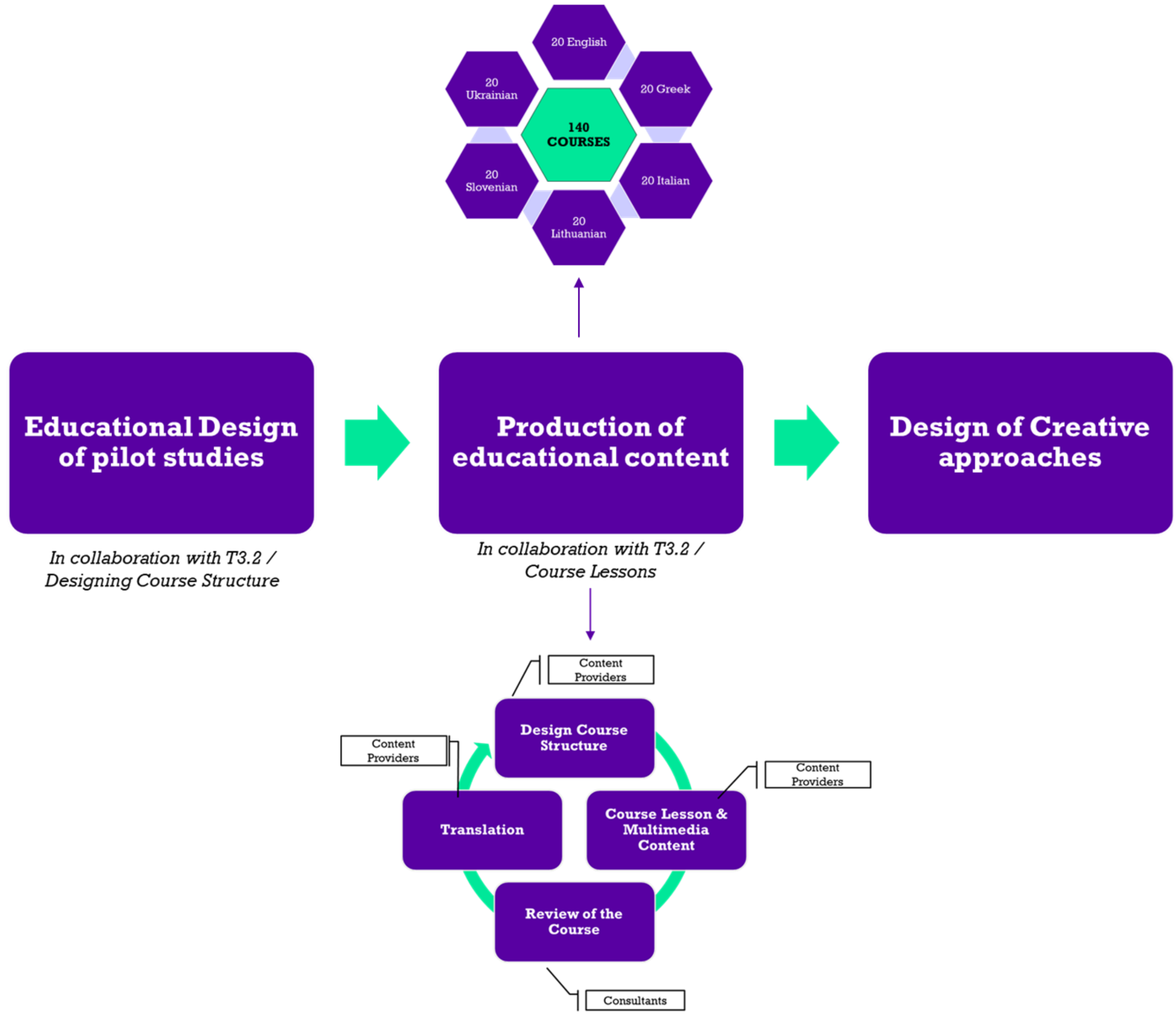


Figure 1: Educational Content Development Methodology

Educational Design of Pilot Studies:

The initial phase of the methodology involved the preparation of the educational design. This phase was conducted in close collaboration with Task T3.2, which focused on designing the course structure. The collaborative brainstorming sessions with content providers and consultants were critical in identifying potential courses and shaping their design.

Production of Educational Content:

Once the design phase was completed, the focus shifted to developing the educational content for the identified 20 courses (as those reported in detail in D3.2, and in summary in Table 1). Each content provider, as identified in the e-learning ecosystem, was responsible for preparing the educational content for their assigned courses. This content included detailed presentations, quizzes, and formative assessment questions designed to reinforce learning and ensure comprehensive coverage of the subject matter.

Table 1: List of TRUSTFOOD Courses

Course #	Title
1	Introduction to Blockchain Technology and Digital Assets
2	Exploring Digital Asset Management and Tokenization
3	MiCA (The Markets in Crypto-Assets) Regulation and CBDC (Central Bank Digital Currency)
4	FinTech with Example Applications in Food Supply Chain
5	Tokenization with Example Applications in Food Supply Chain
6	Introduction to Blockchain in the Food Supply Chain: Building Trust and Ensuring Safety
7	Basic Blockchain Skills
8	Advanced Blockchain Skills
9	Areas of application for Blockchain Technology
10	Smart Contracts with Example Applications in Food Supply Chain
11	Blockchain platforms
12	Blockchain and Traceability in relation to Food Supply Chain Integrity
13	Blockchain Applications for Food Quality Assurance and Certification
14	“ESG and SDGs in Food Supply Chain using Blockchain Technology
15	Climate Action, Energy transition and Blockchain in Food Supply chain
16	Blockchain Adoption Strategies for Small and Medium-sized Enterprises in the Food Sector
17	Ethical Considerations and Governance in Blockchain-enabled Food Supply Chain
18	Combined Powers: Blockchain and Internet of Things in Transforming the Food Supply Chain
19	Combined Powers: Blockchain and Artificial Intelligence in Transforming the Food Supply Chain
20	Roadmap for the use of Blockchain Technologies in the Food Supply

Similarly to the design cycle reported in D3.2, the content creation methodology followed a structured approach as described below:

- *Content Creation:* Content providers developed the educational materials, ensuring alignment with the predefined course structure and objectives.
- *Review:* Consultants reviewed the created content to ensure it met educational standards and learning outcomes.
- *Revision:* Based on the feedback from the consultants, content providers revised the materials to enhance clarity, engagement, and educational effectiveness.

Upon the successful review and revision of the course content in the default language (English), the translation phase initiated. Each course was translated into six languages by designated translators (as those reported in D3.2). Specifically, TRUSTFOOD provides courses in English, Greek, Italian, Romanian, Lithuanian, Slovenian and Ukrainian. This extensive translation effort ensures that the educational content will be accessible to a broad audience, enhancing the reach and impact of the TRUSTFOOD Learning Ecosystem.

Design and Development of Creative Approaches:

In parallel with content creation and translation, Content Providers collaborated with the web platform developers and the Infrastructure Consultants, to identify and provide interactive and creative learning approaches. This included the creation of instructional videos, interactive quizzes, and other multimedia resources designed to engage learners and provide a more immersive educational experience. Details are presented in Section 5 of this document.

The methodology employed in Task T3.4 is characterized by its collaborative nature and iterative processes. By building on the foundation established in Task T3.2, the TRUSTFOOD project (and particularly the WP3 team) was able to create an efficient educational ecosystem and provide a set of 140 short courses in total, that are able to up-skill and re-skill interested participants in blockchain technology in the area of food supply chain.

3. Development of Case Studies and Scenarios

In the TRUSTFOOD project, and under the scope of WP3, the development of case studies and scenarios was strategically approached by identifying thematic areas of the educational courses, that act as case studies. This approach ensures a seamless transition from the theoretical framework establishment in Task T3.2 to the practical application of the courses, within the educational ecosystem.

Each of the thematic areas specified under T3.4.1, covers a wide variety of subjects from basic blockchain understanding to innovative blockchain integrations (e.g. integration of blockchain with AI and IoT). These topic areas are designed to enhance learners' comprehension of specific blockchain applications and demonstrate the practical usability of blockchain in the food supply chain. Figure 2 presents the identified thematic areas of the educational courses, which serve as case studies.

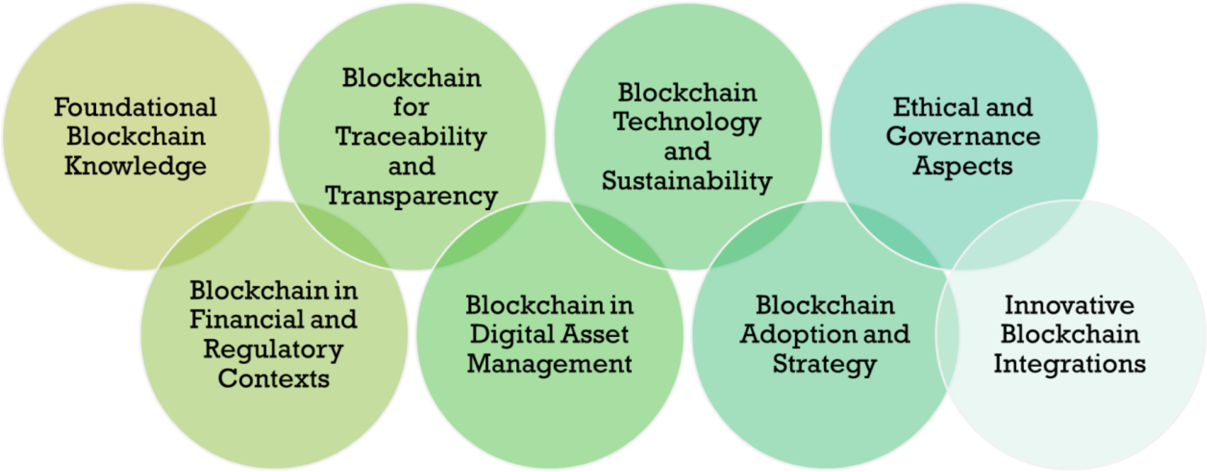


Figure 2: Thematic areas/Case studies of the educational courses.

Table 2 presents the identified thematic areas and the associated educational courses. Additionally, each thematic area was developed as a case study or scenario. This involved:

- Detailed Scenario Development: Each course and its underlying lessons were developed to serve as detailed scenarios that demonstrate the specific objectives and practical applications of blockchain within the food supply chain.
- Use of Interactive Learning Tools: Incorporating quizzes, interactive videos, and questions throughout the course to engage learners and simulate decision-making processes.
- Evaluation Methodology: Establishing clear criteria for assessing each lesson and the respective learning tool.

Table 2: Thematic areas/Case studies and Associated Courses

Thematic Areas/ Case Studies	Associated Courses
Foundational Blockchain Knowledge	Course 1: Introduction to Blockchain Technology and Digital Assets Course 7: Basic Blockchain Skills Course 8: Advanced Blockchain Skills
Blockchain in Financial and Regulatory Contexts	Course 3: MiCA (The Markets in Crypto-Assets) Regulation and CBDC (Central Bank Digital Currency) Course 4: FinTech with Example Applications in Food Supply Chain Course 9: Areas of application for Blockchain Technology
Blockchain for Traceability and Transparency	Course 6: Introduction to Blockchain in the Food Supply Chain: Building Trust and Ensuring Safety Course 12: Blockchain and Traceability in relation to Food Supply Chain Integrity Course 13: Blockchain Applications for Food Quality Assurance and Certification
Blockchain in Digital Asset Management	Course 2: Exploring Digital Asset Management and Tokenization Course 5: Tokenization with Example Applications in Food Supply Chain Course 10: Smart Contracts with Example Applications in Food Supply Chain
Blockchain Technology and Sustainability	Course 14: ESG and SDGs in Food Supply Chain using Blockchain Technology Course 15: Climate Action, Energy transition and Blockchain in Food Supply chain
Blockchain Adoption and Strategy	Course 16: Blockchain Adoption Strategies for Small and Medium-sized Enterprises in the Food Sector Course 20: Roadmap for the use of Blockchain Technologies in the Food Supply
Ethical and Governance Aspects	Course 17: Ethical Considerations and Governance in Blockchain-enabled Food Supply Chains
Innovative Blockchain Integrations	Course 18: Combined Powers: Blockchain and Internet of Things in Transforming the Food Supply Chains Course 19: Combined Powers: Blockchain and Artificial Intelligence in Transforming the Food Supply Chain

It is worth noting that by leveraging identified thematic areas as case studies, Task T3.4.1 has effectively utilized the educational content to simulate real-world applications of blockchain technology. This approach has not only facilitated a deeper understanding of blockchain's potential impact but also ensured that the educational offerings are practically oriented, directly benefiting learners by preparing them for actual challenges in the food supply chain.

4. Educational Content Development

Based on the specified topic areas/case studies, such as those shown in Table 2, the development of educational material under WP3 was planned to create a thorough understanding of blockchain technology throughout many sectors of the food supply chain. The goal of developing an educational experience that would appeal to a diverse European audience while being interesting, approachable, and pedagogically sound was at the center of this development. The project's collaborative and methodical approach to educational content development, comprised several stages, all of which were essential to accomplishing the project's overall educational objectives. Detailed course planning, content production, multimedia integration and a multilingual translation approach meant to increase learner accessibility, were all part of these phases.

Course Development and Structure:

Annex 1 provides a detailed presentation of the guidelines that were strictly adhered to during the preparation of the courses and their corresponding material. Every course followed a uniform format, which started with a title and ended with well-defined learning goals—as elaborated in D3.2. The format of the course, which included videos, presentations, and other materials intended to improve student comprehension, was carefully taken into account while choosing the course content. Consistency in course structure was crucial to ensure conformity with standardized components, including course descriptions, important concepts, learning outcomes, and references. Figure 3 provides an example of the opening slide for Course 1, Lesson 1.

Figure 3: Example of the Opening Slide of a Course

Furthermore, detailed metadata for each course enriched the educational framework, providing essential information tailored to optimize learner engagement. Additionally, the metadata was a crucial aspect of the enhancement and optimization of the Software Training System developed within WP4 (reported in D4.3 and D4.4). Specifically, metadata such as the course duration and the keywords were leveraged to provide filtering capabilities within the TRUSTFOOD Software Training System. This metadata includes the following:

- **Estimated Duration:** Each short-course ranges from 3 to 9 hours, to ensure comprehensive coverage of all topics without overwhelming the learners.
- **Difficulty Level:** Courses were categorized into beginner, intermediate, or advanced levels, enabling learners to choose courses that matched their existing knowledge and skill levels.
- **Target Audience and Accessibility:** Courses were developed to cater to a broad demographic, including variations in age, occupation, and geographic location, ensuring inclusivity and broad accessibility.
- **Number of Lessons and Slide Counts:** Each course comprised several lessons, each with a specified average number of slides to maintain consistent and focused content delivery.
- **Multimedia Integration:** The inclusion of general videos and video presentations was noted, indicating whether each course incorporated these elements to enhance learning through visual and interactive content.
- **Keywords and Sector Relevance:** Each course was tagged with specific keywords related to its content, such as 'blockchain', 'digital assets', 'food supply chain', and 'sustainability'. These keywords not only facilitated an easier navigation of the course catalog but also helped align the courses with relevant industry sectors, enhancing the applicability of the course content in real-world scenarios.

The courses' metadata are presented in Table 3, while the keywords are provided in Table 4.

Table 3: Overview of Educational Courses Metadata

Course	Course Name	Duration (hrs)	Difficulty Level	Lessons	General Videos Included	Video Presentation
1	Introduction to Blockchain Technology and Digital Assets	4	Beginner	7	No	No
2	Exploring Digital Asset Management and Tokenization	5	Intermediate	8	Yes	Yes
3	MiCA Regulation and CBDC	4	Advanced	5	No	Yes
4	FinTech with Example Applications in Food Supply Chain	4	Intermediate	6	Yes	No
5	Tokenization with Example Applications in Food Supply Chain	4	Intermediate	6	Yes	No

6	Introduction to Blockchain in the Food Supply Chain	6	Beginner	8	Yes	Yes
7	Basic Blockchain Skills	4	Beginner	7	No	No
8	Advanced Blockchain Skills	4	Intermediate	6	Yes	Yes
9	Areas of application for Blockchain Technology	5	Beginner	6	Yes	No
10	Smart Contracts with Example Applications in Food Supply Chain	8.5	Advanced	9	Yes	No
11	Blockchain platforms	9	Intermediate	10	Yes	No
12	Blockchain and Traceability in relation to Food Supply Chain Integrity	4.5	Intermediate	6	Yes (in further reading)	No
13	Blockchain Applications for Food Quality Assurance and Certification	4.75	Intermediate	6	Yes	Yes
14	ESG and SDGs in Food Supply Chain using Blockchain Technology	8.5	Intermediate	5	Yes	Yes
15	Climate Action, Energy transition and Blockchain in Food Supply chain	9	Intermediate	6	Yes	Yes
16	Blockchain Adoption Strategies for SMEs in the Food Sector	3	Beginner	4	No	No
17	Ethical Considerations and Governance in Blockchain-enabled Food Supply Chains	3	Advanced	5	Yes	No
18	Combined Powers: Blockchain and IoT in Transforming the Food Supply Chains	2.5	Advanced	4	Yes	No
19	Combined Powers: Blockchain and AI in Transforming the Food Supply Chain	3.5	Intermediate	5	Yes	No
20	Roadmap for the use of Blockchain Technologies in the Food Supply	5	Intermediate	8	Yes	Yes

Table 4: Overview of Educational Courses Keywords

Course #	Course Name	Keywords
1	Introduction to Blockchain Technology and Digital Assets	Distributed ledger, technology, tokenization, bitcoin, Ethereum blockchain
2	Exploring Digital Asset Management and Tokenization	Tokenization, digital assets, agrifood, supply chain management
3	MiCA Regulation and CBDC	Regulation, CBDC, Digital Economy, Blockchain
4	FinTech with Example Applications in Food Supply Chain	FinTech, Food Supply Chain, Blockchain, Real-world Implementation
5	Tokenization with Example Applications in Food Supply Chain	Digital Tokens, Blockchain, Smart Contracts, Asset Digitization
6	Introduction to Blockchain in the Food Supply Chain	Blockchain, Immutability, Consensus Mechanisms, Supply Chain Transparency
7	Basic Blockchain Skills	Blockchain basics, security, distributed ledger
8	Advanced Blockchain Skills	Smart contracts, blockchain security, dApp development
9	Areas of application for Blockchain Technology	Blockchain applications, Distributed Ledger Technology, Supply Chain Management
10	Smart Contracts with Example Applications in Food Supply Chain	Smart contracts, blockchain, food supply chain, Ethereum
11	Blockchain platforms	Blockchain platforms, Ethereum, Hyperledger, IBM, VeChain
12	Blockchain and Traceability in relation to Food Supply Chain Integrity	Food supply chain integrity, traceability, blockchain
13	Blockchain Applications for Food Quality Assurance and Certification	Blockchain, Food supply chain, Transparency, Traceability, Food Certification
14	ESG and SDGs in Food Supply Chain using Blockchain Technology	ESG, SDGs, Food Supply Chain, Blockchain, Sustainability
15	Climate Action, Energy transition and Blockchain in Food Supply chain	Environmental Impact, Sustainability, blockchain, green energy transition
16	Blockchain Adoption Strategies for SMEs in the Food Sector	Blockchain, SMEs, Supply Chain Management
17	Ethical Considerations and Governance in Blockchain-enabled Food Supply Chains	Ethical Considerations, Data Privacy, Governance
18	Combined Powers: Blockchain and Internet of Things in Transforming the Food Supply Chains	Blockchain, IoT, Transformation
19	Combined Powers: Blockchain and Artificial Intelligence in Transforming the Food Supply Chain	Blockchain, AI, food supply chain, Internet of Things
20	Roadmap for the use of Blockchain Technologies in the Food Supply	Blockchain, food supply chain, smart contracts, Internet of Things, future trends

Pedagogical Principles:

The educational content was created using fundamental pedagogical principles, ensuring that each course started with simple, actionable objectives and progressed to more complicated topics. To successfully assess learning progress, formative assessments [1] in the form of targeted questions were strategically placed at the end of each course. These questions are intended to engage students and promote thinking on the subject, improving comprehension and memory of essential topics. Figure 4 is an example from Course 12, Lesson 6.

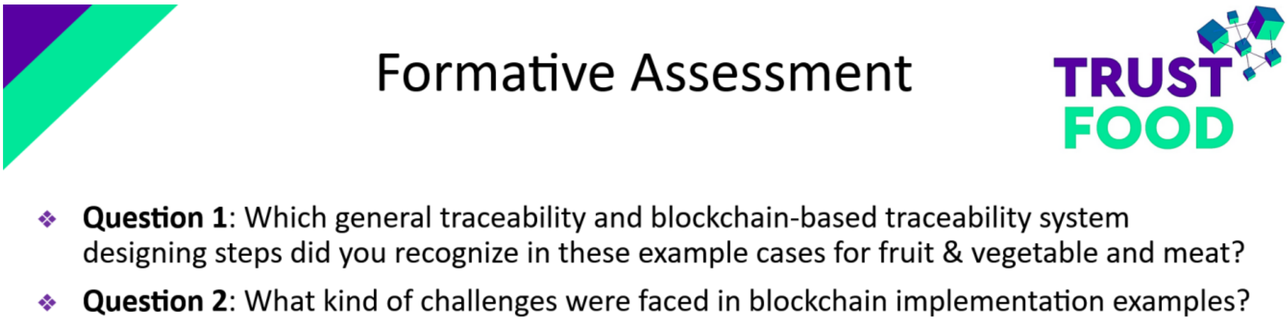


Figure 4: Formative Assessment Example

Summative assessments [2], mostly in the form of quizzes at the end of each course, were also developed, with the recognition that they play an important role in the learning process. These quizzes were carefully designed to correspond with the goal, objectives, and learning outcomes of each course, and they include a variety of question styles to assess different levels of student comprehension. These quizzes provide rapid feedback (i.e. through the Software Training System developed in WP4), allowing learners to identify areas for growth and promote a cycle of continual learning and progress. The use of both formative and summative assessments allows a thorough evaluation of student learning, connecting educational activities with overall course goals and allowing for accurate measurement of educational achievements. Figure 5 shows an example of a summative assessment.

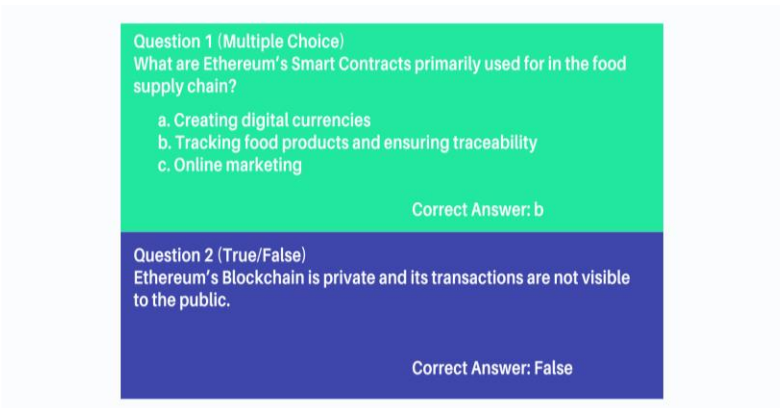


Figure 5: Summative Assessment Example

Multimedia Integration and Learning Experience Enhancement

Every lesson of each course includes a variety of multimedia features to enhance the learning experience and guarantee that the subject is understandable and engaging [3-5]. Images, diagrams, videos and comparative tables were widely used to demonstrate complex topics, explain abstract ideas, and visually engage students. Figures 6 and 7 represent an example from Course 5, Lesson 3.

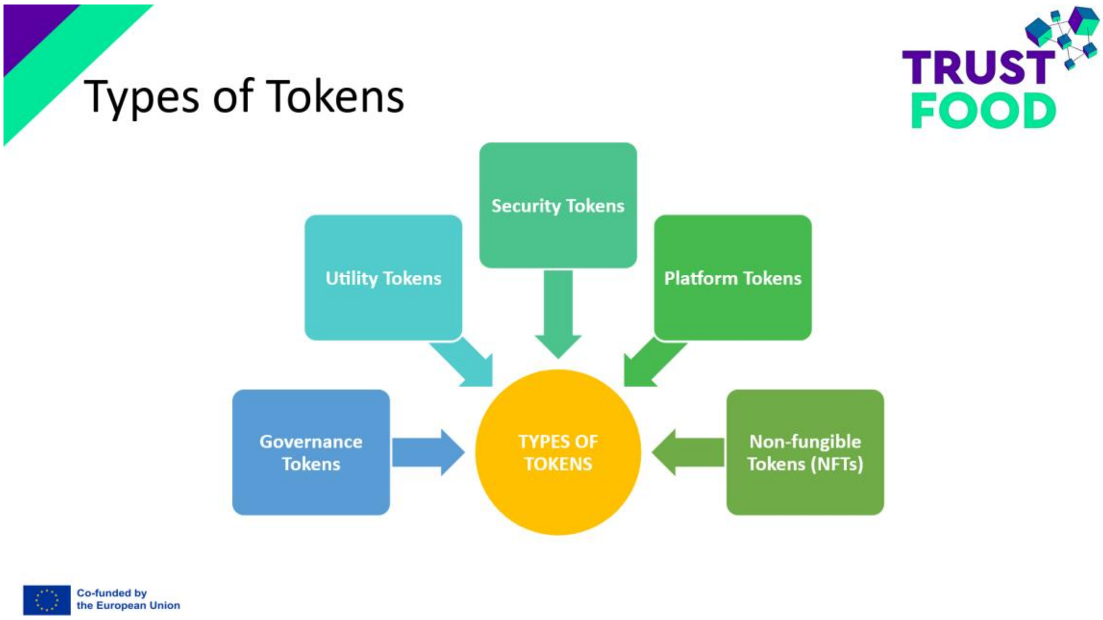


Figure 6: Multimedia Example: Diagram

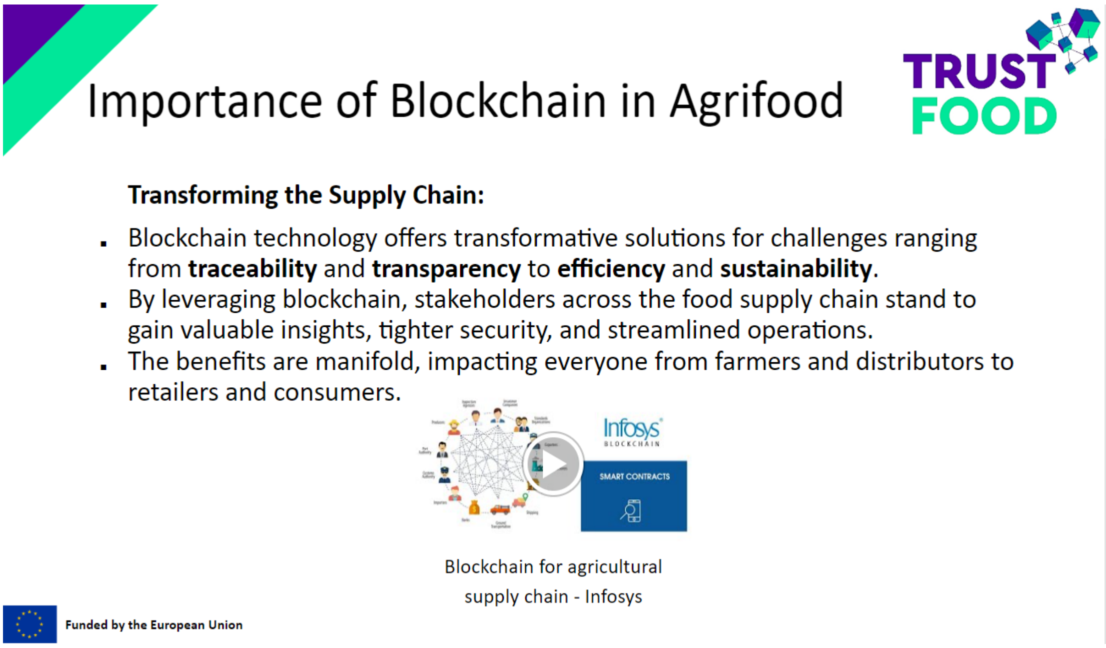


Figure 7: Multimedia Example: General Video

Collaborative Development and Translation

The collaborative content development approach required seamless coordination among project partners, resulting in high-quality teaching resources. Beginning with one partner taking the lead in creating initial content for each course (i.e., the Content Provider as specified in D3.2), a research method was employed to produce accurate and insightful material, drawing on evidence-based knowledge and reliable sources. Following that, the content was thoroughly reviewed by another consortium partner (i.e., the Consultant as described in D3.2) to ensure accuracy, relevance, and effectiveness, with constructive feedback driving necessary revisions to ensure alignment with course objectives and pedagogical principles. The review criteria are detailed in Annex 2. After incorporating input, the content was revised to improve clarity and engagement, ensuring that each course met high quality requirements.

After the review and finalization, the content was prepared for translation into multiple languages, including Greek, Italian, Romanian, Lithuanian, Slovenian, and Ukrainian, to accommodate diverse linguistic needs. Translators ensured that the meaning of the content was communicated accurately in each language, taking into account cultural differences and linguistic variances. This technique ensures that learners with varied linguistic backgrounds can effectively engage with the topic. The aforementioned process is presented in Figure 8, below.

Figure 8: Collaborative Course Development Process

Finally, trainer and trainee handbooks were crafted for each course, under the scope of T3.3, providing comprehensive guidance and support (i.e. handbooks can be accessed through D3.3). These handbooks empower both educators and learners, offering valuable insights into course structure, objectives, teaching methodologies, and study resources. The trainer handbook provides detailed lesson delivery suggestions and assessment strategies, while the trainee handbook highlights key concepts and study tips to optimize learning outcomes. It is also notable that all the courses were developed under the Massive Open Online Courses (MOOC) design principles [6].

5. Design of Creative Approaches

Moving a step forward, the TRUSTFOOD ecosystem shall combine innovative design with engaging content delivery methods tailored to the unique characteristics of blockchain technology as well as the diverse categories of the target audience [7]. Therefore, the "Design of Creative Approaches" had been initiated, to design creative approaches for the TRUSTFOOD educational ecosystem, aiming to deliver content in ways that are both innovative and effective at engaging diverse target groups [8]. This process was crucial for enhancing the educational impact of blockchain technologies in the Food Supply Chain through diverse and engaging methods. This has been based on a two-step process. Specifically, during the first step "Brainstorming Creative Educational Ideas" the project partners were asked to contribute with their ideas for the design of creative approaches. During the second step, all contributions/ideas have been evaluated in terms of scope, feasibility, technical implementation restrictions and/or requirements, overlapping with other contributions or existing features, and additional costs that may occur. The detailed steps towards the design of the TRUSTFOOD creative approaches, are presented below.

Brainstorming Creative Educational Ideas:

The process began with a series of brainstorming sessions, which were critical for gathering a diverse range of new educational and interactive ideas. These sessions included synchronous and asynchronous discussions between content creators, consultants, and technical specialists from WP4. This phase aimed to gather varied ideas for delivering educational content regarding blockchain technologies in the Food Supply Chain, including creative approaches, interactive methods, and potential gamification components. A collaborative spreadsheet was utilised to let partners register and express their ideas in the following areas:

- Idea Register Number: The serial number of the idea.
- Proposed by: The name of the person and the partner who contributed.
- Idea Short Description: A short text description of the idea.
- Idea Full Description: Text describing in the most possible detail the contributed idea.
- Technical Notes: Refers to possible technical issues that need to be addressed by the TrustFood Software Training System (e.g. implementation technology, functionality prevision).
- Potential Challenges: Refers to challenges that the contributor thinks that may occur (e.g. acceptance by the trainees, design complexity).
- Additional Notes: Any other comment that needs to be under consideration.

The brainstorming phase resulted in an initial set of 19 ideas, as presented below:

1. **Knowledge Quizzes:** Quizzes for assessing course comprehension with multiple-choice and true/false questions.
2. **Comprehensive Exams:** Cumulative exams covering all course content to validate overall learning.
3. **Practitioner Interviews:** Video interviews showcasing real-world blockchain applications in the food supply chain.
4. **Assessment Tools:** Interactive questionnaires to help learners assess their blockchain knowledge and application skills.

5. **Adaptive Learning Paths:** Options for learners to choose educational tracks (basic to advanced) tailored to their knowledge level.
6. **AI-Enhanced Learning:** Integration of AI tools like ChatGPT to provide interactive learning and feedback.
7. **Progress Checklists:** Digital tools to track and display learners' progress through courses.
8. **Instant Feedback Mechanisms:** Tools to provide immediate feedback on learners' answers to enhance understanding.
9. **Learner Dashboard:** A central platform feature to manage courses, track progress, and access learning tools.
10. **Community Building Tools:** Features to connect learners with peers, facilitating group learning and interaction.
11. **Learning Analytics:** Usage of analytics to monitor learner engagement and identify patterns in course interaction.
12. **Videos:** Videos to pose questions, engaging learners. These could include general videos, video presentations of the lessons, Q&As etc.
13. **Peer Review Quizzes:** Quizzes where learners validate each other's responses, encouraging collaborative learning.
14. **Scenario-Based Modules:** Interactive learning modules where learners navigate through scenarios to make decisions based on blockchain applications.
15. **Blockchain Simulation:** Interactive games simulating blockchain setup and management within the food supply chain.
16. **Tiered Quizzes:** Level-specific quizzes designed to challenge learners according to their understanding and skills.
17. **Custom Content Delivery:** A feature to personalize content delivery based on the learner's initial profile assessment.
18. **Augmented Reality Game:** A gamified learning experience using AR to engage users with practical blockchain applications.
19. **Narrative Learning Modules:** Story-driven modules where learners take on roles to solve challenges using blockchain.

Evaluation, Selection Criteria and Final Approaches:

During the second step, all contributions were evaluated for feasibility, technical implementation limits and/or needs, overlapping with other contributions or existing features, and potential additional expenses. Accordingly, the scope of the contributed ideas was evaluated based on the TRUSTFOOD ecosystem's aim and objectives, while technical implementation assessments examined its practicality within the existing technological limits of the chosen technical solution. Furthermore, there were contributions that were similar or had a significant degree of overlap, or they were existing elements in the chosen technological solution, thus they were put together under a common implementation strategy. Furthermore, supplementary costs, particularly subscription fees, were carefully analyzed to assure financial independence. The selected approaches focused on enhancing user interaction and learning efficacy through the use of quizzes, personalized learning paths, and assessment tools. The final list of Ideas to be implemented as features in the TRUSTFOOD platform is presented along with their full description and technical notes in Table 5.

Table 5: Interactive Approaches provided under the scope of WP3 & WP4

No.	Approach	Description
1	Knowledge Quizzes	Quizzes for assessing course comprehension with multiple-choice and true/false questions.
4	Assessment Tools	Interactive questionnaires to help learners assess their blockchain knowledge and application skills.
7	Progress Checklists	Digital tools to track and display learners' progress through courses.
11	Learning Analytics	Usage of analytics to monitor learner engagement and identify patterns in course interaction.
12	Videos	Videos to pose questions, engaging learners. These could include general videos, video presentations of the lessons, Q&As etc.
15	Blockchain Simulation	Interactive games simulating blockchain setup and management within the food supply chain.
17	Custom Content Delivery	A feature to personalize content delivery based on the learner's initial profile assessment.
18	Augmented Reality Game	A gamified learning experience using AR to engage users with practical blockchain applications.
19	Narrative Learning Modules	Story-driven modules where learners take on roles to solve challenges using blockchain.

Interactive approaches 1, 4, 7, 11, and 12 have been successfully implemented under WP3 and WP4, demonstrating substantial progress in the development of the TRUSTFOOD Learning Ecosystem. The remaining creative approaches, including Assessment Tools, Blockchain Simulation, Augmented Reality Game and Narrative Learning Modules, are still in the development phase. These are scheduled to be completed and integrated into the learning environment under the scope of WP4, further enriching the educational offerings and learner engagement within the TRUSTFOOD platform.

Finally, special attention has been paid to the development and integration of interactive videos within the TRUSTFOOD Learning Ecosystem, recognizing their significant impact on learner engagement and understanding. The following types are provided and categorized to serve diverse educational purposes:

- External YouTube Video: These are carefully curated links to relevant online videos that complement and enhance the learning content provided in the courses.
- Course/Lesson or Instructional Videos: These videos are specifically designed to support or deliver TRUSTFOOD courses and/or lessons. They incorporate visual aids, narrations and demonstrations to facilitate a comprehensive understanding of complex blockchain applications within the food supply chain.
- Demonstration Videos: Focused on providing visual, step-by-step guidance on practical activities, these videos are essential for illustrating the execution of specific tasks such as setting up smart contracts, demonstrating their functionality within the blockchain framework pertinent to the food supply chain.

- Frequently Asked Questions (Q&A) Video: Aimed at providing quick and accessible answers to common questions.

Table 6 presents the types of videos supported by each course.

Table 6: Overview of Video Resources Across Educational Courses

Course #	Course Title	Content Provider	External Video	Narrative Video	Demo Video	Q&A Video
1	Introduction to Blockchain Technology and Digital Assets	482.solutions	X			
2	Exploring Digital Asset Management and Tokenization	UNIC	X	X		
3	MiCA Regulation and CBDC	UNIC	X	X		
4	FinTech with Example Applications in Food Supply Chain	UNIC	X			
5	Tokenization with Example Applications in Food Supply Chain	UNIC	X			
6	Introduction to Blockchain in the Food Supply Chain	UNIC	X	X		
7	Basic Blockchain Skills	482.solutions	X			
8	Advanced Blockchain Skills	482.solutions	X			
9	Areas of application for Blockchain Technology	UNIC	X			
10	Smart Contracts with Example Applications in Food Supply Chain	REZOS	X			
11	Blockchain platforms	UNIC	X			
12	Blockchain and Traceability in relation to Food Supply Chain Integrity	WU	X			
13	Blockchain Applications for Food Quality Assurance and Certification	AUA	X		X	X
14	ESG and SDGs in Food Supply Chain using Blockchain Technology	482.solutions	X			

15	Climate Action, Energy transition and Blockchain in Food Supply chain	482.solutions	X			
16	Blockchain Adoption Strategies for SMEs in the Food Sector	UNIC	X			
17	Ethical Considerations and Governance in Blockchain-enabled Food Supply Chains	UNIC	X			
18	Combined Powers: Blockchain and IoT in Transforming the Food Supply Chains	UNIC	X			
19	Combined Powers: Blockchain and AI in Transforming the Food Supply Chain	REZOS	X			
20	Roadmap for the use of Blockchain Technologies in the Food Supply	AFC - AGRIFOOD CROATIA	X			

6. Conclusions

The TRUSTFOOD project has made significant progress in advancing digital skills in blockchain technology for the agri-food sector. Through WP3 and the development of 140 short courses, the project has established a robust foundation for enhancing blockchain technology education within this sector. The project's achievements include the creation of 20 courses in English, which were subsequently translated into six additional languages, resulting in 140 courses in total, ensuring broad accessibility and dissemination of blockchain knowledge. The courses cover topics from the principles of blockchain technology to its specialized applications in food supply chain management, including traceability, smart contracts, and ethical considerations.

The educational design and content development followed a collaborative and iterative process, involving multiple stakeholders, including content providers, consultants, and translators. Each course was designed to evolve from fundamental principles to more advanced ones, ensuring a thorough understanding of blockchain technology and its potential impact on the food supply chain. The project incorporated innovative and creative approaches to enhance the learning experience, such as the use of multimedia elements and quizzes, to engage learners and provide a more immersive educational experience.

A significant focus of the educational content was on providing knowledge about blockchain technology and its relevance to the food supply chain. This ensures that learners understand the theoretical principles and potential benefits of blockchain, enhancing their ability to conceptualize and manage blockchain solutions effectively. Strong emphasis was placed on the needs of SMEs and job seekers in the agri-food sector. By offering accessible blockchain education, TRUSTFOOD aims to level the playing field, enabling SMEs to compete more effectively in the global market and improve their operational efficiency and product quality. Additionally, the inclusion of both formative and summative assessments in the courses ensures a thorough evaluation of learner progress. These assessments provide immediate feedback, helping learners identify areas for improvement and promoting continuous learning and development.

7. References

[1] Bennett, Randy Elliot. "Formative assessment: A critical review." Assessment in education: principles, policy & practice 18.1 (2011): 5-25.

[2] Biggs, John. "Assessment and classroom learning: A role for summative assessment?" Assessment in Education: Principles, policy & practice 5.1 (1998): 103-110.

[3] Vagg, Tamara, et al. "Multimedia in education: what do the students think?" Health Professions Education 6.3 (2020): 325-333.

[4] Tuhuteru, Laros, et al. "The Effectiveness of Multimedia-Based Learning To Accelerate Learning After The Pandemic At The Basic Education Level." Tafkir: Interdisciplinary Journal of Islamic Education 4.1 (2023): 128-141.

[5] Abduraxmanova, Shaxnoza Abduhakimovna. "Individualization of professional education process on the basis of digital technologies." World Bulletin of Social Sciences 8 (2022): 65-67.

[6] Amado, Carolina, et al. "MOOCs design: A conceptual framework for continuous teacher training in Portugal." Education Sciences 12.5 (2022): 308.

[7] Aguilera, David, and Jairo Ortiz-Revilla. "STEM vs. STEAM education and student creativity: A systematic literature review." Education Sciences 11.7 (2021): 331.

[8] Beghetto, Ronald A. "Creative learning in education." The Palgrave handbook of positive education. Cham: Springer International Publishing, 2021. 473-491.

[9] TRUSTFOOD Consortium, “Software Training System”, Available at: https://trust-food.ubitech.eu/

8. Annexes

Annex 1: Courses' Development Guidelines

Course Structure:

- Consistency: Ensure that you follow the standardized structure, as described in the project scope (i.e., Title, Course Description, Key Concepts, Learning Outcomes, References).
- Courses Template: As documented in D3.2.
- Metadata: Include metadata for each course
- Course estimated duration.
- Difficulty level (beginner, intermediate, advanced)
- Target Audience
- Keywords
- Number of Lessons:
- Duration: Aim for each lesson to be between 15-30 minutes in duration.
- References: Use Harvard reference styling.
- Further Reading: Use Harvard reference styling.

Course Content:

- Research-Based: Content should be grounded in research and/or quality articles. References are important.
- Varied Sources: Use a mix of textbooks, journal articles and industry reports.
- Engagement: Include questions (theoretical questions) throughout the content to keep learners engaged. It is important to provide also the answers *(this will be extremely useful for the Handbooks)*
- Real-World Application: Offer practical examples or case studies that allow learners to apply theoretical knowledge.

Content in General

- Please at all cases make sure that you use UK English
- All amounts should be in Euros
- We need to refer to blockchain and not Blockchain, unless we are making reference to a specific organization where they use it in their name/ title
- We need to refer to bitcoin and not Bitcoin
- Use commas (,) for thousands and dots (.) for decimals for consistency with GB-English. (Example: 4,294,967,295.00)
- Check acronyms throughout (they should be spelt out at first instance because readers won't know what is being referred to)
- It is advisable to create a table with acronyms at the beginning of the presentation.\

Multimedia Use:

- Use multimedia elements to support and enhance the content.
- Use consistent color schemes, fonts, and styles.
- Ensure graphics and images are clear, relevant, and high-resolution.

Pedagogical Principles:

- Clearly define what the learner should know or be able to do by the end of the course.
- Start with foundational concepts and progressively introduce more complex ideas, building upon what learners already know.
- Incorporate quizzes or short tests at the end of each lesson to help learners assess their grasp of the content. It is important to provide also the answers.

Stylistic:

- All fonts need to be "Calibri"
- Where 2 equal columns are introduced, please align vertical gap
- Avoid excessive paragraph marks, replace with line breaks/slide breaks
- Uniform spacing between titles and body text lines
- Uniform margins for text boxes
- Make sure to align the elements per slide

Fonts:

- Font size:
    - Title Slide: 44 points
    - Headers or Slide Titles: 20 to 18 point.
    - Main Body Text: 18 to 14 point
- Emphasized Text: whenever possible use **bold** to indicate text you wish to emphasize rather than underlining it.
- The use of color to emphasize text is discouraged, as is the extensive use of bold.
- Italics should be used for quotes or other similar direct references.
- Keep Consistency: Ensure consistency in font sizes for titles, subtitles, main body text and other elements across all slides. This will give your presentation a cohesive look.

Plagiarism:

Plagiarism is the act of presenting someone else's work, ideas, or intellectual property as one's own without proper attribution. This includes, but is not limited to, text, images, videos, and other multimedia.

- Zero-Tolerance Policy: We maintain a strict zero-tolerance policy towards plagiarism. Any content found to be plagiarized will result in immediate corrective actions.
- Cite Sources Properly: Always give credit to the original authors, creators, or sources.
- Original Content: Always aim to produce original content.
- Use plagiarism detection tools to check content before submission.

Do’s:

- Content Quality
    - Research: Ensure content is evidence-based and backed by credible sources.
    - Diversity: Use diverse references and materials to offer a holistic perspective.
- Pedagogical Best Practices
    - Clear Objectives: Begin each module or course with well-defined learning objectives.
    - Assessments: Incorporate both formative (during the course) and summative (at the end) assessments.
- Presentation & Structure
    - Consistency: Maintain a consistent format and structure throughout the course.
    - Multimedia Integration
    - Ensure multimedia is directly relevant and complementary to the content.
    - Quality: Use high-quality graphics, videos, and audio.

Don'ts:

- Content Quality
    - Avoid Overloading: Don’t provide overwhelming information. Keep it concise and relevant.
    - Avoid presenting information from a biased perspective.
- Lack of Real-world Application: Don't provide only theory without providing real-world examples or applications.
- Don’t vary the structure or format dramatically within a course or between lessons.
- Don't leave out crucial information or instructions, which might leave learners confused.
- Don't overuse multimedia to the point it distracts from the main content.

Course’s Checklist:

- 1 PowerPoint presentation for each Lesson of the Course.
- At least 1 Summative Assessment (e.g., quiz) (along with answers) for each Lesson of the Course.
- At least 1 Formative Assessment (e.g., a question) (along with answers) per Lesson for engaging the student (incorporated within the presentation).
- Course Metadata.
- Multimedia elements within each lesson (figures, infographics, general videos etc.).
- Optional: Video presentation of the course.

Annex 2: Courses' Review Criteria

When conducting the review, the Consultants (i.e. the course reviewers) should consider the following criteria:

- **Course Objectives:** Reviewers should assess whether the stated objectives are clear, specific, and aligned with the overall project goals. The objectives should accurately represent what the course intends to achieve, and the skills or knowledge students are expected to acquire.
- **Course Outline:** Reviewers should evaluate the course outline to determine if it provides a comprehensive and logical breakdown of the content. They should assess whether the sub-topics listed cover all the necessary aspects of the subject matter and if they flow in a coherent and sequential manner.
- **Course Material:** Reviewers should consider the initial ideas proposed for the course material or content format. They should assess whether these ideas are suitable for effectively conveying the intended information to the students. Reviewers may evaluate the proposed content format, such as presentations, videos, or any other resources, based on its potential to enhance understanding and engagement.

Additionally, reviewers should keep in mind the overall quality, clarity, and coherence of the course material. They should pay attention to the language used, ensuring it is appropriate for the target audience and easy to comprehend. It would be beneficial for reviewers to consider the following aspects:

- **Relevance:** Assess whether the course material aligns with the objectives and covers the necessary topics and concepts.
- **Accuracy:** Verify the accuracy of the information presented and check for any potential errors or inconsistencies.
- **Completeness:** Ensure that the course material adequately covers all the essential aspects of the subject matter and provides comprehensive knowledge or skills to the learners.
- **Organization:** Evaluate the structure and organization of the course material to ensure it is logical, coherent, and easy to follow.

It is important for the reviewers to provide constructive feedback on areas of improvement and suggest specific recommendations for enhancing the course content, structure, or format. Please be thorough in your review and provide clear and actionable feedback to ensure the final courses meet the highest quality standards.

Annex 3: List of Educational Courses

Course #	Course Name
1	Introduction to Blockchain Technology and Digital Assets
2	Exploring Digital Asset Management and Tokenization
3	MiCA Regulation and CBDC
4	FinTech with Example Applications in Food Supply Chain
5	Tokenization with Example Applications in Food Supply Chain
6	Introduction to Blockchain in the Food Supply Chain
7	Basic Blockchain Skills
8	Advanced Blockchain Skills
9	Areas of application for Blockchain Technology
10	Smart Contracts with Example Applications in Food Supply Chain
11	Blockchain platforms
12	Blockchain and Traceability in relation to Food Supply Chain Integrity
13	Blockchain Applications for Food Quality Assurance and Certification
14	ESG and SDGs in Food Supply Chain using Blockchain Technology
15	Climate Action, Energy transition and Blockchain in Food Supply chain
16	Blockchain Adoption Strategies for SMEs in the Food Sector
17	Ethical Considerations and Governance in Blockchain-enabled Food Supply Chains
18	Combined Powers: Blockchain and IoT in Transforming the Food Supply Chains
19	Combined Powers: Blockchain and AI in Transforming the Food Supply Chain
20	Roadmap for the use of Blockchain Technologies in the Food Supply

Annex 4: List of Languages

The courses provided by TRUSFOOD project are provided in the following languages:

#	Course Name
1	English
2	Greek
3	Italian
4	Romanian
5	Slovenian
6	Lithuanian
7	Ukrainian

Annex 5: Example Course

In this annex, we provide an example of one of our courses (i.e. Course #6 - Introduction to Blockchain in the Food Supply Chain: Building Trust and Ensuring Safety), complete with all associated presentations and quizzes for each lesson. This serves as a representative demonstration of the engaging and informative content that the TRUST-FOOD Learning Ecosystem offers. The complete range of courses is demonstrated online through the TRUST-FOOD Software Training System (https://trust-food.ubitech.eu/).

TRUSTFOOD
Introduction to Blockchain in the Food Supply Chain: Building Trust and Ensuring Safety

Lesson 1: Supply Chain Essentials and Challenges in the Food Industry

Co-funded by the European Union

Introduction and Objectives

INTRODUCTION & LESSON DESCRIPTION:

- Lesson 1 provides a comprehensive overview of the food supply chain, describing its essential components and the inherent challenges faced within this sector. This lesson underscores the intricate complexities involved in achieving precise and effective food delivery while addressing the challenges in the food supply chain.

OBJECTIVES:

- Offer an understanding of the key stages in the food supply chain, tracing the journey of food products.
- Highlight the roles of primary and secondary stakeholders within the food supply chain, emphasizing their interconnected responsibilities.
- Examine challenges in the food supply chain, from logistical issues to quality assurance.

Co-funded by
the European Union

Key Concepts

- **Supply Chain:** The supply chain represents the sequence of processes and entities involved in the production and distribution of a product, from the procurement of raw materials to the delivery of the final product to the end consumer.

- **Food Supply Chain:** This refers to the specific network of key stages and stakeholders involved in the journey of food products, from their origin in farms to their final consumption.

- **Supply Chain Challenges:** These are obstacles and hurdles that can disrupt the smooth functioning of the (food) supply chain. Common challenges in the food industry include maintaining product quality, transportation inefficiencies, and adapting to regulatory changes.

Co-funded by the European Union

Learning Outcomes

TRUST FOOD

By the end of this lesson, participants will be able to:

- Comprehend the complex design and key stages comprising the food supply chain, recognizing the passage of food products from agricultural sources to end users and the relevant parties engaged at each phase.
- Differentiate between primary and secondary stakeholders in the food supply chain, gaining clarity on their distinct roles, responsibilities, and impacts.
- Recognize the various obstacles that the food supply chain faces, from logistical problems to quality control.

Co-funded by
the European Union

Supply Chain

The supply chain represents the sequence of processes and entities involved in the production and distribution of a product, from the procurement of raw materials to the delivery of the final product to the end consumer.

Source: https://www.shipbob.com/blog/supply-chain-management/

Co-funded by
the European Union

Supply Chain Processes (1/2)

1) **Quality Assurance and Checks**
   - **Standards Compliance:** Ensuring products meet industry and regulatory standards.
   - **Testing and Inspection:** Periodic checks to ensure product consistency and quality.
   - **Feedback Loops:** Mechanisms to integrate consumer and client feedback into product improvement.
   - **Documentation:** Proper record-keeping of all quality tests, checks, and compliance certificates.

2) **Inventory Management**
   - **Demand Forecasting:** Using historical data to predict future demand for efficient stocking.
   - **Stock Control:** Systems and protocols to manage stock levels and reorder points.
   - **Order Management:** Mechanisms to handle order inflow, processing, and fulfillment.
   - **Inventory Audits:** Regular checks to ensure physical stock matches recorded stock.

Co-funded by the European Union

Supply Chain Processes (2/2)

TRUST FOOD

3) Transportation and Logistics

- **Route Planning:** Determining the most efficient and cost-effective routes for shipments.
- **Carrier Selection:** Choosing the best transportation methods based on cargo type, destination, and timing.
- **Freight Management:** Overseeing the movement of goods from one point to another.
- **Tracking and Reporting:** Tools and systems in place to monitor shipments and provide updates.

4) Warehousing

- **Layout Design:** Designing warehouse layout for optimal space utilization and workflow efficiency.
- **Stock Rotation:** Implementing systems to ensure that older stock is used/sold first.
- **Security Measures:** Protocols to prevent theft, damage, and unauthorized access.
- **Warehouse Technology:** Use of modern technologies for tracking, picking, and storage.

Co-funded by
the European Union

Food Supply Chain

Food Supply Chain (FSC) refers to the specific network of key stages and stakeholders involved in the journey of food products, from their origin in farms to their final consumption.

Source: https://www.shipbob.com/blog/supply-chain-management/

Co-funded by
the European Union

Overview of Food Supply Chain

TRUST FOOD

In any food supply chain, there are some primary key stakeholders:

- **Producers of raw materials:** They are at the beginning of the chain, responsible for cultivating and harvesting the basic agricultural products that fuel the entire system.
- **Distributors (Logistics):** Their main role is to transport and distribute the processed food products efficiently from producers and processors to the retail outlets.
- **Retailers:** They are responsible for the final point of sale, offering a variety of products in accessible locations.
- **Consumers:** They are the end-users, purchasing and consuming the products, thus driving the demand that fuels the entire chain.

Source: FAO (2020)

Co-funded by the European Union

Rethinking Our Food Supply Chain

Rethinking Our Food Supply Chain - Future Proofing Your Food | Kieran Kelly | TEDxDerryLondonderry
Source: https://www.youtube.com/watch?v=2qSdeVrgN8I

Co-funded by the European Union

Food Supply Chain Stages (1/3)

1) **Production**

- **Sourcing of Food:** Food products are either grown or developed based on local and international guidelines.
- **Quality Assurance:** Ensuring adherence to laws and regulations to maintain food quality, appearance, and safety.
- **Food Production Systems:** Differentiating between organic, conventional, and GMO production methods.

2) **Handling and Storage**

- **Preparation Post-Harvest**: Necessary preparations are carried out after harvesting, e.g., washing certain potatoes before packing.
- **Storage:** Preserving the quality and safety of food products, especially perishable items.
- **Safety Protocols:** Ensuring that food storage facilities meet necessary standards to avoid contamination and spoilage.

Co-funded by the European Union

Food Supply Chain Stages (2/3)

TRUST FOOD

3) **Processing and Packaging**

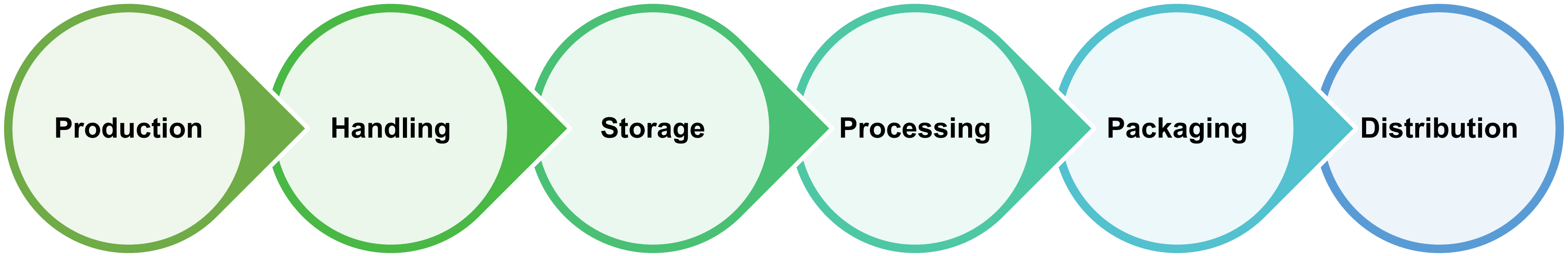
- **Food Safety:** Ensuring products meet stringent food safety requirements.
- **Transformation:** Turning raw products into consumable forms or items (e.g., turning potatoes into crisps).
- **Packaging:** Ensuring the food is stored in appropriate materials that extend shelf life and provide information to consumers.

4) **Distribution**

- **Shipping & Transportation:** Transporting food products to their final destinations, considering the most efficient and safe methods.
- **Food Miles:** Evaluating the distance food travels from its production location to the consumer, serving as an environmental impact measure.
- **Final Destinations:** This includes markets, restaurants, and other segments of the food industry.

Co-funded by the European Union

Food Supply Chain Stages (3/3)



Co-funded by
the European Union

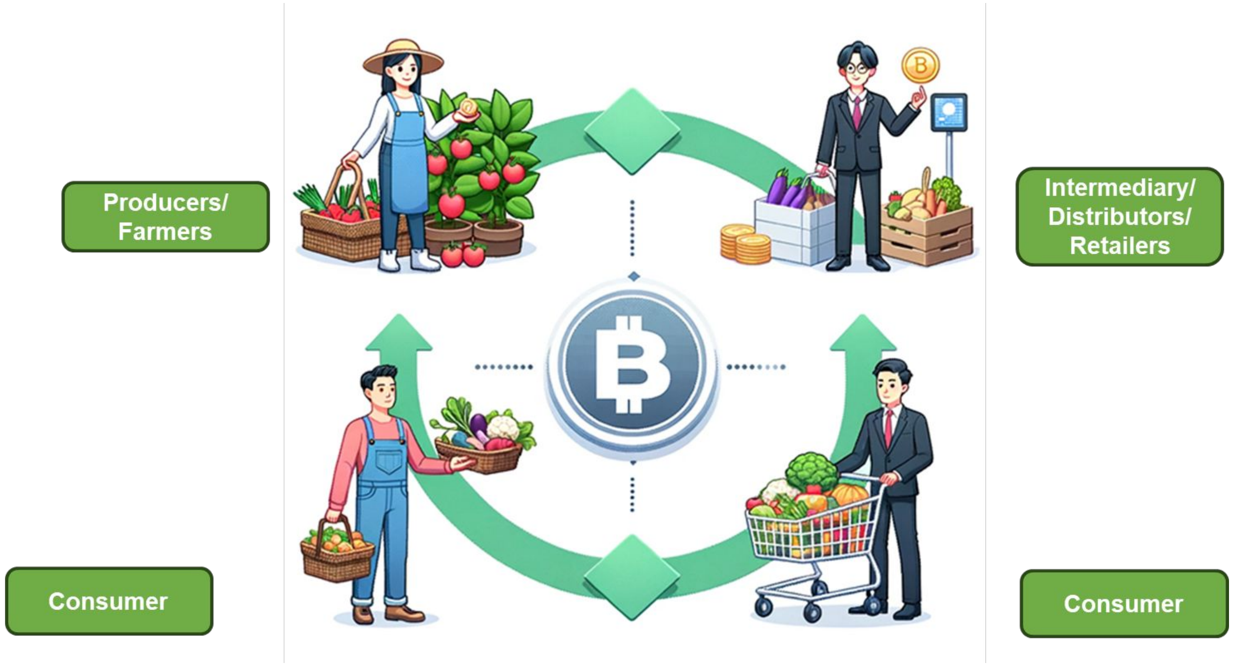
Stakeholders in the Food Supply Chain

Primary Stakeholders & Secondary Stakeholders

Co-funded by
the European Union

Stakeholders in the Food Supply Chain

- **Farmers & Producers:**
  - Directly tokenize their produce for better traceability.
  - Ensure fair compensation through transparent and tamper-proof records.
- **Distributors & Retailers:**
  - Benefit from faster and more transparent supply chain processes.
  - Enhance trust with consumers through verifiable product histories.
- **Consumers:**
  - Access detailed information about the products they purchase.
  - Make informed choices based on product origin, handling, and authenticity.



Co-funded by the European Union

Primary Stakeholders: Farmers/Producers

Description: Farmers are the foundational pillar of the food supply chain. They engage directly with the land and its produce, making their practices pivotal for environmental and economic outcomes. They are tasked with blending tradition with evolving practices to meet the changing demands of the world.

- **Direct producers of agricultural goods:** Cultivate the crops and livestock that are the base for most products.
- **Manage and influence land and soil health:** Farming practices have direct impacts on the environment and ecosystem health.
- **React to market demands and standards:** Modify practices based on buyer requirements and consumer trends.
- **Play a key role in sustainability at the ground level:** Through sustainable farming, they directly affect the environment positively.

Co-funded by the European Union

Primary Stakeholders: Retailers

Description: Retailers are the linchpin between the vast world of production and the individual consumer. Their decisions significantly influence market trends, consumer habits, and even production standards. Their unique position allows them to set the tone for market demands and sustainability practices.

- **React to and shape consumer demand:** Offer promotions and sales to steer consumer purchasing habits.
- **Control product placement and visibility:** Decide on shelf space and prominence of products, influencing purchase decisions.
- **Bridge between producers and consumers:** Act as the main interface for consumers, determining which products are stocked and how they are displayed.
- **Influence supply chain sustainability:** By setting requirements for suppliers, retailers can push for more environmentally friendly and sustainable products.

Co-funded by
the European Union

Primary Stakeholders: Retailers

Description: Retail companies breathe life into raw materials, transforming them into products for consumers. These companies, with their brands and products, shape consumer lifestyles and choices, all while navigating a landscape of trends, feedback, and shifting market dynamics.

- **Develop and package consumer goods:** Create the products that fill retailer shelves.
- **Shape consumer trends and preferences:** Through marketing and product innovation.
- **Collaborate across the supply chain:** Partner with distributors, grain buyers, and farmers to ensure product standards.
- **Implement and promote sustainable practices:** Can lead the way in environmental and ethical responsibility.

Co-funded by
the European Union

Primary Stakeholders: Distributors

Description: Distributors crucial connectors in the supply chain, ensuring that goods move seamlessly from producers to retailers. Their role is essential in ensuring product availability, quality maintenance, and logistical efficiency.

- **Vital link in getting products to retailers:** Handle logistics to ensure products are available when and where needed.
- **Influence product availability:** Based on storage capacities and transportation networks.
- **React quickly to shifts in market demand: Adjust** distribution schedules and routes as needed.
- **Ensure product storage and handling quality:** Prevent losses due to spoilage or damage.

Co-funded by
the European Union

Primary Stakeholders: Consumers

Description: Consumers are more than just end-users. Their preferences, demands, and feedback directly shape the market, pushing industries to evolve. In the modern era, consumers are becoming increasingly conscious, driving a significant push towards sustainability and ethical practices.

- **Drive demand for specific products:** Personal preferences and purchasing habits shape the market.
- **Influence market trends:** Through collective demand and feedback.
- **Possess purchasing power:** Determine the success of products through buying decisions.
- **Shape brand perception and value:** Through reviews, feedback, and brand loyalty.

Co-funded by the European Union

Secondary Stakeholders:
Grain Buyers

Description: Grain buyers act as vital intermediaries, linking the agrarian world with the industrial. Their choices set standards and determine trends in farming, making their role integral for aligning production practices with market demands.

- **Mediate between farmers and food companies:** Act as intermediaries ensuring grain quality.
- **Set standards for grain quality and sustainability:** Influence farming practices through their purchasing choices.
- **Connect market demand to agricultural supply:** Act based on what the market and food companies need.
- **Collaborate with farmers for mutual benefits:** Create win-win situations through partnerships.

Co-funded by
the European Union

Secondary Stakeholders:
Agricultural Service Providers

Description: Agricultural Service Providers are the support pillars for farmers. They equip them with knowledge, tools, and best practices, ensuring the agricultural community remains updated and efficient. Their role fosters innovation and bridges the gap between tradition and modernity.

- **Offer technical support to farmers:** Assist with knowledge on best practices and new technologies.
- **Disseminate new farming techniques:** Play a key role in innovation and knowledge spread.
- **Advocate for sustainable practices:** Push for practices that are beneficial to the environment and long-term profitability.
- **Bridge knowledge gap in the agricultural community:** Offer training and support.

Co-funded by
the European Union

Secondary Stakeholders:
Raw Material Production

Description: This group represents the transformation and movement specialists in the food industry. They take raw materials and turn them into consumable items, then ensure these items reach the right places.

- **Kickstart the production process:** Source materials that initiate the entire supply chain.
- **Influence quality from the outset:** The quality and sustainability of raw materials set the tone for the end product.
- **Adapt to consumer concerns:** Modify production based on feedback and market demands.
- **Innovate in response to market dynamics:** Adopt new methods or materials based on changing needs.

Co-funded by
the European Union

Secondary Stakeholders:
Food Processors, Transport, and Logistics

Description: Raw Material Producers initiate the product journey from source to shelf. Their practices, innovations, and choices set the foundation for everything that follows in the supply chain.

- **Manage movement and transformation of raw goods:** Turn raw materials into consumable products and ensure they reach retailers.
- **Maintain quality during transportation:** Implement storage and transportation techniques to preserve product integrity.
- **React to global market dynamics:** Adjust routes and processes based on international events or changes.
- **Prioritize timely delivery:** Ensure products are available when consumers want them.

Co-funded by the European Union

Food Supply Chain Challenges

Poor Inventory Control

- Spoilage and waste due to improper inventory management.
- Negative customer reactions from lack of desired products.

Temperature-Controlled Shipping Hurdles

- Ensuring food remains at optimal temperatures during transit.
- Complexity of managing the cold chain.
- The rise of technology in monitoring temperature throughout.

Carrier Capacity Issues

- Causes include labor shortages, high demand, etc.
- Need for transparency and communication to manage expectations.

High Costs

- Rising prices in various sectors, including food.
- Balancing cost-cutting with maintaining quality and safety.

Lack of Traceability and Transparency

- Outdated systems and manual tracking causing errors.
- Essential to uphold brand integrity and customer trust.
- Technological solutions like blockchain can provide answers.

Distribution Capacity Constraints

- Trucker shortages and port delays disrupt global supply chains.
- Shipping container scarcity drives up trade costs and affects availability.

Co-funded by the European Union

Formative Assessment

What are some of the primary challenges that stakeholders typically encounter in the food supply chain?

Co-funded by the European Union

Summary and Key Takeaways

SUMMARY

- Lesson 1 provides an introduction to the essentials of the food supply chain, detailing its stages and highlighting the challenges faced by stakeholders in the food industry.

KEY TAKEAWAYS:

- **Foundational Understanding:** The lesson outlines the vital stages of the food supply chain, detailing the trajectory from raw material sourcing to the delivery of the final product to consumers.
- **Stakeholder Roles:** Emphasis on the crucial roles of different stakeholders emphasizes the necessity for effective collaboration and streamlined communication for an optimized food supply chain.
- **Food Supply Chain Challenges:** Introduction to the most common challenges faced in food supply chain.

Co-funded by
the European Union

References

1. Bhat, R. and Jõudu, I., 2019. 'Emerging issues and challenges in agri-food supply chain.' In: *Sustainable food supply chains*, pp.23-37.
2. Kumar, M., Raut, R.D., Jagtap, S. and Choubey, V.K., 2023. 'Circular economy adoption challenges in the food supply chain for sustainable development.' *Business Strategy and the Environment*, 32(4), pp.1334-1356.
3. Thomas, D.J. and Griffin, P.M., 1996. 'Coordinated supply chain management.' *European Journal of Operational Research*, 94(1), pp.1-15.
4. GEP Blogs, 2023. A Comprehensive Guide to Food Supply Chain. Available at: https://www.gep.com/blog/strategy/food-supply-chain-stages-models-challenges-best-practices (Accessed: 03 November 2023).
5. Hayes, A. 'The supply chain: From raw materials to order fulfillment.' *Investopedia*. Available at: https://www.investopedia.com/terms/s/supplychain.asp (Accessed: 03 November 2023).

Co-funded by
the European Union

References

6. Osman, M., 2023. 'A guide to the supply chain process.' *HubSpot Blog*. Available at: https://blog.hubspot.com/the-hustle/supply-chain-process (Accessed: 03 November 2023).
7. Supply Chain Solutions Center, (no date) 'Identify key stakeholders: Agriculture.' Available at: https://supplychain.edf.org/resources/identify-stakeholders-agriculture/ (Accessed: 03 November 2023).
8. Curoe, M., 2023. '5 challenges facing the National Food Supply Chain.' *Redwood*. Available at: https://www.redwoodlogistics.com/insights/5-challenges-facing-the-national-food-supply-chain (Accessed: 03 November 2023).
9. Asaad, J., 2022. 'Fixing the 5 big problems in the Food Supply Chain.' *The Network Effect*. Available at: https://supplychainbeyond.com/5-big-problems-in-the-food-supply-chain/ (Accessed: 03 November 2023).
10. Aptean.com, (no date) 'Overcoming the 4 biggest food supply chain issues.' Available at: https://www.aptean.com/en-US/insights/blog/biggest-food-supply-chain-issues (Accessed: 03 November 2023).

Co-funded by
the European Union

Further Readings

1. Malik, S., Kanhere, S.S. and Jurdak, R., 2018. 'Productchain: Scalable blockchain framework to support provenance in supply chains.' In: *2018 IEEE 17th International Symposium on Network Computing and Applications (NCA)*. IEEE.
2. ShipBob Blog, 'What is Supply Chain Management? SCM Definition & Examples.' Available at: https://www.shipbob.com/blog/supply-chain-management/ (Accessed: 14 November 2023).
3. Inecta.com, 'What is Supply Chain Management for the Food Industry?' Available at: https://www.inecta.com/blog/food-supply-chain-management (Accessed: 14 November 2023).
4. Burke, D., 'How to Fix Broken Supply Chains.' Available at: https://www.youtube.com/watch?v=y_EjCSz1aBo (Accessed: 14 November 2023).
5. Tyink, A., 'Disrupting the Food System: Innovative Models of Fresh Food Delivery.' Available at: https://www.youtube.com/watch?v=AyD3ImCytlg (Accessed: 14 November 2023).

Co-funded by the European Union

THANK YOU

Disclaimer: The content provided in this course is for informational purposes only and should not be considered as legal, financial, or professional advice.

Acknowledgment: The content in this course has been developed as part of the TRUSTFOOD project, which has received funding from the European Union's Digital Europe Programme under Grant Agreement No. 101100804.

Comments and inquiries may be addressed to Andreas Delladetsimas (delladetsimas.a@unic.ac.cy) and Evgenia Kapassa (kapassa.e@unic.ac.cy), University of Nicosia

Co-funded by the European Union

TRUSTFOOD
Introduction to Blockchain in the Food Supply Chain: Building Trust and Ensuring Safety

Lesson 2: Blockchain Technology Essentials – Part I

Co-funded by
the European Union

Introduction and Objectives

INTRODUCTION & LESSON DESCRIPTION:

- Lesson 2 presents the foundational concepts of blockchain technology. Learners will gain an understanding of the basic principles that drive blockchain and its standout features, such as immutability and decentralization, as well as how blockchain works.

OBJECTIVES:

- Introduces learners to the fundamental concepts of blockchain technology.
- Understand how blockchain works.
- Emphasizes the importance of blockchain's characteristics, such as its immutability and more.

Co-funded by
the European Union

Key Concepts

- **Blockchain Technology:** At its core, blockchain is a digital ledger, a continuously growing list of records (i.e. blocks) that chronicle transactions in a tamper-evident way. This makes data alteration extremely challenging, ensuring data integrity.
- **Decentralization in Blockchain:** Unlike traditional systems where a single entity holds control, in blockchain, authority is decentralized. This means every participant, or node, holds a copy of the ledger, enhancing security and transparency.
- **Immutability Principle:** One of the foundational pillars of blockchain is its immutability. Once data is written onto the blockchain, it's nearly impossible to change it. This feature ensures trustworthiness and reliability of the data.
- **Hash:** Hash is a function that converts an input of letters and numbers into an encrypted output of a fixed length
- **SHA-256 (Secure Hash Algorithm):** generates a unique, fixed size 256-bit (32-byte) hash (64 characters long).

Example

- Input: TrustFood2023
- The SHA-256 hash for "TrustFood2023" is: `f6ac03edcc3651883960c2ff45d5a2510f60c4113b5482859068994099774de5`

Co-funded by the European Union

Learning Outcomes

By the end of this lesson, participants will be able to:

- Recognize the key elements of blockchain technology, including how its blocks store digital data and the importance of its tamper-evident nature.
- Examine the significance of blockchain's decentralization, understanding how it promotes security, transparency, and the elimination of single points of failure.
- Recognize how important immutability is to maintaining the reliability and integrity of data recorded on a blockchain.
- Understand how blockchain works.

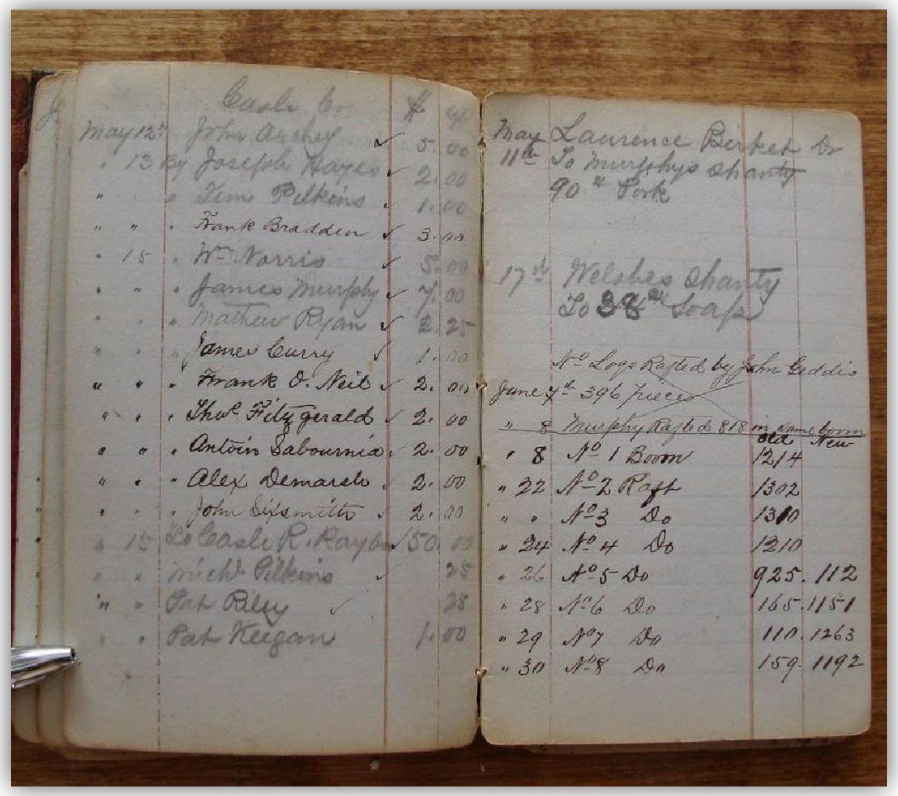
Co-funded by
the European Union

Transaction Ledgers (1/2)

What is a Ledger?

- Used to record economic activities and prove the ownership and the transfer of the value of assets among various stakeholders such as:
  - Consumers
  - Suppliers
  - Producers
  - Market makers

- Assets in a ledger include among others:
  - Tangible (e.g., motor vehicles, houses).
  - Intangible (e.g., stocks, digital rights).



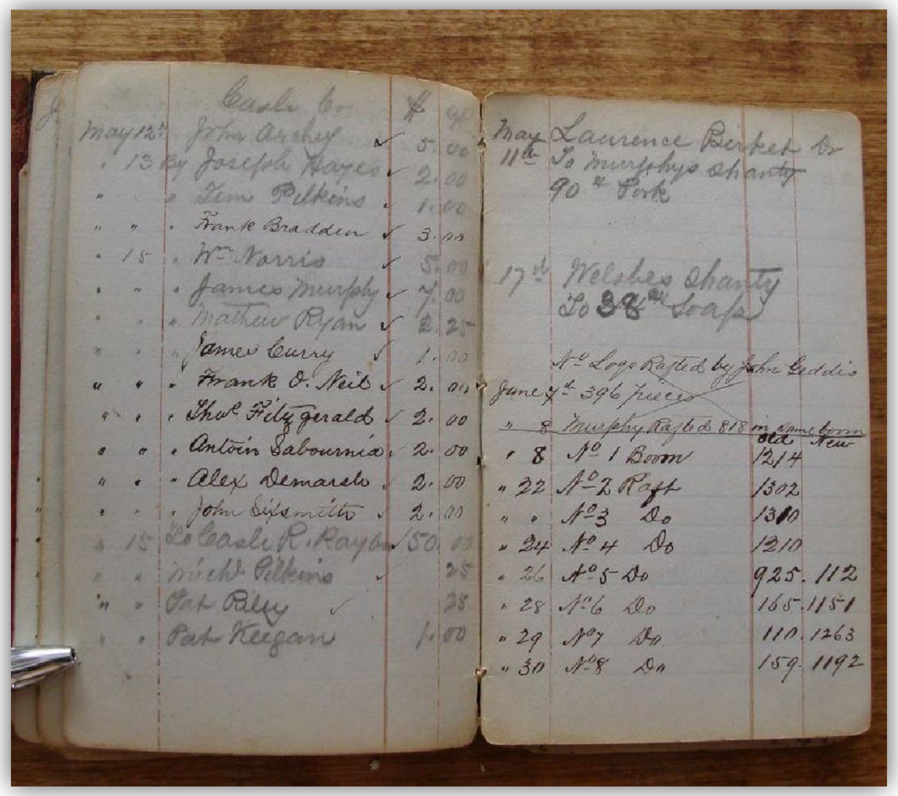
Co-funded by
the European Union

Transaction Ledgers (2/2)

TRUST FOOD

Problems with Traditional Ledgers

- Not only buyers and sellers are involved in transactions recorded within current traditional ledgers.
- Intermediaries such as banks, clearing houses, financial institutions and auditors are also involved and act as third parties.
- This centralized process causes problems such as:
  - **Inefficiency** – Slow transaction settlements.
  - **High costs** – Not only these third parties need to get paid, but potential disputes need additional costs to be covered for such as insurance provision.
  - **Lack of transparency** - Not all stakeholders have access to information relevant to them.
  - **Fraud and errors** – May lead to bad decision making and missed opportunities.



Co-funded by the European Union

What is Blockchain?

Co-funded by
the European Union

What is Blockchain? (1/2)

- **Definition:**
  - **Digital Ledger:** A constantly growing list of records (blocks) that document transactions and other information.
  - **Decentralized Network:** Distributed across multiple computers (nodes) which operate collaboratively but independently.
  - **Security & Immutability:** Cryptographically secured, ensuring that once a record is added, it becomes near-impossible to alter.
- **Key Points:**
  - Allows parties that do not know or trust each other to transact together.
  - Invulnerable to censorship and exclusion.
  - Invulnerable to malfeasance by record-keepers.
  - Invulnerable to loss of records.
  - Bitcoin is the first practical use case of Blockchain.

Co-funded by the European Union

What is Blockchain? (2/2)

- Blockchain is a type of Distributed Ledger Technology (DLT), which allows the **recording, sharing and storing of cryptographic data** across multiple records (ledgers).
- Each ledger has the exact same synchronized information and is **collectively maintained** and controlled by a distributed network of computer servers (i.e. nodes).
- **No human intermediaries** & no human errors / interests.
- Blockchain enables the users to **store cryptographic data** in distinct but continuative structure of blocks (groups). The ratio behind it is to better control and spot any infection on the chain (safety valves).
- Algorithms create and verify the continuously growing data structure (add-only) that takes the form of chain of blocks of information.

Co-funded by the European Union

Source: BlockPool EU project, GA ID: 828888

Blockchain characteristics

Co-funded by
the European Union

Blockchain Key Characteristics (1/3)

TRUST FOOD

1) Decentralization

- **No central authority:** Transactions aren't controlled by a single entity.
- **Peer-to-peer network:** All participants (nodes) have access to the complete database and its complete history.
- **Enhanced security:** The blockchain’s decentralized nature makes it difficult for any single entity to take control or manipulate.

2) Transparency

- **Open-source structure:** Most blockchains allow any user to view its complete transaction history and code.
- **Public transaction history:** While identities aren't disclosed, all transaction details are openly accessible.
- **Trustworthiness:** Transparency ensures all participants can agree on the validity of the blockchain.

Co-funded by
the European Union

Blockchain Key Characteristics (2/3)

3) Immutability

- **Tamper-evident records:** Once a transaction is added, it can't be changed or removed.
- **Cryptographic security:** Transactions are secured using cryptographic principles ensuring they remain unaltered.
- **Chain linkage:** Each block contains a unique code (hash) from the previous one, creating a linked chain.

4) Efficiency

- **24/7 operations:** Blockchain operates round the clock, ensuring swift transactions.
- **Direct transactions:** Transactions occur directly between parties without intermediaries, reducing time and costs.
- **Scalability solutions:** Innovations aim to increase the transaction speed and volume the network can handle.

Co-funded by
the European Union

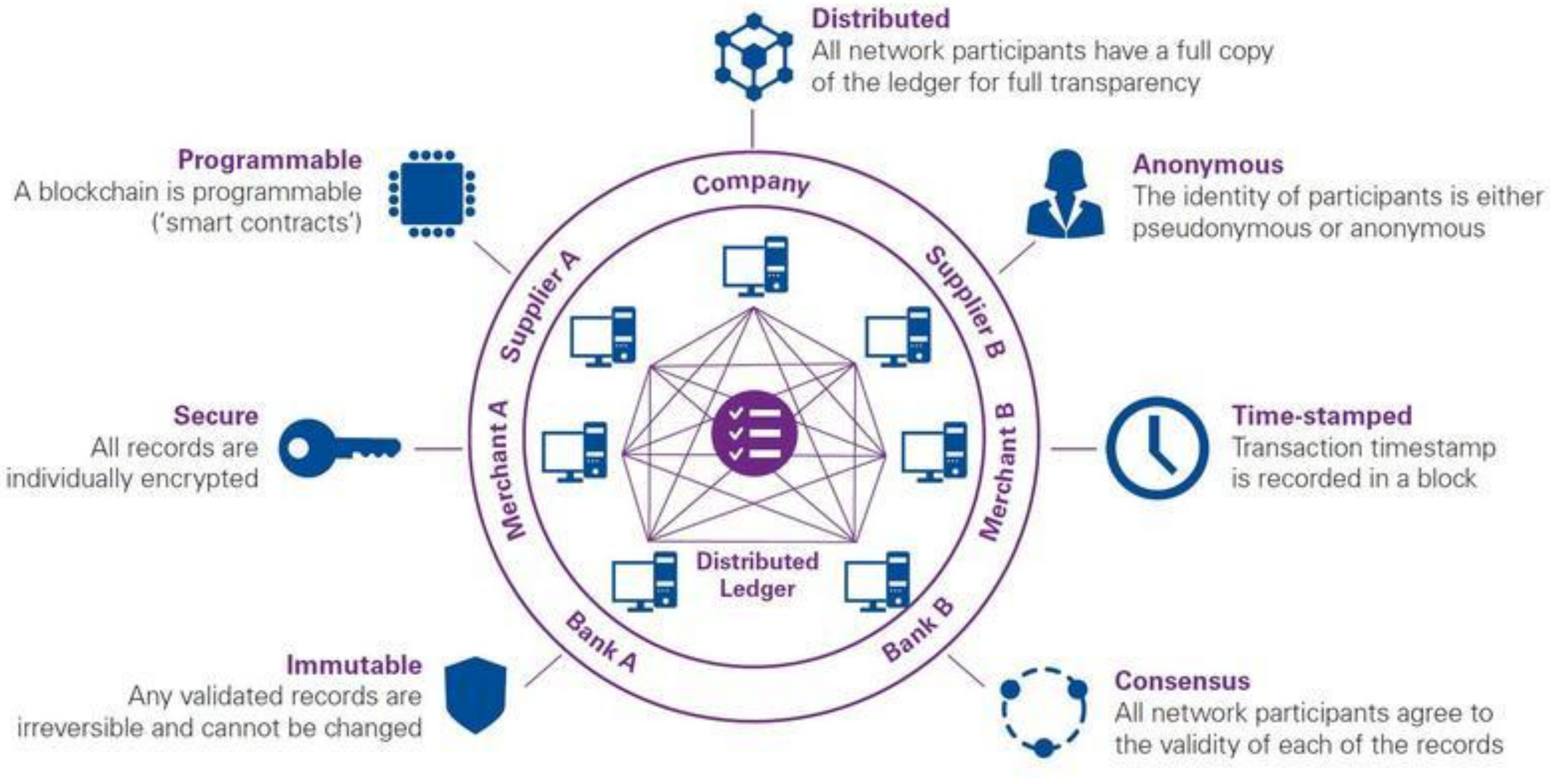
Blockchain Key Characteristics (3/3)

5) Security

- **Cryptography:** Employs cryptographic hashing and key pairs (public and private keys) for secure data encryption and identity verification, making data alteration extremely difficult.
- **Consensus Mechanisms:** Implements methods like Proof of Work or Proof of Stake to validate transactions, offering protection against fraud and Sybil attacks.
- **Immutability:** Blockchain records are irreversible and tamper-proof, ensuring a permanent and traceable history of all transactions, which enhances accountability.
- **Smart Contracts:** Automated execution of contracts when predefined conditions are met, reducing fraud, manipulation, and human error.
- **Transaction Verification:** For a transaction to be added to the blockchain, network participants must agree on its validity.
- **Protocols:** Implements methods like Proof-of-Work (PoW) or Proof-of-Stake (PoS) to achieve consensus.
- **Trust Mechanism:** Ensures that all transactions are genuine and prevents double-spending or fraud within the system.

Co-funded by
the European Union

Properties of Bitcoin Blockchain



Source: https://home.kpmg/bh/en/home/insights/2018/09/blockchain-in-insurance-fs.html

Co-funded by the European Union

Blockchain components

Co-funded by
the European Union

Core Components of a Blockchain

- **Nodes:**
  - Individual computers in the blockchain network responsible for validating transactions and maintaining synchronized copies of the distributed ledger.
  - This enhances the network's resiliency and decentralization.

- **Blocks:**
  - Data structures that contain a list of transactions, each cryptographically hashed and time-stamped.
  - They form the chronological backbone of a blockchain.

- **Chains:**
  - A linear sequence of blocks, each containing a reference to the previous block's hash,
  - This establishes an immutable chain of recorded transactions.

- **Consensus Mechanism:**
  - The set of rules or algorithms, such as Proof of Work (PoW) (e.g., Bitcoin) or Proof of Stake (PoS) (e.g., Ethereum).
  - Network nodes follow these rules to collectively agree on the validity and ordering of transactions.

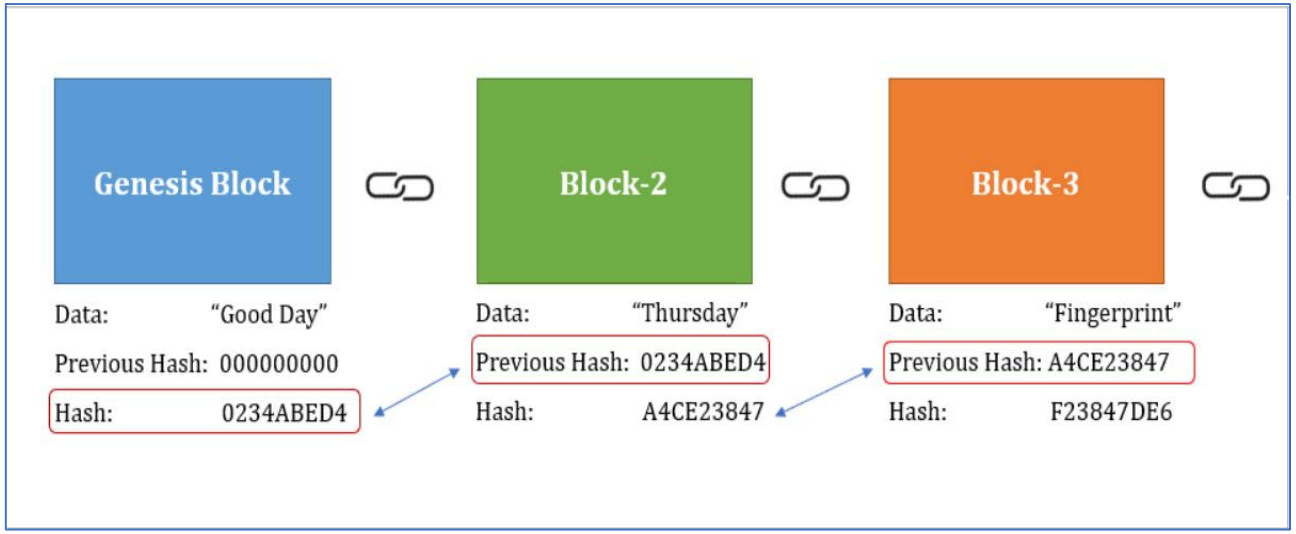
Co-funded by
the European Union

How blockchain works?

Co-funded by
the European Union

How blockchain works?

- Transactions are recorded in Blocks.
- Each Block contains a signature of the previous Block.
- Linking them together in a chain.
- Transactions are administrated in a distributed and decentralized way.
- Rise of a new way to store and exchange information.

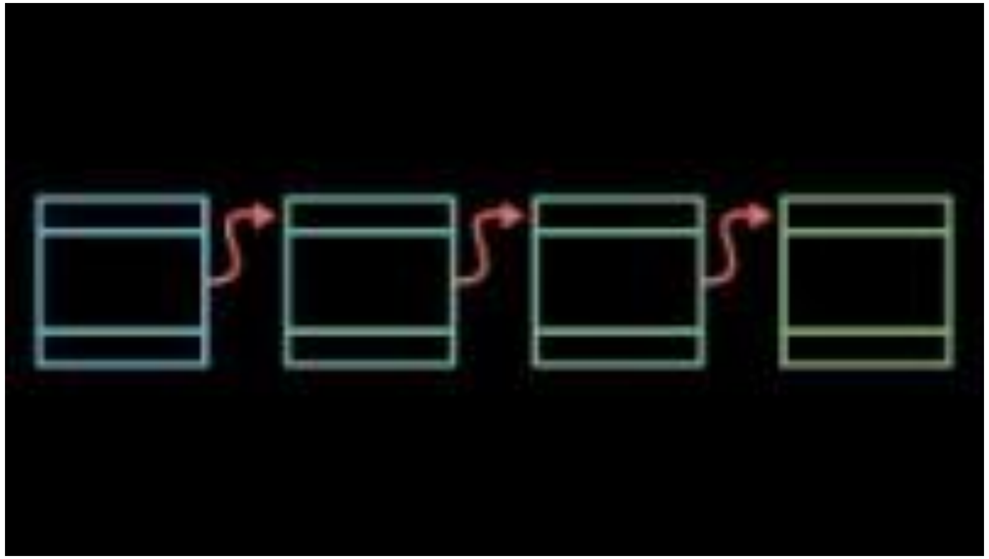


Source: Blockpool EU project, GA ID: 828888

Co-funded by the European Union

How blockchain works?

- **A transcation (in Bitcoin network):** *Source: BlockPool EU project, GA ID: 828888*
  - Notifies the Blockchain network about owner of a number of Bitcoins has authorized transfer of some to another owner.
  - Contains proof of ownership for amount of bitcoins.
  - Can be validated by anyone in the Bitcoin network.
  - Contains one or more inputs which are debits against Bitcoin account.
  - Contains one or more outputs which are credited to a Bitcoin account.



Source: https://www.youtube.com/watch?v=bBC-nXj3Ng4

Co-funded by the European Union

Important Aspects

Blockchain significance, security aspects, cryptographic principles, smart contracts

Co-funded by the European Union

Blockchain Significance

TRUST FOOD

Decentralization Benefits

- **Equality:** Every node has the ability to participate in the network and validate transactions.
- **Resilience:** Decentralized systems are less vulnerable to single points of failure.
- **Independence:** No one entity has control, reducing risks of censorship or external manipulations.

Transparency Benefits

- **Accountability:** Entities are more likely to act honestly when their actions can be tracked.
- **Trust-building:** Transparency ensures all participants can verify transactions and blocks.
- **Auditability:** Facilitates external reviews and audits, crucial for regulatory and compliance checks.

Co-funded by
the European Union

The Security Aspects of Blockchain

Tamper-Evident

Any changes or discrepancies are immediately noticeable

Cryptography

Ensures secure transaction records and helps in verifying the identity of transaction participants

Redundancy

Multiple copies of the blockchain across nodes ensure data availability and resilience against malicious attacks

Co-funded by the European Union

Cryptographic Principles in Blockchain

TRUST FOOD

- **Public and Private Keys:** A mathematically-linked pair, where the private key signs and the public key verifies.
- **Hash Functions:** Converts an input into a fixed size string of bytes, ensuring data integrity.
- **Enhanced Security:** Cryptographic techniques underpin blockchain's security, ensuring data confidentiality, integrity, and authentication.

Co-funded by the European Union

What Are Smart Contracts? (1/3)

- **Automated Digital Agreements:**
  - First proposed by Nick Szabo in 1990 and later brought to fruition on the Ethereum blockchain in 2014, smart contracts are specialized computer programs engineered to automate the execution of contractual agreements. These self-executing contracts fulfill the terms and conditions laid out in the agreement, eliminating the need for manual intervention and streamlining the transaction process.
- **Trust Minimization:**
  - A central idea behind smart contracts is the elimination of the need for trusted intermediaries. With smart contracts, the contractual rules can be embedded in code and executed by the network, making the process more transparent and secure.

Co-funded by
the European Union

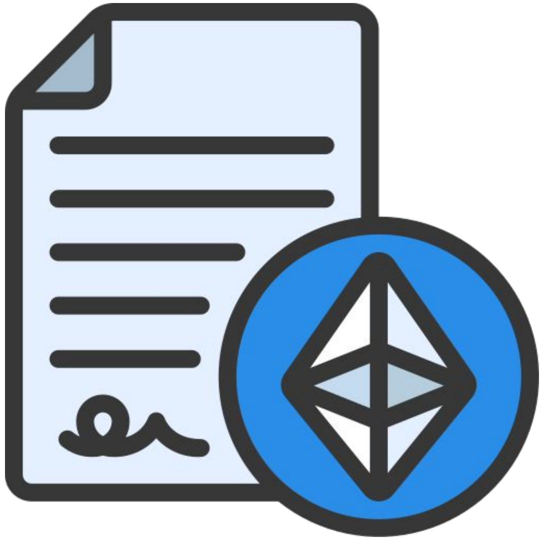
What Are Smart Contracts? (2/3)

- **Self-Executing and Self-Enforcing:**
  - Unlike traditional contracts that require external enforcement mechanisms, smart contracts are both self-executing when the conditions are met and self-enforcing in terms of compliance and dispute resolution.
  - **Self-Executing:** A smart contract automatically carries out the actions it is supposed to do without any human intervention, once the predefined conditions are met. Just like our bet about the weather: If the condition (it rains tomorrow) is true, the smart contract immediately executes the action (sends the $10 to the winner).
  - **Self-Enforcing:** The smart contract enforces the rules of the agreement on its own. This means once the contract is set in motion, it will ensure that the agreement is followed through exactly as written. There's no need for a lawyer or a judge to enforce the contract because the smart contract does it by itself. If the contract says pay $10 when it rains, it will happen automatically if the specified weather service confirms it rained. No one needs to argue or agree that it happened; the smart contract verifies it and enforces the payout.

Co-funded by
the European Union

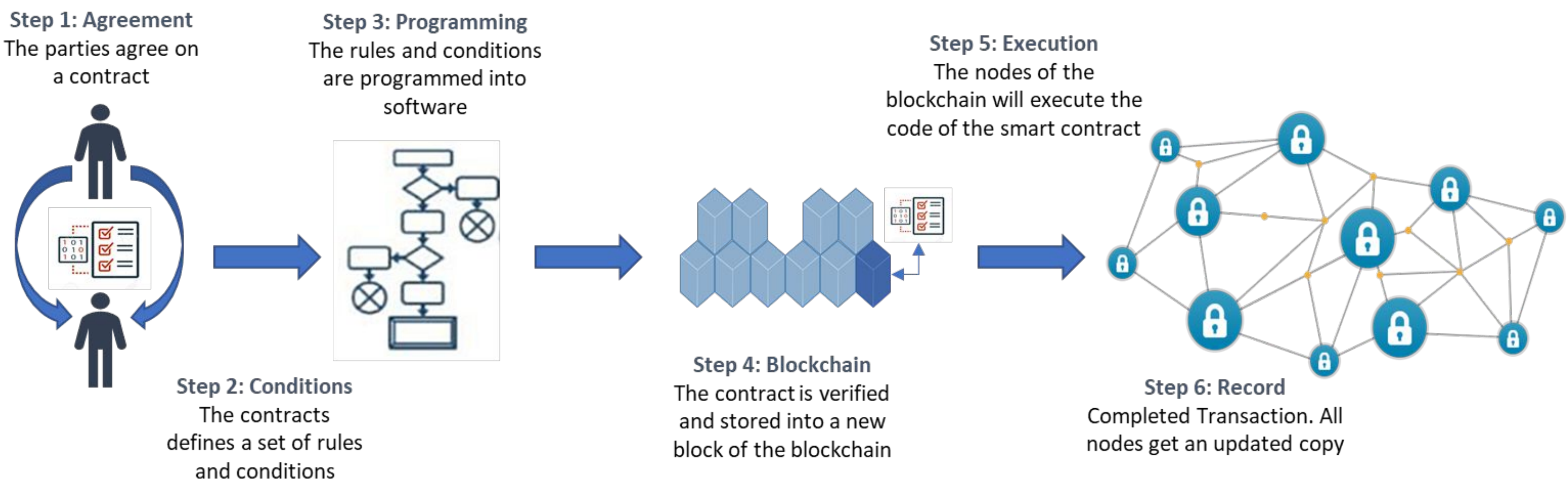
What Are Smart Contracts? (3/3)

- A contractual agreement that is implemented using software
  - **Machine-Readable**
  - **Machine-Executable**
- Also defined as “Smart Agreements”
  - Agreement with the power to re-engineer itself dynamically, depending on the **terms and conditions** of the market/commercial context to which it applies via the implementation of an implicitly encoded set of rules
- Smart contact is **self-enforced**
  - may be self-executed, depending on whether specific conditions monitored through software are met



Co-funded by the European Union

Automated Execution of Transactions with Smart Contracts



Co-funded by the European Union

Smart Contracts in Agrifood Supply Chains

- **Trust & Transparency**
  - Automate and verify transactions without intermediaries.
  - Transparent history of product from farm to consumer.
- **Efficiency & Automation**
  - Streamline payment processes (e.g., automatic payments upon delivery).
  - Reduce paperwork and manual interventions.
- **Quality Assurance**
  - Trigger alerts for deviations (e.g., temperature changes during transport).
  - Enforce compliance with quality standards automatically.
- **Reduced Fraud**
  - Immutable records prevent tampering and misrepresentation.
  - Ensure all parties adhere to agreed terms.
- **Cost Savings**
  - Reduce administrative costs and disputes.
  - Minimize losses from spoilage or breaches in contract.
- **Enhanced Traceability**
  - Seamless tracking of products at every stage.
  - Instantly accessible information for recalls or verifications.

Co-funded by the European Union

Formative Assessment

What are three key features of blockchain technology, and how do they contribute to its robustness?

Co-funded by the European Union

Summary and Key Takeaways

TRUST FOOD

SUMMARY

- Lesson 2 presents the core fundamentals of blockchain technology. It introduces learners to the basic principles that underpin this revolutionary technology and then expands on its distinguishing features like immutability and decentralization, which make it a standout in the realm of secure and transparent transaction systems.

KEY TAKEAWAYS:

- **Immutable Nature:**

  One of blockchain's key features is its immutability. Once data is added to the blockchain, it cannot be tampered with, ensuring data integrity and trustworthiness.

- **Decentralization's Role:**

  The lesson delves into the significance of decentralization in blockchain, emphasizing how this feature eliminates the need for central authorities and reduces vulnerabilities, leading to enhanced security and reliability.

Co-funded by
the European Union

References

1. Antonopoulos, A., Giaglis, G. and Polemitis, A., 2022. Introduction to Digital Currencies [MOOC]. UNIC. Available at: https://www.unic.ac.cy/blockchain/free-mooc/ (Accessed: 03 November 2023).
2. Bashir, I., 2018. *Mastering Blockchain: Distributed ledger technology, decentralization, and smart contracts explained*. Packt Publishing Ltd.
3. Arya, J., Kumar, A., Singh, A.P., Mishra, T.K. and Chong, P.H., 2021. 'Blockchain: Basics, applications, challenges and opportunities.'
4. Hayes, A. 'Blockchain facts: What is it, how it works, and how it can be used.' *Investopedia*. Available at: https://www.investopedia.com/terms/b/blockchain.asp (Accessed: 03 November 2023).
5. Nakamoto, S., 2009. 'Bitcoin: A peer-to-peer electronic cash system.'
6. Singhal, B., et al., 2018. 'How blockchain works.' In: *Beginning Blockchain: A Beginner's Guide to Building Blockchain Solutions*, pp.31-148

Co-funded by
the European Union

Further Readings

1. Sarmah, S.S., 2018. 'Understanding blockchain technology.' *Computer Science and Engineering*, 8(2), pp.23-29.
2. Niranjanamurthy, M., Nithya, B.N. and Jagannatha, S.J.C.C., 2019. 'Analysis of Blockchain technology: pros, cons and SWOT.' *Cluster Computing*, 22, pp.14743-14757.
3. Makridakis, S. et al., 2018. 'Blockchain: The next breakthrough in the rapid progress of AI.' *Artificial Intelligence-Emerging Trends and Applications*, 10.
4. Makridakis, S. et al., 2018. 'Blockchain: Current Achievements, Future Prospects/Challenges and Its Combination with AI.' pp.1-21.

Co-funded by
the European Union

THANK YOU

Disclaimer: The content provided in this course is for informational purposes only and should not be considered as legal, financial, or professional advice.

Acknowledgment: The content in this course has been developed as part of the TRUSTFOOD project, which has received funding from the European Union's Digital Europe Programme under Grant Agreement No. 101100804.

Comments and inquiries may be addressed to Andreas Delladetsimas (delladetsimas.a@unic.ac.cy) and Evgenia Kapassa (kapassa.e@unic.ac.cy), University of Nicosia

Co-funded by
the European Union

TRUSTFOOD
Introduction to Blockchain in the Food Supply Chain: Building Trust and Ensuring Safety

Lesson 3: Blockchain Technology Essentials – Part II

Co-funded by the European Union

Introduction and Objectives

INTRODUCTION & LESSON DESCRIPTION:

- Lesson 3 delves deeper into the multifaceted world of blockchain, exploring the different types of blockchains that exist and their unique characteristics. Participants will gain insights into the advantages and disadvantages of each blockchain type, supplemented by real-world use cases.

OBJECTIVES:

- Equip participants with a thorough understanding of the different types of blockchains available, breaking down their core structures and mechanisms.
- Through real-world use cases, enable participants to witness the practical implementations of each blockchain type, driving home the relevance and impact of these technologies in diverse sectors.

Co-funded by
the European Union

Key Concepts

- **Real-World Use Cases:** From public blockchains underpinning cryptocurrencies like Bitcoin to private blockchains streamlining supply chain management, the practical applications of these technologies are vast and varied.

- **Advantages and Disadvantages:** Each blockchain type has its strengths and weaknesses. For instance, while public blockchains offer high transparency, they might suffer from slower transaction times. Private blockchains might be faster but are more centralized.

Co-funded by
the European Union

Learning Outcomes

By the end of this lesson, participants will be able to:

- Distinguish between various blockchain types, understanding their unique features, and the underlying structures that define them.
- Weigh the advantages and disadvantages of each blockchain type, enabling them to evaluate their suitability for different scenarios.
- Correlate the theoretical knowledge of blockchains with real-world applications, understanding how these technologies are shaping industries and solving real-world problems.

Co-funded by
the European Union

Emergence of Various Blockchain Types

- **Growth:** As the popularity of Bitcoin grew, so did the interest in the technology behind it, leading to the emergence of Ethereum, which expanded the possibilities with smart contracts.
- **Diversification:** Over time, as the potential of the blockchain was realized, it evolved beyond cryptocurrency, leading to different types of blockchains customized for various purposes.
- **Need for Variability:** As industries recognized the potential of blockchain, the need for more controlled, private, and permissioned blockchains arose.
- **Response to Limitations:** Certain limitations of public blockchains, like scalability issues and energy consumption, led to the creation of alternative types.

Co-funded by
the European Union

Types of Blockchains

- **Public Blockchains**
  - Permissionless
  - Open to all and fully decentralized. Anyone can join, verify blocks, and create smart contracts.
  - Examples: Bitcoin, Ethereum
- **Private Blockchains**
  - Permissioned
  - Controlled by a single organization. Participants need an invitation. Centralized decision-making.
  - Examples: Hyperledger Fabric
- **Consortium Blockchains**
  - Permissioned
  - Joint control by multiple organizations. Examples: Quorum, R3 Corda.
- **Hybrid Blockchains**
  - Blend of Public and Private
  - Mixes features of public and private blockchains. Offers customizable transparency levels.
  - Examples: Dragonchain.
- **Sidechains**
  - Extensions to Main Blockchains
  - Separate chains linked to a 'parent' blockchain. Facilitates asset use across multiple blockchains.
  - Examples: Liquid network for Bitcoin.

Co-funded by the European Union

Public Blockchains

Permissioned & Permissionless

Co-funded by
the European Union

Public Blockchains

- **Definition:** Decentralized and transparent, where anyone can join, participate, and view all the transactions. They are generally maintained by a distributed community.
- **Public Blockchains:**
  - Emphasis on the openness to the general public.
  - Anyone can validate and transact on the ledger.
- **Public Blockchains can be:**
  - **Permissionless:** Anyone can participate without any restrictions.
  - **Permissioned:** Requires specific authorization to participate in certain activities on the blockchain.

Co-funded by the European Union

Permissionless (Public) Blockchains

Open to all and fully decentralized. Anyone can join, verify blocks, and create smart contracts.

Examples: Bitcoin, Ethereum

Co-funded by
the European Union

Key Features

Permissionless Blockchains

- **Transparency:** The complete transaction history is visible and accessible by anyone in the network.
- **Decentralization:** There is no central authority and decisions are made based on consensus mechanisms.
- **Inclusivity:** Everyone can be a part of the network – be it for transacting, validating, or even forking to create a new chain.
- **Security:** Difficult to hack due to its distributed nature. Altering data would require consensus, making unauthorized changes nearly impossible.
- **Smart Contracts:** self-executing contracts with the terms of the agreement directly written into lines of code. They automatically enforce and execute the terms of a contract when predetermined conditions are met.
- **The decentralized nature** of permission-less blockchains provides an ideal environment for smart contracts, as it ensures transparency, security, and trustless-ness in their execution.
- **Empowerment:** Every participant has a say in the network, fostering a sense of community ownership.

Co-funded by
the European Union

Advantages & Disadvantages

Permissionless Blockchains

Advantages

- Censorship-resistant
- Incentivized participation
- High transparency: Anyone can verify transactions

Disadvantages

- Slower transaction times
- High energy consumption (for some consensus methods)
- Less privacy: All transactions are visible.

Co-funded by the European Union

Examples

Permissionless Blockchains

- **Bitcoin:** The most famous use case is Bitcoin, a decentralized cryptocurrency. It allows peer-to-peer transfers without intermediaries.

- **Ethereum:** Beyond being a cryptocurrency, Ethereum enables the development of decentralized applications (DApps) through its smart contracts functionality. Use cases include decentralized finance (DeFi) applications, games, and more.

- **Litecoin:** Developed as the "silver" to Bitcoin's gold, it provides a faster and more efficient alternative for peer-to-peer transactions.

Co-funded by
the European Union

Real-World Use Cases

Permissionless Blockchains

- **Cryptocurrency Transactions:** Enabling peer-to-peer transfers of value without intermediaries.
- **Decentralized Applications (DApps):** Applications that operate on a blockchain, serving various functionalities ranging from games to decentralized finance.
- **Smart Contracts:** Automated, self-executing contracts where the agreement between buyer and seller is directly written into lines of code.
- **Decentralized Identity Systems:** Identity verification tools that allow users to have a single, reusable verified identity.

Co-funded by the European Union

Permissioned (Private) Blockchains

Controlled by a single organization. Participants need an invitation. Centralized decision-making.

Examples: Hyperledger Fabric

Co-funded by
the European Union

Key Features
Permissioned Blockchains

- **Selective Transparency:** While they are open for viewing, participation in consensus or adding to the chain requires permissions.
- **Regulated Decentralization:** They maintain decentralization but with checks and balances in place.
- **Efficiency and Flexibility:** Can be tailored to allow faster transactions and scalability than fully public blockchains.
- **Enhanced Security Measures:** By knowing who the participants are, the network can deter malicious activities and maintain integrity more effectively.
- **Customizability for Specific Needs:** Open permissioned blockchains can be tailored to cater to unique industry requirements, ensuring a flexible application.

Co-funded by
the European Union

Advantages & Disadvantages
Permissioned Blockchains

Advantages

- Selective transparency.
- Regulated decentralization.
- Efficiency & flexibility.
- Enhanced security with vetted participation.
- Adaptable for specific industry needs.

Disadvantages

- Not fully decentralized.
- Dependency on governing entities for permissions.
- Less transparent than public blockchains.

Co-funded by
the European Union

Examples
Permissioned Blockchains

- **Ripple (XRP):** While its ledger is public, the validators are a controlled set. Ripple connects banks, payment providers, and digital asset exchanges for faster, low-cost global transactions**.**

- **Stellar:** Similar to Ripple in its aim to connect financial institutions for cross-border payments, but with a more open approach to decentralization.

Co-funded by
the European Union

Real-World Use Cases
Permissioned Blockchains

TRUST FOOD

- **Cross-Border Payments:** Facilitating international money transfers between banks or financial institutions at reduced costs and faster speeds.
- **Supply Chain and Logistics:** Tracking products from origin to delivery, ensuring authenticity and transparency.
- **Voting Systems:** Creating transparent and tamper-proof voting mechanisms for elections or organizational decision-making.
- **Real Estate:** Speeding up the process of property transfer, making it more transparent and reducing the need for intermediaries.

Co-funded by
the European Union

Consortium Blockchains

Permissioned blockchains

Joint control by multiple organizations. Examples: Quorum, R3 Corda

Co-funded by
the European Union

Consortium Blockchains

- **Definition:** These blockchains are exclusively designed and maintained, granting access solely to designated members within a particular organization or consortium, ensuring both security and data integrity.

Co-funded by the European Union

Key Features
Consortium Blockchains

- **High Efficiency:** As the number of nodes is limited, transactions can be much faster.
- **Controlled Access:** Only authorized entities can read or write to the blockchain, ensuring data privacy.
- **Customization:** These can be tailored precisely to the needs of the organization or consortium.
- **Simplified Governance:** With fewer participants, decision-making processes are more efficient and less prone to disputes.
- **Enhanced Interoperability:** Private blockchains can be designed to seamlessly integrate with other business systems and software.

Co-funded by the European Union

Advantages & Disadvantages

Consortium Blockchains

Advantages

- High efficiency.
- Enhanced security due to controlled access.
- Customizable to organizational needs.
- Data integrity ensured by trusted participants.
- Reduced risks of fraudulent activities.

Disadvantages

- Highly centralized.
- Lacks the broader security of a larger, diverse network.
- Potential for misuse by dominant members.

Co-funded by
the European Union

Examples

Consortium Blockchains

- **Quorum:** An enterprise-focused version of Ethereum that's designed for transaction and contract privacy. Used by financial institutions for clearing and settlements.

- **R3 Corda:** Designed for the financial sector, Corda's architecture doesn't require every transaction to be copied to every participant in the network. Used by various banks for financial transactions.

Co-funded by the European Union

Examples
Consortium Blockchains

The Case of Corda: corda

- Corda, developed by R3, is not a traditional blockchain platform but is often referred to as a blockchain-inspired or distributed ledger technology (DLT).
- It is designed primarily for businesses and offers **both private and permissioned** network options.
- Corda allows for the development of **"CorDapps"** to facilitate transactions and other interactions in a private, secure, and scalable manner.
- These networks are typically **consortium blockchains**, where multiple organizations come together to establish a common network with shared rules and governance. In a consortium setup, the participants are known and vetted, differing from the public and permissionless nature of networks like Bitcoin and Litecoin.
- Corda can be utilized for both private networks, where a single organization governs and operates the network, and for consortium networks, which are governed by a group of organizations.
- It is **not public or permissionless** like some other blockchain networks.

Co-funded by
the European Union

Real-World Use Cases Examples

Consortium Blockchains

- **Internal Business Processes:** Enhancing and automating internal processes, like HR operations or financial reconciliations, within a confined environment.
- **Audit Trails:** Keeping immutable records for auditing purposes, ensuring data integrity and traceability.
- **Inventory Management:** Keeping track of products in real-time, from manufacturing to sales, within a specific company or set of partners.
- **Intellectual Property Protection:** Storing and verifying copyrights, patents, or trademarks to prevent unauthorized replication or fraud.
- **Interbank Transactions:** Enabling banks in a consortium to transfer assets or settle trades quickly and securely.

Co-funded by
the European Union

Examples

Public & Permissionless

Private & Permissioned

Consortium & Permissioned

Co-funded by
the European Union

Formative Assessment

What are the differences between public and private blockchains and in what scenarios might each be preferable.

Co-funded by the European Union

Summary and Key Takeaways

TRUST FOOD

SUMMARY

Lesson 3 delved deeper into the world of blockchain, building upon the foundational knowledge from Lesson 2. This lesson was centered around the various types of blockchains, each with its unique characteristics and potential applications, thereby offering a overview of their benefits, limitations, and impact.

KEY TAKEAWAYS:

- **Diverse Blockchain Types:**

  Lesson 3 uncovers the three primary types of blockchains - Public, Permissioned, and Private. This provides clarity on the accessibility and governance structures of these networks, from completely open environments to controlled, organization-specific systems.

- **Advantages Explored:**

  The lesson breaks down the specific benefits each type of blockchain brings to the table, from the sheer transparency of public blockchains to the tailored efficiency of private networks.

Co-funded by
the European Union

References

1. Antonopoulos, A., Giaglis, G. & Polemitis, A. (2022) *Introduction to Digital Currencies* [MOOC]. UNIC. Available at: https://www.unic.ac.cy/blockchain/free-mooc/ (Accessed: date).
2. Bashir, I. (2018) *Mastering Blockchain: Distributed ledger technology, decentralization, and smart contracts explained*. Packt Publishing Ltd.
3. Arya, J., Kumar, A., Singh, A.P., Mishra, T.K. and Chong, P.H. (2021) 'Blockchain: Basics, applications, challenges and opportunities'.
4. Seth, S. (no date) 'Public, private, permissioned blockchains compared', *Investopedia*. Available at: https://www.investopedia.com/news/public-private-permissioned-blockchains-compared/ (Accessed: 03 November 2023).
5. Sharma, T. K. (2022) 'Permissioned and permissionless blockchains: A comprehensive guide', *Blockchain Council*, 3 November. Available at: https://www.blockchain-council.org/ (Accessed: date).
6. Frankenfield, J. (no date) 'Permissioned blockchain: Definition, examples, vs. permissionless', *Investopedia*. Available at: https://www.investopedia.com/terms/p/permissioned-blockchains.asp (Accessed: 03 November 2023).
7. 'Advantages and disadvantages of blockchains' (2023) *ZebPay*. Available at: https://zebpay.com/blog/advantages-and-disadvantages-of-blockchains (Accessed: 03 November 2023).
8. '34 blockchain applications and real-world use cases' (no date) *Built In*. Available at: https://builtin.com/blockchain/blockchain-applications (Accessed: 03 November 2023).
9. Zīle, K. and Strazdiņa, R. (2018) 'Blockchain use cases and their feasibility', *Applied Computer Systems*, 23(1), pp.12-20.

Co-funded by
the European Union

References

10. Hedera. Available at: https://hedera.com (Accessed: 14 November 2023).
11. Ripple. Available at: https://ripple.com (Accessed: 14 November 2023).
12. Stellar. Available at: https://stellar.org (Accessed: 14 November 2023).
13. Antonopoulos, A. M. and Wood, G. (2018) *Mastering Ethereum: building smart contracts and dapps*. O'Reilly Media.
14. Hyperledger. Hyperledger Fabric. Available at: https://www.hyperledger.org/projects/fabric (Accessed: 14 November 2023).
15. R3. Corda. Available at: https://r3.com/products/corda/ (Accessed: 14 November 2023).
16. ConsenSys. Quorum. Available at: https://consensys.net/quorum/ (Accessed: 14 November 2023).
17. Litecoin. Available at: https://litecoin.org (Accessed: 14 November 2023).

Co-funded by
the European Union

Further Readings

1. Sabry, S.S., Kaittan, N.M. and Majeed, I., 2019. 'The road to the blockchain technology: Concept and types.' Periodicals of Engineering and Natural Sciences, 7(4), pp.1821-1832.
2. Shrivas, M.K. and Yeboah, T., 2019. 'The disruptive blockchain: types, platforms and applications.' Texila International Journal of Academic Research, 3, pp.17-39.
3. Zhang, S. and Lee, J.-H., 2020. 'Analysis of the main consensus protocols of blockchain.' ICT Express, 6(2), pp.93-97.
4. Touloupou, M. et al., 2022. 'A systematic literature review towards a blockchain benchmarking framework.' IEEE Access.
5. Touloupou, M. et al., 2022. 'Benchmarking Blockchains: The case of XRP Ledger and Beyond.'
6. Touloupou, M. et al., 2021. 'Towards a framework for understanding the performance of blockchains.' In: 2021 3rd Conference on Blockchain Research & Applications for Innovative Networks and Services (BRAINS). IEEE.

Co-funded by
the European Union

THANK YOU

Acknowledgment: The content in this course has been developed as part of the TRUSTFOOD project, which has received funding from the European Union's Digital Europe Programme under Grant Agreement No. 101100804.

Comments and inquiries may be addressed to Andreas Delladetsimas (delladetsimas.a@unic.ac.cy) and Evgenia Kapassa (kapassa.e@unic.ac.cy), University of Nicosia

Co-funded by
the European Union

TRUSTFOOD
Introduction to Blockchain in the Food Supply Chain: Building Trust and Ensuring Safety

Lesson 4: Role of Blockchain in Optimizing the Food Supply Chain

Co-funded by
the European Union

Introduction and Objectives

INTRODUCTION & LESSON DESCRIPTION:

- Lesson 4 introduces participants to the transformative power of blockchain technology in the food supply chain. With an ever-growing global population and rising concerns about food safety, traceability, and sustainability, there is an urgent need for robust and transparent systems. Blockchain offers an innovative solution that can bridge these gaps.

OBJECTIVES:

- Provide a summary of how the introduction of transparency, traceability, and efficiency through blockchain technology might act as an incentive for positive change.

Co-funded by the European Union

Key Concepts

- **Transparency and Traceability:** These twin pillars are essential for ensuring food safety and consumer trust. Blockchain's decentralized and immutable nature ensures every transaction is logged, ensuring end-to-end visibility.

- **Efficiency and Cost-Saving:** Beyond traceability, blockchain can expedite transactions, reduce paperwork, and curtail costs through streamlined processes.

- **Fraud Prevention:** Misrepresentation and fraud, especially in organic or specialized food markets, can be combated with the tamper-evident nature of blockchain.

- **Stakeholder Engagement**: Every actor, from farmers to retailers, plays an important role. Blockchain facilitates seamless collaboration among these stakeholders.

Co-funded by
the European Union

Learning Outcomes

By the end of this lesson, participants will be able to:

- Identify the core attributes of blockchain technology that make it a viable solution for the food supply chain's challenges.
- Imagine a future where the integration of blockchain technology drives the global food supply chain to become more efficient, safe, and sustainable.

Co-funded by
the European Union

Importance of Blockchain in Agrifood

Transforming Agrifood

- Blockchain technology offers transformative solutions for challenges ranging from traceability and transparency to efficiency and sustainability. By leveraging blockchain, stakeholders across the food supply chain stand to gain valuable insights, tighter security, and streamlined operations. The benefits are manifold, impacting everyone from farmers and distributors to retailers and consumers.

Source: https://www.linkedin.com/pulse/blockchain-platform-revolutionize-agri-food-supply-chains-menon

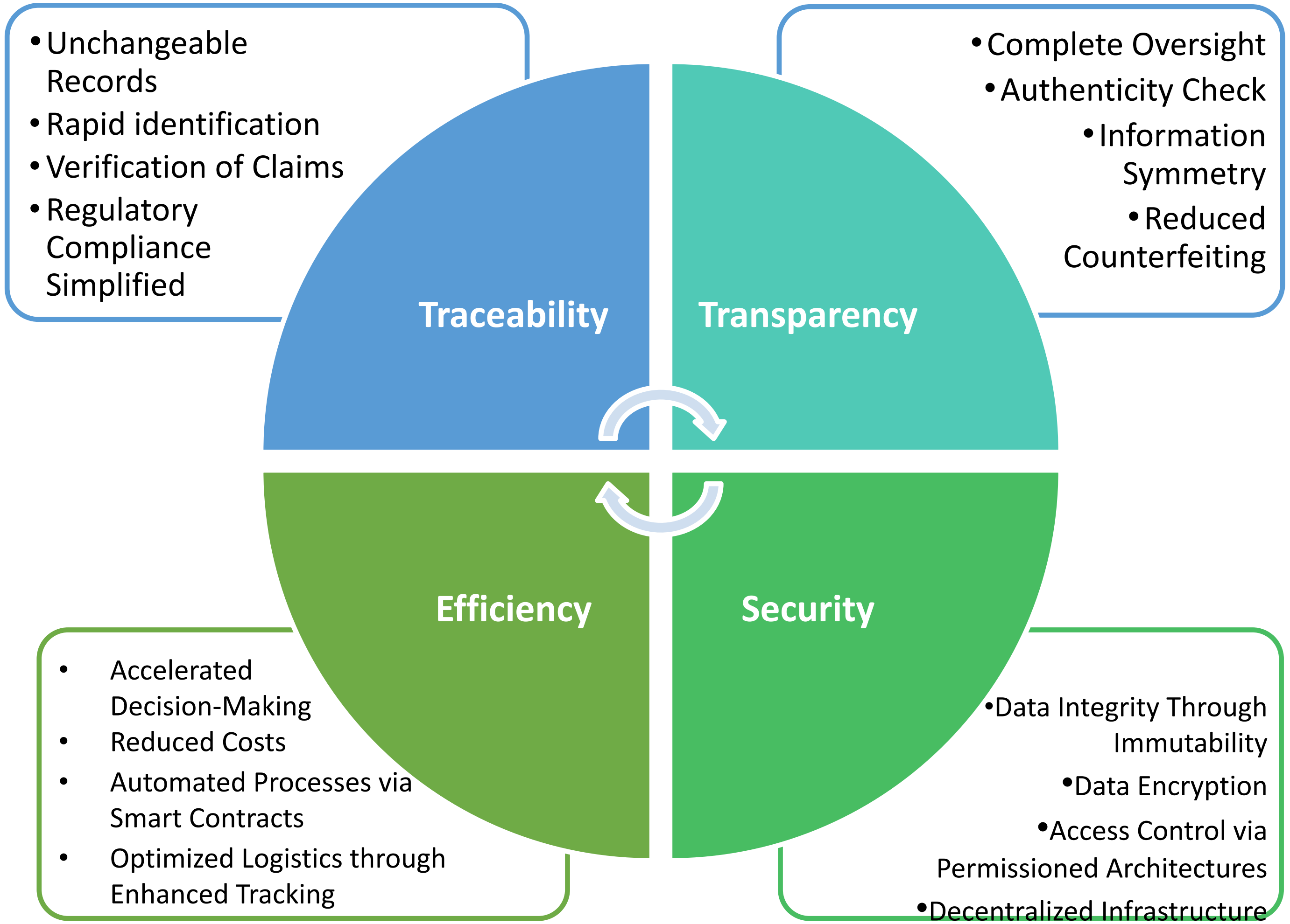
Co-funded by
the European Union

Impact of Blockchain in Food Supply Chain

Transparency, Traceability, Efficiency, Cost savings, Fraud prevention

Co-funded by
the European Union

Impact of Blockchain in Food Supply Chain



Co-funded by the European Union

Improved Transparency

- **Comprehensive Oversight:**
  - Every transaction is transparent to all in the network.
  - Minimizes potential for fraud, errors, or manipulation.
- **Authenticity & Trust Building:**
  - Precise tracing back to product's origin.
  - Boosts trust in sectors like organic farming or pharmaceuticals.
- **Equitable Information Sharing:**
  - Equal access to crucial data for all stakeholders.
  - Promotes informed decisions across the supply chain.
- **Counterfeit Mitigation:**
  - Enhanced visibility deters counterfeit/adulterated products.
  - Essential in areas like healthcare to ensure safety.
- **Enhanced Consumer Trust:**
  - Reinforces belief in product quality and source.
  - Supports ethical consumer choices (e.g., fair trade)
- **Efficient Risk Management:**
  - Quick identification of supply chain disruptions.
  - Assures compliance, reducing chances of recalls.

Co-funded by
the European Union

Enhanced Traceability

- **Immutable & Transparent Records:**
  - Each transaction is permanently and time-stamped.
  - Ensures unalterable logs from source to consumer.
- **Proactive Risk Management:**
  - Quick tracing identifies contaminated or faulty items.
  - Speeds up recalls and minimizes health risks.
- **Verification & Authenticity:**
  - Facilitates verification of claims like organic, non-GMO.
  - Empowers informed choices for consumers and vendor..
- **Simplified Regulatory Compliance:**
  - Transparent blockchain aids in food safety audits.
  - Reduces administrative efforts and ensures legal adherence.
- **End-to-End Visibility:**
  - Transparent view from producer to consumer.
  - Supports verification of product journey and claims.
- **Decentralized Validation:**
  - Multiple parties validate each transaction.
  - Minimizes chances of errors or unauthorized tampering.

Co-funded by the European Union

Efficiency & Cost Savings

- **Simplified Operations:**
  - Automated smart contracts facilitate seamless transactions.
  - Accelerated decision-making due to real-time data availability.
- **Cost Efficiency:**
  - Direct peer-to-peer exchanges minimize intermediary fees.
  - Facilitates cost-effective cross-border transactions.
- **Quick Reconciliation:**
  - Real-time shared ledger ensures all parties have the same data.
  - Speeds up settlements and reduces disputes.
- **Optimized Supply Chain:**
  - Efficient inventory management reduces overstocking and waste.
  - Enhanced traceability ensures optimal stocking and minimizes associated costs.
- **Paperwork Reduction:**
  - Digital documentation decreases administrative costs and enhances efficiency.
  - Cuts down administrative costs and expedites processes.
- **Automated & Reliable Processes:**
  - Immediate reconciliations ensure data consistency across parties.
  - Smart contracts reduce manual interventions and associated human errors.

Co-funded by the European Union

Security and Fraud Prevention

- **Tamper-Evident Records:**
  - Any changes to the blockchain are easily noticeable.
  - Helps detect and deter unauthorized alterations.
- **Verification and Data Encryption:**
  - Decentralized consensus mechanisms ensure data accuracy.
  - Minimizes the chance of fraudulent entries.
  - Blockchain technology utilizes advanced encryption algorithms to secure the data within each block.
- **Certification Validation:**
  - Enables the authentication of certifications like organic, GMO-free, etc.
  - Ensures that products meet the stated standards.
- **Supply Chain Accountability:**
  - Every stakeholder’s actions are transparent and traceable.
  - Increases accountability and reduces chances of misinformation.
- **Consumer Verification:**
  - Empowers consumers to verify product claims through QR codes or apps.
  - Enhances trust and reduces reliance on blind faith.
- **Access Control:**
  - Permissioned Architectures are useful for safeguarding sensitive information.
  - This feature significantly improves data security by restricting unauthorized access.

Co-funded by
the European Union

Formative Assessment

In what ways can blockchain technology increase efficiency within the food supply chain?

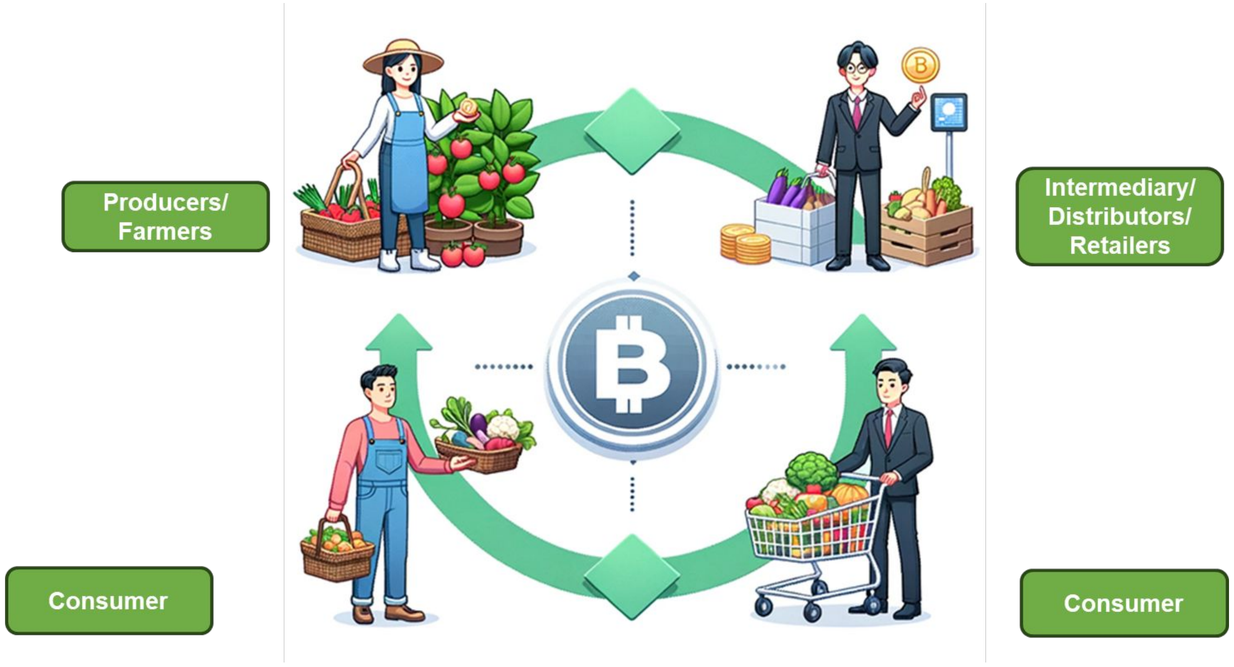
Co-funded by the European Union

Stakeholders’ Collaboration

Co-funded by
the European Union

Stakeholders in the Food Supply Chain

- **Farmers & Producers:**
  - Directly tokenize their produce for better traceability.
  - Ensure fair compensation through transparent and tamper-proof records.
- **Distributors & Retailers:**
  - Benefit from faster and more transparent supply chain processes.
  - Enhance trust with consumers through verifiable product histories.
- **Consumers:**
  - Access detailed information about the products they purchase.
  - Make informed choices based on product origin, handling, and authenticity.



Stakeholder Collaboration

Unified Platform

- Blockchain provides a common platform for all stakeholders to interact.
- Facilitates seamless communication across the supply chain.

Instant Updates & Notifications

- Real-time data sharing keeps all parties informed.
- Enhances responsiveness to changes or disruptions

Empowered Small Players

- Blockchain levels the playing field, allowing small producers to have a voice.
- Ensures that every stakeholder, big or small, has equal access to information

Shared Vision

- Stakeholders can align their objectives for mutual benefit.
- Encourages collaborative problem-solving and innovation.

Co-funded by
the European Union

Digital Assets in Food Supply Chain

Digital assets for food traceability and quality assurance

Co-funded by
the European Union

Digital Assets in Food Traceability

- **Data Integrity and Immutability:** The blockchain ledger offers a tamper-proof record, ensuring the integrity of data key metrics within the food supply chain.

- **Decentralized Proof of Delivery (PoD):** Blockchain enables a secure, transparent, and decentralized PoD system for digital assets, reducing reliance on a centralized trusted third party.

- **Enhanced Food Security and Safety:** Blockchain technology can help trace the origin of an agricultural product and verify the authenticity of farming inputs, providing a solution to food production and consumption crises.

Co-funded by
the European Union

Digital Assets for Quality Assurance

- **Data Integrity and Immutability:** The Blockchain's decentralized ledgers offer tamper-proof records of quality checks and certifications.
- **Transparency:** Digital assets on the blockchain provide visible quality metrics that can be verified by any party, enhancing consumer trust.
- **Automation and Accountability:** Smart contracts execute and govern all transactions, including automatic payments, making the system highly accountable and automating the supply chain. Automated smart contracts can facilitate instant quality checks, reducing delays.
- **Accountability:** With digital assets representing real-world items, anyone responsible for a decrease in quality can be easily identified.
- **Cost-Effectiveness:** Eliminating the need for manual quality checks can significantly reduce operational costs.

Co-funded by
the European Union

Benefits to Consumers

Co-funded by
the European Union

The Benefits of Blockchain for Consumer Interactions in Food Supply

Transparent Evolution:

- Just as consumers demand clearer ingredient lists, they also seek transparency in a product's journey. Blockchain offers a traceable path from farm to table, reinforcing trust in the authenticity and history of a product.

Truth in Labeling:

- Misinformation has plagued many industries, leading to skepticism. With blockchain, claims of being organic or non-GMO can be verified, debunking false promises and endorsing genuine practices.

Recall Revolution:

- Traditional recalls are cumbersome and uncertain. Blockchain's precision transforms this process, allowing for swift identification and resolution of affected items, enhancing consumer safety.

Brand Resilience:

- In an age of information, brand reputations are fragile. By embracing blockchain's transparency, brands can foster deeper loyalty, positioning themselves as consumer-centric entities.

Co-funded by
the European Union

Blockchain's Role in Sustainable Food Supply

Co-funded by the European Union

Blockchain's Role in Sustainable Food Supply

- **Ethical Epoch:**
  - Demand for ethical sourcing increasing.
  - Blockchain validates eco-friendly and humane practices.
  - Sets new standards in the food industry.
- **Waste Warfare:**
  - Blockchain aids in the fight against waste.
  - Enhanced traceability for better inventory management.
  - Moves food ecosystem towards reduced waste.
- **Carbon Consciousness:**
  - Climate change concerns are critical.
  - Blockchain simplifies logistics.
  - Helps reduce transportation emissions and carbon footprint.
- **Fair Trade Transition:**
  - Blockchain verifies fair pay and ethical sourcing.
  - Empowers smaller producers.
  - Transforms trade practices in the food industry.

Co-funded by the European Union

Summary and Key Takeaways

SUMMARY:

Lesson 4 explores how blockchain technology is affecting the food supply chain. This course demonstrates how supply chains may be redesigned using blockchain technology to guarantee authenticity, cut waste, and increase consumer trust.

KEY TAKEAWAYS:

- **Enhanced Traceability and Transparency:**

  Lesson 4 underscores blockchain's capability to provide a transparent and tamper-proof record of every food product's journey, thereby ensuring its authenticity and source credibility.

- **Empowerment of Stakeholders:**

  The lesson touches upon how all parties involved, from farmers to retailers, benefit from simplified processes, equitable access to information, and reduced operational bottlenecks.

References

1. Patelli, N. and Mandrioli, M., 2020. 'Blockchain technology and traceability in the agrifood industry.' *Journal of Food Science*, 85(11), pp.3670-3678.
2. Compagnucci, L., Lepore, D., Spigarelli, F., Frontoni, E., Baldi, M. and Di Berardino, L., 2022. 'Uncovering the potential of blockchain in the agri-food supply chain: An interdisciplinary case study.' *Journal of Engineering and Technology Management*, 65, p.101700.
3. Hasan, H.R. and Salah, K., 2018. 'Proof of delivery of digital assets using blockchain and smart contracts.' *IEEE Access*, 6, pp.65439-65448.
4. Zhao, G., Liu, S., Lopez, C., Lu, H., Elgueta, S., Chen, H. and Boshkoska, B.M., 2019. 'Blockchain technology in agri-food value chain management: A synthesis of applications, challenges and future research directions.' *Computers in Industry*, 109, pp.83-99.
5. Aldag, M.C., 2019. 'The use of blockchain technology in agriculture.' *Zeszyty Naukowe Uniwersytetu Ekonomicznego w Krakowie*, 982(4), pp.7-17.
6. Caro, M.P., Ali, M.S., Vecchio, M. and Giaffreda, R., 2018. 'Blockchain-based traceability in Agri-Food supply chain management: A practical implementation.' In: *2018 IoT Vertical and Topical Summit on Agriculture-Tuscany (IOT Tuscany)*, pp. 1-4.

Co-funded by
the European Union

References

7. Schroeder, K., Lampietti, J. and Elabed, G., 2021. *What's cooking: Digital transformation of the Agrifood system.* World Bank Publications.
8. Lin, W., Huang, X., Fang, H., Wang, V., Hua, Y., Wang, J., Yin, H., Yi, D. and Yau, L., 2020. 'Blockchain technology in current agricultural systems: from techniques to applications.' *IEEE Access*, 8, pp.143920-143937.
9. Xiong, H., Dalhaus, T., Wang, P. and Huang, J., 2020. 'Blockchain technology for agriculture: applications and rationale.' *Frontiers in Blockchain*, 3, p.7.
10. Kamilaris, A., Fonts, A. and Prenafeta-BoldÚ, F.X., 2019. 'The rise of blockchain technology in agriculture and food supply chains.' *Trends in Food Science & Technology*, 91, pp.640-652.
11. ScienceSoft, 'Blockchain for the Food Supply Chain: All you need to know.' Available at: https://www.scnsoft.com/blockchain/food-supply-chain (Accessed: 23 October 2023).
12. TraceFood, (2023) 'Blockchain in food supply chain: Food Supply Chain: Blockchain, Food Supply chain Blockchain Solutions.' Available at: https://tracefood.io/benefits-of-blockchain-in-food-supply-chain-industry/ (Accessed: 23 October 2023).
13. Chandan, A., John, M. and Potdar, V., 2023. 'Achieving UN SDGs in Food Supply Chain Using Blockchain Technology.' *Sustainability*, 15(3), p.2109.

Co-funded by
the European Union

Further Readings

1. Keogh, J.G. et al., 2020. 'Optimizing global food supply chains: The case for blockchain and GSI standards.' In: *Building the future of food safety technology*, pp.171.
2. Casino, F. et al., 2019. 'Modeling food supply chain traceability based on blockchain technology.' *IFAC-PapersOnLine*, 52(13), pp.2728-2733.
3. Stranieri, S. et al., 2021. 'Exploring the impact of blockchain on the performance of agri-food supply chains.' *Food Control*, 119, 107495.
4. Saurabh, S. and Dey, K., 2021. 'Blockchain technology adoption, architecture, and sustainable agri-food supply chains.' *Journal of Cleaner Production*, 284, 124731.

Co-funded by
the European Union

THANK YOU

Acknowledgment: The content in this course has been developed as part of the TRUSTFOOD project, which has received funding from the European Union's Digital Europe Programme under Grant Agreement No. 101100804.

Comments and inquiries may be addressed to Andreas Delladetsimas (delladetsimas.a@unic.ac.cy) and Evgenia Kapassa (kapassa.e@unic.ac.cy), University of Nicosia

Co-funded by
the European Union

TRUSTFOOD
Introduction to Blockchain in the Food Supply Chain: Building Trust and Ensuring Safety

Lesson 5: Blockchain for Trust-building in the Food Supply Chain

Co-funded by
the European Union

Introduction and Objectives

INTRODUCTION & LESSON DESCRIPTION:

- In Lesson 5, the relationship between blockchain technology and establishing trust in the food supply chain is investigated. The disadvantages of traditional traceability methods become more evident as supply chains become more complicated and consumers want transparency. From the beginning of farming until the point of ultimate consumption, blockchain technology appears not only as a technological innovation but also as a fundamental foundation that provides trust.

OBJECTIVES:

- To demonstrate how blockchain's inherent properties, such as immutability and transparency, can serve as robust tools to bridge the trust deficit and ensure integrity in entirety of the product journey.

Co-funded by
the European Union

Key Concepts

- **Trust through Immutability:** One of blockchain's core attributes is its immutability. Once data is recorded on the blockchain, it can't be altered, ensuring stakeholders of the authenticity of the information.
- **Transparency for Every Stakeholder:** Blockchain provides a transparent ledger that is accessible to every stakeholder, allowing them to verify product details at each step. This promotes trust not just among businesses but also with consumers who can understand the product's journey.
- **Collaborative Trust-building:** Blockchain’s decentralized nature promotes collaboration. Every participant can contribute to and validate the supply chain, fostering collective trust.
- **Consumer Empowerment:** In an age where consumers demand to know more about their products, blockchain offers a platform for them to verify the origins, processing methods, and handling of the food products they consume, enhancing their trust in brands and systems.

Co-funded by the European Union

Learning Outcomes

By the end of this lesson, participants will be able to:

- Understand the significance of trust within the food supply chain and recognize where traditional systems fall short in ensuring transparency and authenticity.

- Pinpoint the specific properties of blockchain – such as immutability, transparency, and decentralization – that fortify it as a superior mechanism to instill trust in every step of the food's journey.

- Visualize the practical application and transformative potential of integrating blockchain into the food supply chain, emphasizing its role in establishing a safer, more transparent, and efficient global system.

Co-funded by
the European Union

Trust in Supply Chains (1/3)

Nature of Trust

- Involves transparency, shared objectives, and mutual benefit.
- **Multidimensional nature:** Maintained through personal relationships, integrity, reputation and partnerships with shared values.
- **Trust Asymmetry:** Uneven distribution of trust within a supply chain.
- **Enhancing trust:** Transparent systems that minimize errors and ensure data accuracy and integrity.

Importance of Trust

- Ensures smooth operations without constant verification.
- Reduces the cost of monitoring and compliance.
- Facilitates faster decision-making processes.
- Boosts stakeholder confidence, from suppliers to end consumers.

Co-funded by the European Union

Trust in Supply Chains (2/3)

Factors Undermining Trust

1. **Fragmented information** and lack of transparency.
2. Incidents of **fraud** or misrepresentation.
3. **Complex** global operations leading to information gaps.
4. Reliance on multiple **third-party** verification systems.

Co-funded by
the European Union

Trust in Supply Chains (3/3)

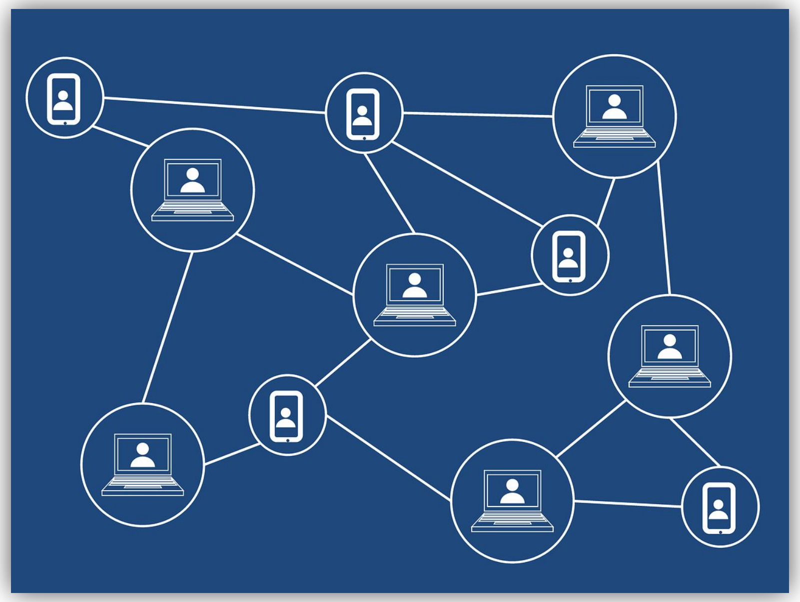
The Consequences of Mistrust

- Increased operational costs.
- Damaged brand reputation.
- Reduced stakeholder collaboration.
- Potential regulatory interventions and penalties.

Co-funded by the European Union

Immutability and Trust

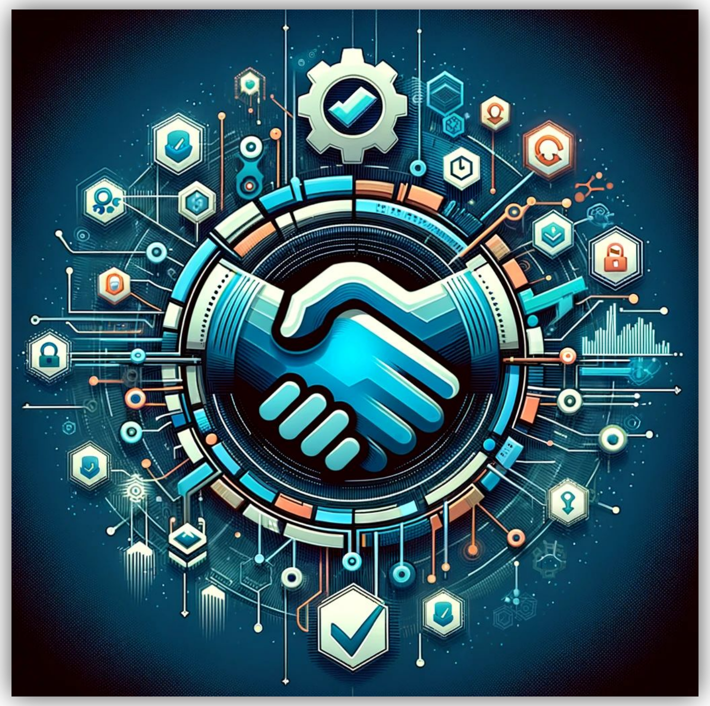
- **Definition:**
  - Immutability, often associated with technologies like blockchain, refers to the **unchanging nature of recorded data.** Once information is stored, it cannot be altered, ensuring data integrity.
- **Single Source of Truth:**
  - Immutable systems ensure that all stakeholders refer to a single, unchangeable record.
  - This eliminates disputes related to data alterations and ensures that all parties are on the same page.
- **Data Visibility and Transparency:**
  - An immutable record, like that on a blockchain, is transparent to all authorized stakeholders.
  - Every transaction is recorded, ensuring complete transparency in operations.
- **Structural Assurance:**
  - Immutability provides structural assurance. Stakeholders trust the system knowing that data once recorded cannot be changed without consensus.



Co-funded by the European Union

Redefining Trust in the Blockchain Era

- While immutability enhances trust, it is important to note that blockchain and similar technologies **do not eliminate the need for trust but redefine it.**
- The technology can support and facilitate trust, but **human and organizational factors remain essential**.
- Trust in technology can be quickly lost if misused or placed in the wrong context.
- Blockchain doesn't create a completely "trustless" environment but rather **shifts how trust is established and maintained in supply chains**.



Co-funded by
the European Union

Blockchain Empowering Stakeholders

Real-time Tracking:

- Enables stakeholders to track goods, transactions, and information in real-time.
- Increases efficiency and reduces the chances of fraud.

Cost Efficiency:

- Direct peer-to-peer exchanges minimize intermediary fees.
- Facilitates cost-effective cross-border transactions.

Quick Reconciliation:

- Real-time shared ledger ensures all parties have the same data.
- Speeds up settlements and reduces disputes.

Optimized Supply Chain:

- Efficient inventory management reduces overstocking and waste.
- Enhanced traceability ensures optimal stocking and minimizes associated costs.

Paperwork Reduction:

- Digital documentation decreases administrative costs and enhances efficiency.

Automated & Reliable Processes:

- Immediate reconciliations ensure data consistency across parties.
- Smart contracts reduce manual interventions and associated human errors.

Co-funded by the European Union

Building Trust Through Shared Data

Central Role of Data Sharing	• Enhances partner trust with collective data repositories. • Unified standards for consistent supply chain practices.
Collaborative Environment	• Cultivates collective data interpretation and action. • Engages stakeholders in analysis and decision-making.
Real-time Data Access	• Enables timely decision-making. • Boosts efficiency and minimizes delays.
Enhanced Decision Making	• Informed decision-making from real-time data. • Proactive issue and opportunity management.
Stakeholder Engagement	• Fosters ownership through active data sharing participation. • Ensures data remains current with regular updates and feedback.
Feedback Mechanisms	• Continuous improvement from stakeholder feedback. • Trust-building by addressing concerns and enhancing clarity.

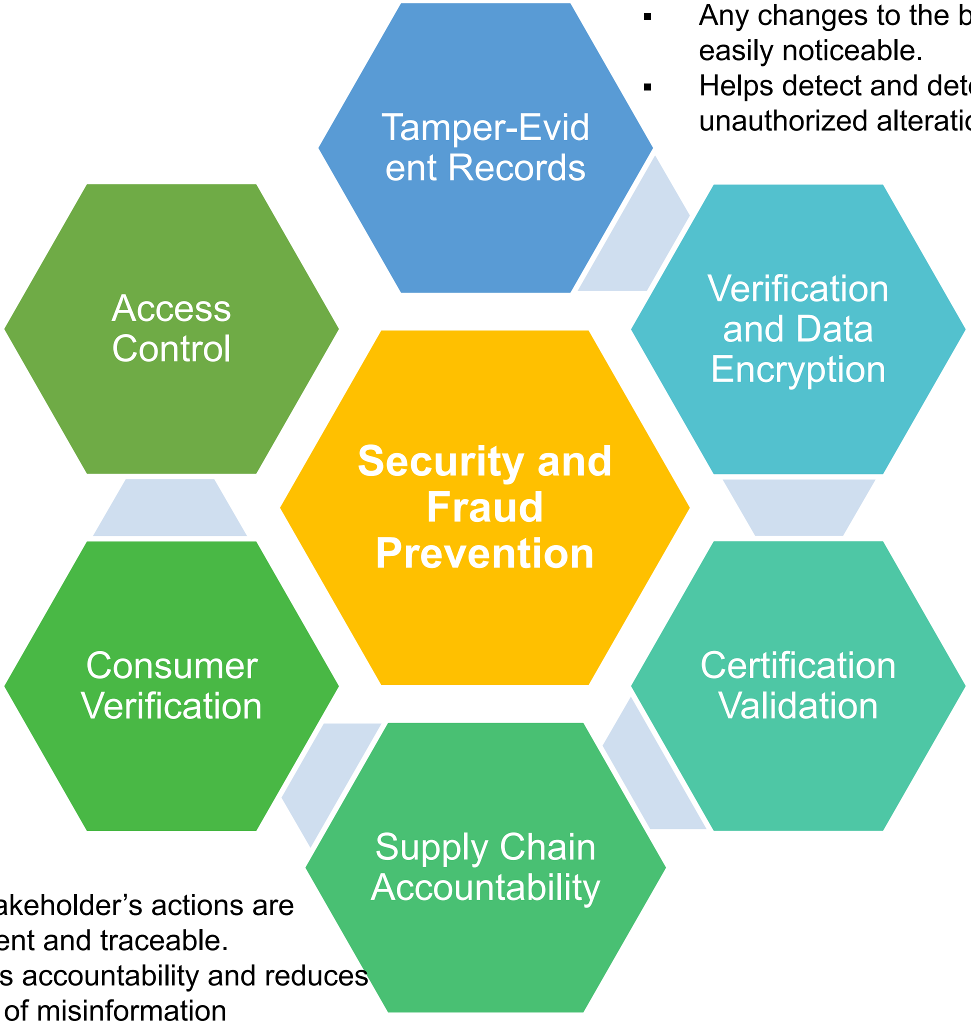
Co-funded by the European Union

Responding to Consumer Demand for Transparency

- **Direct Product Traceability:**
  - Facilitates consumer ability to trace product lineage from its origin to the retail shelf.
  - Allows brands to underline their dedication to ethical and sustainable sourcing and production.
- **Transparent Business Practices:**
  - Businesses can reveal details about their operations, suppliers, and production processes, building deeper trust.
  - Differentiates businesses in markets where consumers prioritize and reward transparency.
- **Feedback and Accountability:**
  - Enables businesses to obtain and address consumer feedback in an open forum.
  - Motivates businesses to maintain integrity and remain true to their pledges.
- **Fighting Counterfeit Goods:**
  - Blockchain's traceability and verification capabilities help in confirming product authenticity.
  - Curtails the spread and sale of counterfeit products, protecting brand reputation and consumer trust.
- **Consumer Empowerment through Information:**
  - By providing detailed product information, consumers can make informed purchasing decisions.
  - Encourages the market to shift towards more transparent and ethical product offerings.
- **Sustainability and Ethical Sourcing Verification:**
  - Blockchain can verify claims of sustainable and ethical sourcing, reassuring consumers of their purchases.
  - Brands can provide undeniable evidence of their sustainability efforts and responsible sourcing.

Co-funded by the European Union

Security and Fraud Prevention



- Any changes to the blockchain are easily noticeable.
- Helps detect and deter unauthorized alterations.

- Permissioned Architectures are useful for safeguarding sensitive information
- This feature significantly improves data security by restricting unauthorized access.

- Decentralized consensus mechanisms ensure data accuracy.
- Minimizes the chance of fraudulent entries.
- Blockchain technology utilizes advanced encryption algorithms to secure the data within each block

- Empowers consumers to verify product claims through QR codes or apps.
- Enhances trust and reduces reliance on blind faith.

- Enables the authentication of certifications like organic, GMO-free, etc.
- Ensures that products meet the stated standards.

- Every stakeholder's actions are transparent and traceable.
- Increases accountability and reduces chances of misinformation

Co-funded by the European Union

Formative Assessment

How does the immutability feature of blockchain foster trust among stakeholders in the food supply chain?

Co-funded by the European Union

Summary and Key Takeaways

SUMMARY

Lesson 5 delves into the importance of trust and the role of blockchain as a cornerstone for trust-building within the food supply chain. It discusses the ways in which the immutable and transparent nature of blockchain technology fosters a reliable environment for all parties involved, from producers to consumers.

KEY TAKEAWAYS:

- **Balancing Trust with Technological Assurance:**

  While blockchain enhances data integrity, it complements rather than replaces traditional trust dynamics, underscoring the importance of a synergistic relationship between technology and trust.

- **Mitigating Supply Chain Risks:**

  The adoption of blockchain aids in pinpointing and managing risks by offering transparent and unalterable transaction records, thereby strengthening the trustworthiness and stability of the food supply chain.

Co-funded by the European Union

References

1. Worldfavor Sustainability Blog. (no date) 'Why building trust is essential to supply chain risk mitigation.' Available at: https://blog.worldfavor.com/why-building-trust-is-essential-to-mitigate-supply-chain-risks (Accessed: 31 October 2023).
2. Brookbanks, M. and Parry, G., 2022. 'The impact of a blockchain platform on trust in established relationships: a case study of wine supply chains.' *Supply Chain Management: An International Journal*, 27(7), pp.128-146.
3. Helo, P. and Hao, Y., 2019. 'Blockchains in operations and supply chains: A model and reference implementation.' *Computers & Industrial Engineering*, 136, pp.242-251.
4. Katsikouli, P., Wilde, A.S., Dragoni, N. and Høgh-Jensen, H., 2021. 'On the benefits and challenges of blockchains for managing food supply chains.' *Journal of the Science of Food and Agriculture*, 101(6), pp.2175-2181.
5. Potemskyi, E., Ivanov, D. and Ampilogova, A., 2023. 'Blockchain in supply chains: Empowering transparency and traceability.' *Trinetix*. Available at: https://www.trinetix.com/insights/blockchain-in-supply-chains-empowering-transparency-and-traceability (Accessed: 31 October 2023).
6. Patelli, N. and Mandrioli, M., 2020. 'Blockchain technology and traceability in the agrifood industry.' *Journal of Food Science*, 85(11), pp.3670-3678.
7. Compagnucci, L., Lepore, D., Spigarelli, F., Frontoni, E., Baldi, M. and Di Berardino, L., 2022. 'Uncovering the potential of blockchain in the agri-food supply chain: An interdisciplinary case study.' *Journal of Engineering and Technology Management*, 65, p.101700.

Co-funded by the European Union

References

8. Kamilaris, A., Fonts, A. and Prenafeta-BoldÚ, F.X., 2019. 'The rise of blockchain technology in agriculture and food supply chains.' *Trends in Food Science & Technology*, 91, pp.640-652.

9. Garwood, G., 2022. 'Report shows modern consumers demand transparency from brands.' *The Food Institute*. Available at: https://foodinstitute.com/focus/report-shows-modern-consumers-demand-transparency-from-brands/ (Accessed: 31 October 2023).

10. Kavakli, B., 2022. 'Council post: Transparency is no longer an option; it's a must.' *Forbes*. Available at: https://www.forbes.com/sites/forbesbusinesscouncil/2021/05/04/transparency-is-no-longer-an-option-its-a-must/ (Accessed: 31 October 2023).

11. ESW, 2023. 'The rising importance of Supply Chain Transparency.' Available at: https://esw.com/blog/the-rising-importance-of-supply-chain-transparency/ (Accessed: 31 October 2023).

12. Deloitte United States, 2023. 'Trust in supply chain.' Available at: https://www2.deloitte.com/us/en/pages/operations/articles/trust-in-supply-chain.html (Accessed: 31 October 2023).

13. GEP, 2016. 'Supply chain transparency: Benefits and how to achieve it.' Available at: https://www.gep.com/supply-chain-transparency (Accessed: 31 October 2023).

14. Doubleday, K., 2019. 'Blockchain immutability - why does it matter?' *Medium*. Available at: https://medium.com/fluree/immutability-and-the-enterprise-an-immense-value-proposition-98cd3bf900b1 (Accessed: 31 October 2023).

Co-funded by
the European Union

Further Readings

1. Köhler, S. and Pizzol, M., 2020. 'Technology assessment of blockchain-based technologies in the food supply chain.' *Journal of Cleaner Production*, 269, 122193.
2. Dujak, D. and Sajter, D., 2019. 'Blockchain applications in supply chain.' In: *SMART Supply Network*, pp.21-46.
3. Powell, W. et al., 2022. 'Revisiting trust in supply chains: How does blockchain redefine trust?' In: *Blockchain Driven Supply Chains and Enterprise Information Systems*. Cham: Springer International Publishing, pp.21-42.

Co-funded by the European Union

THANK YOU

Disclaimer: The content provided in this course is for informational purposes only and should not be considered as legal, financial, or professional advice.

Acknowledgment: The content in this course has been developed as part of the TRUSTFOOD project, which has received funding from the European Union's Digital Europe Programme under Grant Agreement No. 101100804.

Comments and inquiries may be addressed to Andreas Delladetsimas (delladetsimas.a@unic.ac.cy) and Evgenia Kapassa (kapassa.e@unic.ac.cy), University of Nicosia

Co-funded by
the European Union

TRUSTFOOD
Introduction to Blockchain in the Food Supply Chain: Building Trust and Ensuring Safety

Lesson 6: Ensuring Food Safety through Blockchain

Co-funded by the European Union

Introduction and Objectives

INTRODUCTION & LESSON DESCRIPTION:

- Lesson 6 introduces the transformative role of blockchain in safeguarding the global food supply chain. This lesson is structured to inform participants on how blockchain technology can be integrated to track, verify, and ensure the safety and quality of food from producer to consumer. Case studies and regulatory perspectives will provide a comprehensive view of the current landscape and future potential.

OBJECTIVES:

- To provide a clear understanding of the critical role blockchain plays in food safety.
- To illustrate how blockchain technology can be used to address key challenges in tracking and verifying food quality.
- To discuss the impact of blockchain on enhancing food safety protocols.

Co-funded by
the European Union

Key Concepts

- **Food Safety and Blockchain:** A detailed look at how blockchain can help prevent contamination and ensure the integrity of the food supply.

- **Traceability and Recall Efficiency:** Understanding how blockchain facilitates the quick tracing of products in the event of a food safety recall.

Co-funded by
the European Union

Learning Outcomes

By the end of this lesson, participants will be able to:

- Identify how blockchain technology can be implemented to enhance the traceability and safety of food products.
- Understand how blockchain can be a tool for regulatory bodies to monitor and enforce food safety standards.
- Appreciate the potential for blockchain to revolutionize food safety in the context of global supply chains and crisis management.

Co-funded by
the European Union

Food Safety (Definition)

Food safety is a scientific discipline describing the handling, preparation, and storage of food in ways that prevent foodborne illness and injuries.

It encompasses a number of routines that should be followed to avoid potentially severe health hazards.

Co-funded by the European Union

The Fundamentals of Food Safety

Need for Collective Action:

- Sustains life and promotes good health.
- Unsafe food causes diseases, impacting infants, the elderly, and the sick most severely.

Global Impact (WHOrg)

- Foodborne diseases cause significant morbidity and mortality worldwide.
- 600 million cases of food-related illnesses annually.
- 420,000 deaths per year, with children under 5 years old carrying 40% of the disease burden.
- Foodborne illnesses result in productivity losses and medical expenses.
- Estimated loss of 102,6 billion euros in low- and middle-income countries each year.

Co-funded by
the European Union

Major Foodborne Illnesses and Causes

TRUST FOOD

- **Bacterial Contaminants:** Common pathogens like Salmonella, Campylobacter, and E. coli leading to serious illnesses, highlighting the need for stringent food handling and processing standards.

- **Viral and Parasitic Infections:** Foodborne viruses like Norovirus and Hepatitis A, and parasites like tapeworms and Ascaris, demonstrating the diversity of threats and the importance of comprehensive safety measures.

- **Chemical and Environmental Contaminants:** Mycotoxins, heavy metals, and other chemicals in the food chain pose long-term health risks, such as cancer and neurodevelopmental disorders.

Co-funded by
the European Union

Food Safety Challenges

- **Public Health and Economic Burden**
  - Foodborne illnesses are often underestimated due to underreporting, leading to insufficient attention and resources allocated for prevention and control.

- **Changing Landscape of Food Safety**
  - Urbanization, globalization, and climate change are adding layers of complexity to food safety, requiring adaptive and robust safety systems.

Blockchain's Role in Safety Verification

TRUST FOOD

Enhancing Transparency

- **Immutable Ledger**: Blockchain creates an unalterable record of a food item's journey.
- **Transparency**: Ensures data accuracy from farm to table.
- **Integrity**: Prevents tampering, maintaining food safety data reliability.
- **Trust and Compliance**: Bolsters consumer trust and regulatory compliance.

Verification and Compliance

- **Reliable Audits**: Blockchain's immutability enhances audit reliability.
- **Real-time Verification**: Simplifies certification of safety standards.
- **Streamlined Operations**: Speeds up response times for stakeholders in food safety and quality assurance.

Co-funded by
the European Union

Traceability and Recall Efficiency

- **Traceability** is the ability to track any food through all stages of production, processing, and distribution (including importation and at retail).
- Blockchain enhances traceability by providing a time-stamped, unchangeable record of every transaction and movement of goods.
- When a product’s journey is monitored using blockchain, this allows for a transparent view of the its lifecycle and helps in verifying its **authenticity** and **safety**.

Co-funded by
the European Union

Example: Trace my Egg

- **Idea Definition:** "Trace My Egg" is an innovative program designed to enhance transparency and traceability in the egg supply chain. Through a unique 5-digit code stamped onto each egg, consumers can easily trace the origin of their eggs back to the specific farm and production method.

- **More than 15 Participating Brands Including** Wholefood Markets, Chester Road, Heyden Farms and Countdown.

- **Benefits:**
  - Enhances consumer trust through transparency.
  - Allows for quick and effective tracking in case of recalls.
  - Promotes responsible farming practices through third-party audits.

- **Key Features:**
  - **5-Digit Code**: A unique identifier that provides information about the production farming method and the specific farm the egg originates from. The first two letters denote the production method and the following three represent the specific farm where the egg was produced.
  - **Third-party Audits**: All participating farms are subject to annual independent audits, as well as random checks to ensure ongoing program integrity.
  - **User-friendly Interface**: Consumers can easily enter the 5-digit code on the Trace My Egg website to get information about the origin of their eggs.

TRACE MY EGG

Co-funded by the European Union

Example: OriginChain

Idea Definition: OriginChain EU is a **proof-of-concept** traceability solution designed to bring transparency and accountability to supply chains within the European Union.

- Utilizing advanced technologies such as blockchain and QR codes, Origin Chain EU empowers consumers and businesses to easily verify the origin and journey of a wide range of products (Bakery, Dairy, Fruit & Vegetables, Meat, Prepared Food, Seafood).

- **Benefits:**
  - Increases consumer confidence through transparent practices.
  - Streamlines regulatory compliance processes.
  - Enhances supply chain efficiency and accountability.

- **Key Features:**
  - **European Union Specific:** Designed specifically for the European Union's diverse and intricate supply chains, ensuring localized relevance and compliance.
  - **Wide Product Scope:** Covers a broad spectrum of products, making it versatile across various segments of the food industry.
  - **QR Code Technology:** Products are equipped with a QR code that, when scanned, provide detailed information about their origin, journey, and more. This feature facilitates instant verification and information retrieval.
  - **Blockchain Integration:** Leverages blockchain technology, which ensures that product information is immutable and transparent.

ORIGINCHAIN

Co-funded by the European Union

Formative Assessment

How can blockchain technology aid in the rapid identification and resolution of a food contamination issue?

Co-funded by
the European Union

Summary and Key Takeaways

SUMMARY

Lesson 6 introduces the transformative role of blockchain in safeguarding the global food supply chain. This lesson is structured to inform participants on how blockchain technology can be integrated to track, verify, and ensure the safety and quality of food from producer to consumer. Two example case studies were also presented to provide a comprehensive view of the current landscape.

KEY TAKEAWAYS:

- **Enhanced Safety and Recall Efficiency:**

  Lesson 6 illustrates how blockchain acts as a safety protocol, ensuring a seamless safeguard against contamination and fraud in the food supply chain.

Co-funded by
the European Union

References

1. Patelli, N. and Mandrioli, M., 2020. 'Blockchain technology and traceability in the agrifood industry.' *Journal of Food Science*, 85(11), pp.3670-3678.
2. Xu, X., Lu, Q., Liu, Y., Zhu, L., Yao, H. and Vasilakos, A.V., 2019. 'Designing blockchain-based applications a case study for imported product traceability.' *Future Generation Computer Systems*, 92, pp.399-406.
3. Xiong, H., Dalhaus, T., Wang, P. and Huang, J., 2020. 'Blockchain technology for agriculture: applications and rationale.' *Frontiers in Blockchain*, 3, p.7.
4. Lin, W., Huang, X., Fang, H., Wang, V., Hua, Y., Wang, J., Yin, H., Yi, D. and Yau, L., 2020. 'Blockchain technology in current agricultural systems: from techniques to applications.' *IEEE Access*, 8, pp.143920-143937.
5. Zhao, G., Liu, S., Lopez, C., Lu, H., Elgueta, S., Chen, H. and Boshkoska, B.M., 2019. 'Blockchain technology in agri-food value chain management: A synthesis of applications, challenges and future research directions.' *Computers in Industry*, 109, pp.83-99.
6. Bhusal, C. S., 2021. 'Blockchain technology in agriculture: a case study of blockchain start-up companies.' *International Journal of Computer Science & Information Technology (IJCSIT)*, 13.
7. van Wassenaer, L., Verdouw, C., Kassahun, A., van Hilten, M., van der Meij, K., and Tekinerdogan, B., 2023. 'Tokenizing circularity in agri-food systems: A conceptual framework and exploratory study.' *Journal of Cleaner Production*, 413, 137527.

Co-funded by
the European Union

References

8. World Health Organization, (no date a) 'Food safety.' Available at: https://www.who.int/news-room/fact-sheets/detail/food-safety (Accessed: 03 November 2023).

9. ScienceDirect Topics, (no date b) 'Food safety - an overview.' Available at: https://www.sciencedirect.com/topics/social-sciences/food-safety (Accessed: 03 November 2023).

10. Origin Chain Networks, (no date) 'Food Ecosystem.' Available at: https://www.originchain.eu/ecosystem (Accessed: 25 October 2023).

11. TE, 2020. 'Food - the #1 end-to-end food traceability solution.' Available at: https://te-food.com/ (Accessed: 25 October 2023).

12. Trace My Egg - The Egg Producers Federation of NZ, (no date) Available at: https://tracemyegg.co.nz/ (Accessed: 03 November 2023).

13. Ripe.io, Available at: https://www.ripe.io/ (Accessed: 03 November 2023).

Co-funded by the European Union

Further Readings

TRUST FOOD

1. IBM, (no date) 'IBM Supply Chain Intelligence Suite - Food Trust.' Available at: https://www.ibm.com/products/supply-chain-intelligence-suite/food-trust (Accessed: 03 November 2023).
2. Fishcoin Project, 'Fishcoin: Blockchain based seafood traceability & data ecosystem.' Available at: https://fishcoin.co/ (Accessed: 03 November 2023).
3. European Union. 'Food safety in the EU.' Available at: https://european-union.europa.eu/priorities-and-actions/actions-topic/food-safety_en (Accessed: 15 November 2023).
4. World Health Organization. 'Food safety.' Available at: https://www.who.int/health-topics/food-safety#tab=tab_1 (Accessed: 15 November 2023).
5. 1Kosmos. 'Blockchain Verification.' Available at: https://www.1kosmos.com/blockchain/blockchain-verification/ (Accessed: 15 November 2023).
6. Pu, S. and Lam, J.S.L., 2023. 'The benefits of blockchain for digital certificates: A multiple case study analysis.' *Technology in Society*, 72, 102176.

Co-funded by
the European Union

THANK YOU

Disclaimer: The content provided in this course is for informational purposes only and should not be considered as legal, financial, or professional advice.

Acknowledgment: The content in this course has been developed as part of the TRUSTFOOD project, which has received funding from the European Union's Digital Europe Programme under Grant Agreement No. 101100804.

Comments and inquiries may be addressed to Andreas Delladetsimas (delladetsimas.a@unic.ac.cy) and Evgenia Kapassa (kapassa.e@unic.ac.cy), University of Nicosia

Co-funded by the European Union

TRUSTFOOD
Introduction to Blockchain in the Food Supply Chain: Building Trust and Ensuring Safety

Lesson 7: Exploring Real-world Implementations

Co-funded by
the European Union

Introduction and Objectives

INTRODUCTION & LESSON DESCRIPTION:

- Lesson 7 takes a deep dive into how blockchain technology is being applied within the food supply chain. It presents various case studies that highlight the impactful integration of blockchain in enhancing transparency and efficiency in food logistics. The focus is on understanding the challenges of the sector and how blockchain serves as a problem-solver.

OBJECTIVES:

- Highlight the use of blockchain technology in the food supply chain through detailed case studies.
- Discuss the challenges faced within these implementations and the blockchain solutions applied.

Co-funded by
the European Union

Key Concepts

- **Real-World Use Cases:** From public blockchains underpinning cryptocurrencies like Bitcoin to private blockchains streamlining supply chain management, the practical applications of these technologies are vast and varied.

- **Advantages and Disadvantages:** Each blockchain type has its strengths and weaknesses. For instance, while public blockchains offer high transparency, they might suffer from slower transaction times. Private blockchains might be faster but are more centralized.

Co-funded by
the European Union

Learning Outcomes

By the end of this lesson, participants will be able to:

- Evaluate blockchain applications in the food supply chain through real-world case studies.
- Recognize the challenges within the food supply industry and how blockchain addresses these issues.
- Understand the integration process and benefits of blockchain for increased transparency and trust in food systems.

Co-funded by the European Union

Benefits of Blockchain Adoption in the Agrifood Sector for the Stakeholders

TRUST FOOD

Farmers/Producers:
- Utilize blockchain for crop yield, quality control, and traceability.
- Record-keeping for production and sales.

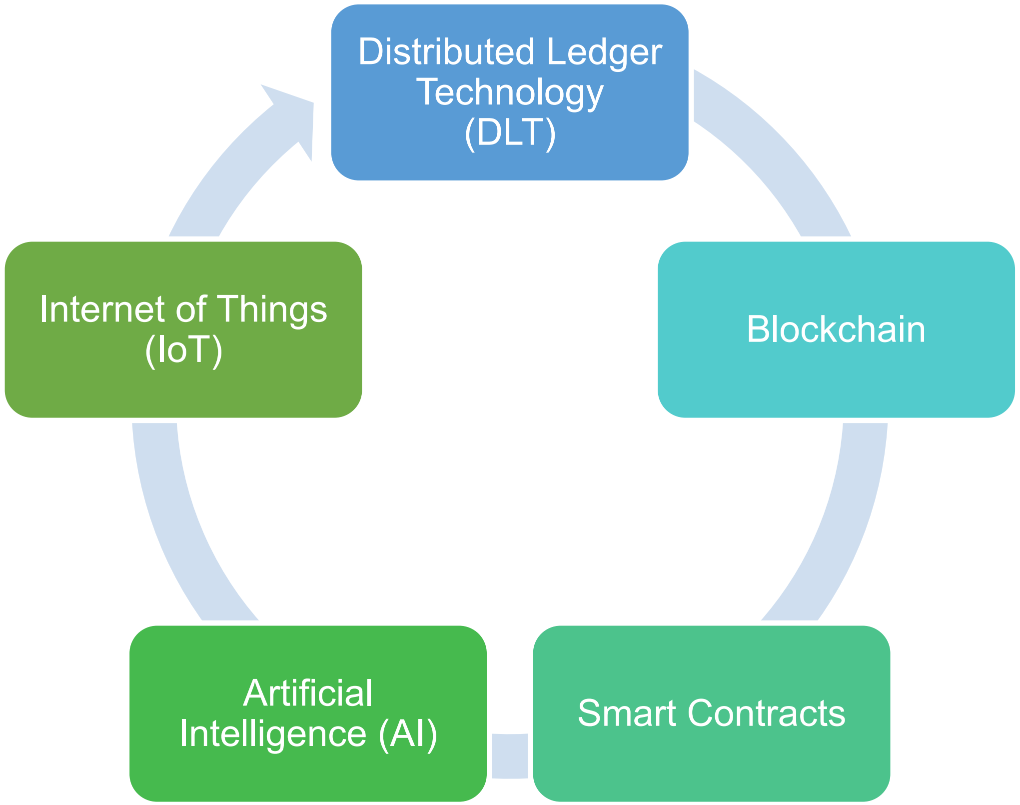
Food Manufacturers/Processors:
- Secure, transparent traceability systems.
- Compliance with safety standards and customer demands.

Retailers:
- Enhanced product identification for safety and quality.
- Simplified processes, reduced inventory costs.

Co-funded by the European Union

Technologies

- **Distributed Ledger Technology (DLT):** Decentralized record-keeping, encourages transparency and collaboration.
- **Smart Contracts:** Automated execution of contracts, efficient trade and exchange.
- **Artificial Intelligence (AI):** Predictive analytics for informed agricultural decisions provides enhanced efficiency in financial decisions.
- **Internet of Things (IoT):** Connected sensors for monitoring production and storage conditions aid in preventing foodborne illness outbreaks.



Co-funded by the European Union

Case Study 1: Trace my Egg

Offering Transparency for a Specific Product

TRUST FOOD

- Link: https://tracemyegg.co.nz/
- **Idea Definition:**
  - “Trace My Egg” is an innovative program designed to enhance transparency and traceability in the egg supply chain.
  - Through a unique 5-digit code stamped onto each egg, consumers can easily trace the origin of their eggs back to the specific farm and production method.
- More than **15 Participating Brands**
  - Including Wholefood Markets, Chester Road, Heyden Farms and Countdown.

Co-funded by
the European Union

Case Study 1: Trace my Egg

Offering Transparency for a Specific Product

- **Benefits:**
  - Enhances consumer trust through transparency.
  - Allows for quick and effective tracking in case of recalls.
  - Promotes responsible farming practices through third-party audits.
- **5-Digit Code:**
  - Unique identifier for eggs.
  - First two letters indicate production method.
  - Next three digits identify the specific farm of origin.
- **User-friendly Interface:**
  - Enter 5-digit code on "Trace My Egg" website.
  - Provides information about egg origin.

Co-funded by
the European Union

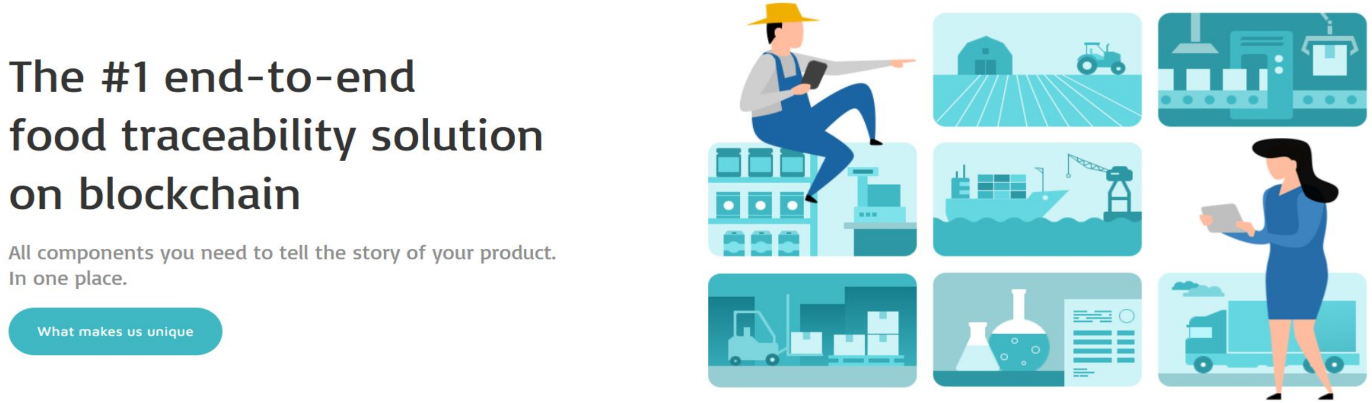
Case Study 2: TE-FOOD

Offering Transparency for a Specific Product

- Link: https://te-food.com

Idea Definition:

- TE-FOOD is a public permissioned blockchain-based system focused on **offering comprehensive farm-to-table food traceability**. It serves various stakeholders in the food supply chain, from farmers and processors to retailers and consumers, by providing transparency and efficiency through blockchain technology. It supports different business models, from private to institutional, and offers a complete set of tools for end-to-end operational visibility and process control.
- More than 400.000 operations and more than 6000 business customers.



Co-funded by
the European Union

Case Study 2: TE-FOOD

Offering Transparency for a Specific Product

TRUST FOOD

Benefits:

- IoT sensors help to identify contaminated products early, reducing foodborne illnesses
- Provides greater supply chain knowledge, enabling improved operational efficiencies and compliance with export rules.

Key Features:

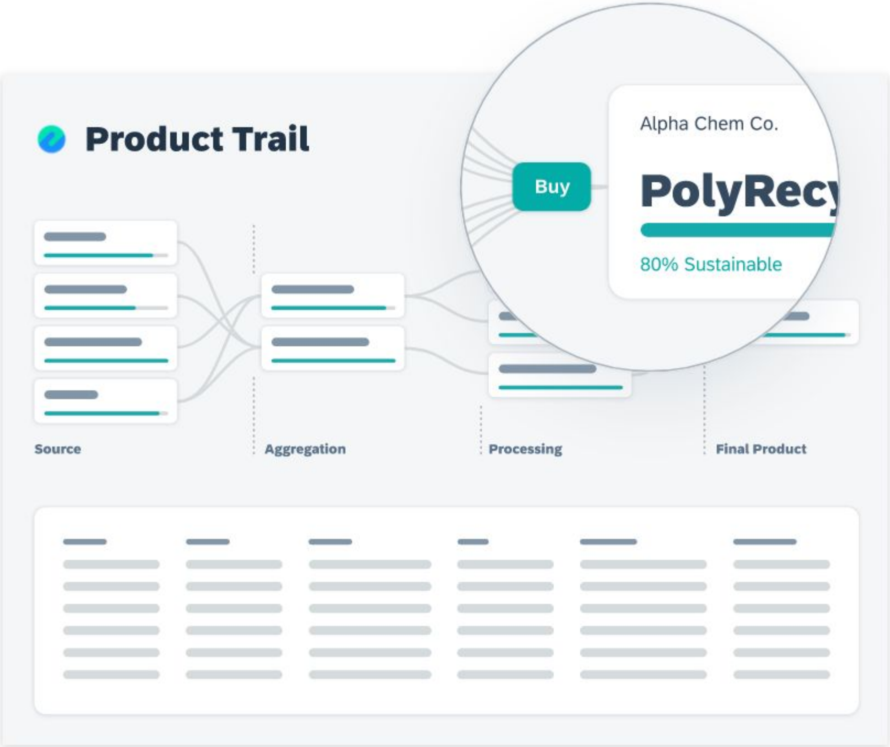
- **Multi-Tier Traceability**: Utilizes a multi-layered approach, offering B2B, B2C, and B2A (Business-to-Authorities) services, catering to businesses, consumers, and regulatory bodies.
- **Identification Tools:** Includes a variety of identification materials such as 1D/2D barcodes, RFID ear tags, and security seals for comprehensive traceability.
- **Traceability Tools:** Features a B2B administration mobile and web app, central system, and external interfaces for complete traceability.
- **Retail and Consumer Tools:** Includes a B2C mobile app and web app for tracking fresh produce history and other retail-side digital signage tools.
- **IoT Integration:** Provides an API for integration with IoT sensors for real-time tracking and condition monitoring.

Co-funded by the European Union

Case Study 3: GreenToken

Supplier Transparency

- **Link:** https://www.green-token.io/
- **Purpose**: Enables full transparency in supply chains.
- **Focus**: Targets the "suppliers of suppliers" rather than individual products or producers.
- **Goal**: Allows businesses to inform customers about complete product information.
- **Technology**: Uses blockchain to track and verify.
- **Coverage**: Monitors Environmental, Social, and Governance (ESG) factors.



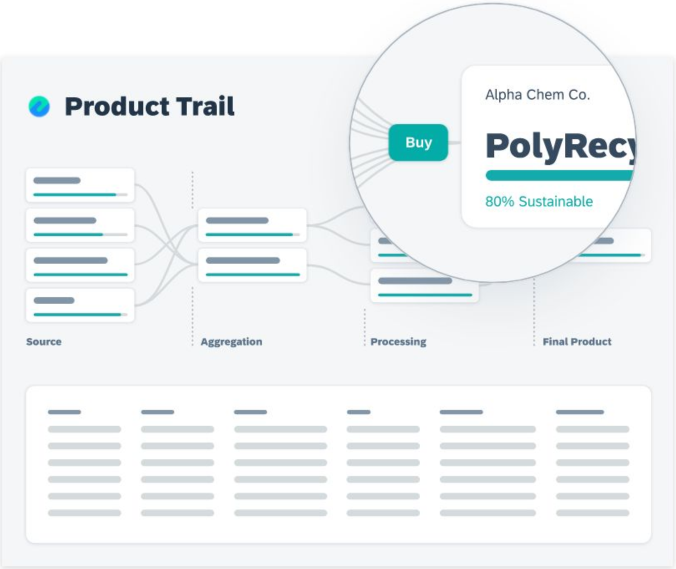
Co-funded by the European Union

Case Study 3: GreenToken

Supplier Transparency

Key Features:

- **Blockchain Digital Twins**:
  - Uses blockchain to create unique digital representations for raw materials.
  - Enables traceability of ESG facts, including origin and labor conditions.
- **Mass Balance Accounting**:
  - Applies mass balance principles to accurately model sustainability credits.
  - Securely shares credits via blockchain tokens.
- **Eliminate Double Counting**:
  - Each token matches a unique certificate of fact.
  - Avoids duplication of 'fact certificates' in supply chains.
- **Automated Audit Reporting**:
  - Blockchain records the full journey of raw materials.
  - Streamlines the audit process for sustainability claims.



Co-funded by
the European Union

Case Study 4: OriginChain

Traceability in Agrifood Transformation

- **Link:** https://www.originchain.eu/ecosystem
- **Nature**: Proof-of-concept traceability solution.
- **Objective**: Enhance transparency and accountability in EU supply chains.
- **Technologies**:
  - Uses blockchain for secure and transparent tracking.
  - Employs QR codes for easy product identification and verification.
- **Benefits**:
  - Enables consumers and businesses to authenticate product origin and journey.

Co-funded by the European Union

Case Study 5: AgroToken

Revolutionizing Agrifood through Grain Tokenization

TRUST FOOD

- **Link:** https://agrotoken.com/en/
- **Idea Definition:**
  - Agrotoken is the first **global tokenization infrastructure** for agro-commodities. It acts as a bridge to **connect the world of agribusiness with the crypto economy**, issuing stablecoins backed by real assets such as soybeans, corn, and wheat. These stablecoins function independently of government-issued fiat currencies, offering a unique form of asset-backed value in the digital space.
- **Benefits:**
  - Excellent tool against inflation, suitable for low-risk profile investors in medium to long-term investments.
  - All tokens are collateralized by real-world commodities, making them reliable and transparent.
  - Plans to extend operations globally, making it a worldwide platform.

Co-funded by
the European Union

Case Study 5: AgroToken

Revolutionizing Agrifood through Grain Tokenization

- **Key Features:**
  - **PoGR Certificates**: Utilizes Proof of Grain Reserves (PoGR) certificates guaranteed by blockchain oracles to ensure compliance and credibility.
  - **High Liquidity**: Aims to provide high liquidity by making stablecoins usable in exchanges, DeFi applications, and marketplaces.
  - **Smart Contracts & Governance**: Employs blockchain governance and smart contracts to mint or burn tokens, ensuring a transparent, auditable system.
  - **Risk Diversification:** Offers an alternative form of stablecoin that complements those backed by fiat, allowing for portfolio diversification for institutional investors.

Co-funded by the European Union

Case Study 6: AgriLedger

Transforming Global Agrifood Systems

- **Link:** https://agriledger.io/
- **Idea Definition:** AgriLedger is a mobile app aiming to revolutionize global agriculture with blockchain-based solutions, bridging gaps between producers, consumers, and stakeholders for a transparent product journey.
- **Benefits:**
  - End-to-end food tracking from farm to table using SmartChain solutions.
  - Streamlining carbon credit systems, promoting sustainability, and driving economic growth.
  - Dynamic analytics engine couple with AI and ML capabilities, turning vast data points into actionable insights.
  - Aims to reduce GHG by 45% by 2030 and achieve net-zero by 2050.

Co-funded by
the European Union

Case Study 6: AgriLedger

Transforming Global Agrifood Systems

SMARTCHAIN SOLUTIONS

A blockchain-based AI solution offering an end-to-end platform to track food from farm to table, across the globe.

- Builds unparalleled trust among stakeholders
- Streamlines operations, and reduces inefficiencies
- Granting food producers and service providers direct access to global markets.

Learn more

CARBON SOLUTIONS

With our blockchain-based platform and blended finance approach, we streamline the carbon value chain, adding trust and transparency into the carbon market.

- Streamlining carbon credit verification, accounting, and trading
- Champions sustainable practices in emerging markets
- Channelling finance towards decarbonization and rewarding producers.

Learn more

DATA ANALYTICS SOLUTIONS

Beyond mere record-keeping, our platform stands as a dynamic data analytics engine, transforming vast data points into actionable insights.

- Equips stakeholders with enlightened decision-making tools
- Catering to producers, investors, and policymakers
- Ensuring they remain ahead of the curve.

Learn more

Co-funded by the European Union

Case Study 6: AgriLedger

Transforming Global Agrifood Systems

Co-funded by
the European Union

Case Study 7: IBM Food Trust (BaaS)

Introduction: IBM Food Trust™ platform was launched in 2017. It utilizes blockchain technology (private networks) to ensure a transparent, accountable, and sustainable global food supply chain, connecting all stakeholders from growers to consumers

Key Features & Benefits:

- Increased supply chain efficiency & reduced waste.
- Enhanced sustainability, safety monitoring, and brand trust.
- Compliance confidence with traceability for food safety regulations.
- IBM Food Trust aids in compliance with upcoming FDA food traceability rule

IBM Food Trust™

- Utilizes **IoT-enabled smart sensors** and blockchain-connected devices for real-time data collection throughout the supply chain.

- Aggregates **diverse data**, from temperature and moisture levels during various stages to information from shipping and logistics providers.

Other Services:

- **Virtually Guided Onboarding (VGO):** Remote onboarding assistance with IFT experts.
- **Assisted Onboarding:** Hands-on guidance from IFT architects for integration.
- **Architect Support:** 10 hours of remote expert support for custom engagements.
- **Sandbox Environment:** Non-production platform access for demos and evaluations.

Co-funded by
the European Union

Case Study 8: Beefledger

Introduction:
BeefLedger provides enhanced supply chain transparency and streamlined transactions, addressing key concerns of food safety and fraud, especially in regions like China

Key Features:

- **Integrated Platform:** Harnessing blockchain for beef provenance, security, and payments.
- **Consumer Validation:** Enables consumers to authenticate their beef purchases.
- **Information Symmetry**: Aims to bridge information gaps among transaction participants.
- **Asset Tracker:** Securely creates and tracks digital assets in the supply chain on Ethereum's network.
- **Transactions Engine (Not yet operational):** Will manage blockchain-tracked asset transfers via the BEEF token.

Benefits:

- **Reinforced Consumer Trust:** Transparent, verifiable product credentials.
- **Efficient Supply Chain:** Mitigated information discrepancies.
- **Robust Credentialing:** Countering meat fraud risks, especially in expanding markets.
- **Data Monetization:** Transforms data into tangible value for producers.

BEEFLEDGER
牛 币

Co-funded by
the European Union

Case Study 9: ProducePay

Introduction: ProducePay is a Fintech launched in 2014 that helps bridge the gap between farmers and buyers, offering them unparalleled market access, financial solutions, and trade protection. ProducePay is reshaping how fresh produce is transacted globally.

- ProducePay boasts more than 160k transactions, reflecting its dedication to providing consistent, high-quality produce from regions spanning the US, Mexico, and Latin America.
- Every day, over 35k individuals rely on ProducePay for insights into pricing and comprehensive commodity information.

Mission and Vision:

- Offer custom financial solutions and trusted trade partners for stability.
- Enhanced Delivery: Guarantee fresher, responsibly sourced produce for buyers.
- Aims to cut down 60%+ of global food and economic waste.

Key Features:

- **Trusted Marketplace:** Fosters trust, focusing on transparency and long-term relationships between Buyers and Sellers.
- **Financing Solutions:** Empowers growers with financial options tailored for both planned and unexpected needs, with some responses as swift as 24 hours.
- **On-Farm Intelligence:** Traders benefit from up-to-date reports and in-depth whitepapers, ensuring they remain informed and competitive.
- **Verified Trading:** Ensures worry-free transactions by thoroughly evaluating each member, revealing their expertise, potential, and financial health.
- **Risk Mitigation:** ProducePay's unique Trading Performance rating system emphasizes its pledge to safeguarded and clear-cut trading.
- **Quality Assurance:** Through regular and unexpected site checks, ProducePay showcases its unwavering dedication to upholding and predicting top-notch production standards.

Co-funded by the European Union

Case Study 10: IGrow

Introduction: Founded in 2013 by University of Indonesia alumnus, Andreas Senjaya, I-Grow revolutionized the nexus of FinTech and Agriculture, by combining financial solutions with traditional farming practices.

Key Features:

- **Transparent Project Details:** Investors gain a deep understanding of ventures, fostering informed decisions.
- **Intuitive Margin Simulation:** Harnesses the power of predictive analytics to forecast potential returns accurately**.**
- **Variety & Security:** A diverse array of agricultural projects is available, each reinforced with I-Grow's Default Insurance for added peace of mind.
- **Effortless Transactions:** Modern, user-friendly payment gateways ensure smooth and efficient investment processes.

Impact & Commitment::

- **Consistent Returns:** Year-after-year, investors revel in robust returns, ranging between 13%-24% (2018).
- **Idle to Ideal:** I-Grow excels in transforming unused lands into flourishing, profit-yielding agricultural hubs.
- **Greener Tomorrow: Beyond mere business, I-Grow is an advocate for eco-friendly practices, prioritizing reforestation and sustainable farming.**

Recognition & Future:

- **Globally Acclaimed:** 1st place in World Summit Awards, Tech in Asia recognition, etc.
- **Bright Horizon**: Built on a foundation of innovation, integrity, and impact, I-Grow is geared towards expanding its horizons and driving greater societal benefits.

Case Study 11: AgriDigital (1/2)

TRUST FOOD

Introduction: Since 2015, AgriDigital has seamlessly integrated technology into grain management, setting a benchmark for innovation and efficiency in the agribusiness sector. It replaces traditional grain management with digital record-keeping.

AgriDigital By The Numbers:

- **Volume Transacted:** 84.27 MMT
- **Transaction Value:** $13,701M
- **Business Connections:** 19.34K
- Services over 11,600 agribusinesses globally.

AgriDigital OnFarm:

- Tracks trucks in real-time, replacing manual logging.
- Real-time records of storage management.
- Manages contracts efficiently.
- Reconciles RCTIs with AgriDigital deliveries.

Grain Management Features:

- Real-time updates, unlimited team member invitations with custom permissions.
- Prints delivery receipts directly from mobile.
- Offline-first capability ensures data reliability.
- Real-time cloud-based data updates.
- Seamless weighbridge integration.
- Data insights to bolster business growth.
- Consolidated dashboard for deliveries, inventory, orders, prices.
- Real-time notifications connecting the entire supply chain.

Simplifying Operations:

- Streamlines processes for receipts, inventory, orders, and prices.
- Creates a singular data source for informed decisions.
- Approved for AgriDigital Finance.

AgriDigital

Co-funded by the European Union

Case Study 12: AgriDigital (2/2)

AgriDigital Trade:

- Efficient trading system for buy, sell, and finance.
- Single live view for contracts, inventory, orders, prices, invoices, payments.
- Efficient payment and invoicing system.
- Connects buyers & sellers efficiently.

AgriDigital Broker:

- Comprehensive solution for agricultural brokerage.
- Manages broker notes, customer inventory, and invoices.
- Providers user-friendly and accessible cloud-based software.
- Supports businesses of all sizes, making it easier to compete in the grain industry

Co-funded by
the European Union

Case Study 12: FishCoin (1/2)

- **Idea Definition:** Fishcoin utilizes blockchain to provide traceability in the seafood industry. It creates a decentralized peer-to-peer network that allows various stakeholders within the seafood supply chain to share trusted, transparent, and secure data.

- **Benefits:**
  - Incentivizes sustainability and ethical practices by allowing data sharing across the seafood supply chain.
  - Provides transparency, enabling consumers and buyers to have better insight into the product's journey and quality.

- **Key Features:**
  - **Blockchain-Based Traceability:** Ensures verified data from catch to consumer, maintaining integrity at each step of the supply chain.

  - **Digital Vouchers (Tokens):** Offers a form of reward for data sharing, shifting the economic benefit to those who contribute to the transparency of the supply chain.

  - **Ecosystem Approach:** Unlike centralized systems, Fishcoin encourages a community-driven solution to drive industry transformation, rewarding data sharing and responsible practices

Fishcoin PROJECT

Co-funded by the European Union

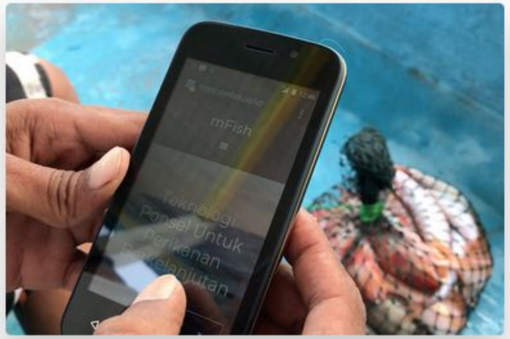
Case Study 12: FishCoin (2/2)

Blockchain based traceability for the seafood industry

To address the fragmentation of most seafood supply chains Fishcoin has been designed as a peer-to-peer network that allows independent industry stakeholders to harness the power of blockchain using a shared protocol so that data can be trusted, transparent, and secure.

A digital voucher that incentivizes data sharing

The flow of digital vouchers (tokens) moves from buyers to sellers in supply chains, thus rewarding those who make the extra effort to capture and communicate data. This shifts the economic burden to downstream actors such as hotels, restaurants and retailers who benefit most from traceability.



An ecosystem approach to industry transformation

Unlike many blockchain initiatives, Fishcoin is not based on a central company or entity. Instead it is designed to be a decentralized ecosystem that incentivizes data capture so that an ecosystem of companies and 3rd party developers can benefit by adding value to the network.

Co-funded by the European Union

Case Study 13: Ripe.io
(Under Development)

Idea Definition: Ripe.io leverages blockchain, IoT, AI, and machine learning to transform food traceability. As a leader in the "Blockchain of Food," ripe.io is building a transparent network that provides detailed histories of food products from origin to delivery. In partnership with R3's Corda, ripe.io's solution enhances trust across the agricultural supply chain. With a vision to evolve into a full-fledged API and transactional platform, ripe.io currently offers a robust SaaS model focused on data integrity and supply chain storytelling.

- **Benefits:**
  - Empowers consumers with knowledge about food origins and conditions.
  - Facilitates farmers in monitoring crucial crop-growing parameters.
  - Ensures the quality and safety of food through accessible, recorded data.

- **Key Features:**
  - **Traceability Across Lifecycles:** Tracks food journey from seed to sale with sensor-driven data.
  - **Data Insights:** Tailored, real-time dashboards via mobile or desktop for immediate insights.
  - **Blockchain and Cloud Integration:** Immutable ledger ensuring continuous data access and transparency.
  - **Food Integrity:** A platform that certifies the quality and transparency of food to supply chain partners and consumers.

ripe.io
Blockchain of Food®

Co-funded by
the European Union

Case Study 13: Bext360
(not agrifood-oriented)

- **Idea Definition:** Bext360 offers a SaaS platform that ensures full accountability in supply chains worldwide. Using blockchain for traceability, it measures and records crucial sustainability metrics from the origin to retail. These include worker pay, and environmental footprints related to carbon, water, and electricity right. Since 2017, Bext360 has been empowering companies to make transparent, ethical, and environmentally sound decisions.

- **Benefits:**
  - Ensures every aspect of the supply chain is accounted for, fostering trust and authenticity.
  - Enhances brand value by enabling consumers to visualize the product’s story and its supply chain through various multimedia integrations.

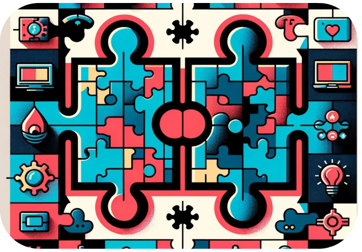
- **Key Features:**
  - **Farm to Retail Traceability:** Tracks and validates the authenticity and journey of products from the very first mile.
  - **Full API Integration:** Offers comprehensive integration capabilities with existing systems for real-time data access and management.
  - **Environmental Footprint Simulation:** Enables simulation of environmental impacts, aiding in strategic decision-making to minimize footprints.
  - **Compliance Reporting Generation:** Generates comprehensive reports to ensure and demonstrate compliance with relevant standards and regulations.

Co-funded by
the European Union

Key Challenges (Overview)

High Implementation Costs

Standardization and Regulation



Lack of Interoperability

Cybersecurity Concerns

Limited Awareness and Adoption

Technology Maturity

Skill Gap and Training Needs

Homogeneity and Legal Framework

Co-funded by the European Union

Key Challenges (1/4)

High Implementation Costs:

- Significant initial investment for setup.
- Ongoing maintenance and system updates incur costs.
- Training for staff represents an additional expense.
- High costs for developing and deploying blockchain applications.

Standardization and Regulation:

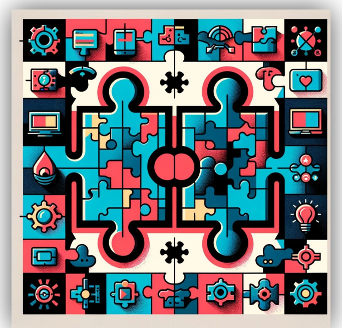
- Varying regulations across regions.
- Lack of legal framework for blockchain integration.
- Difficulties in enforcing compliance on a decentralized platform.
- Potential conflicts between blockchain protocols and food safety laws.

Co-funded by the European Union

Key Challenges (2/4)

Lack of Interoperability:

- Fragmented blockchain ecosystems.
- Challenges integrating with legacy systems.
- Difficulty in data exchange across the supply chain.
- Lack of standardized protocols hindering system cohesion.



Cybersecurity Concerns:

- Susceptibility to 51% attacks.
- Vulnerabilities in smart contracts and user interfaces.
- Risks of immutable fraudulent entries.
- Need for continuous evolution of security protocols.

Co-funded by
the European Union

Key Challenges (3/4)

Limited Awareness and Adoption:

- Low levels of familiarity within the industry.
- Insufficient infrastructure to support blockchain.
- Limited resources allocated for technology education.
- Challenges in demonstrating tangible benefits to stakeholders.

Technology Maturity:

- Blockchain technology is still maturing, with scalability, speed, and security needing demonstration for broader adoption.
- The unchangeable nature of blockchain data can sometimes hinder the adaptability of the supply chain.

Co-funded by the European Union

Key Challenges (4/4)

Skill Gap and Training Needs:

- A worldwide lack of skills and understanding of Blockchain Technology.
- Necessity for education platforms and trainers to simplify the technology for farmers and other primary participants.

Homogeneity and Legal Framework:

- Lack of uniform knowledge between technical experts and policymakers.
- Uncertainties in legal matters surrounding smart contracts within a DLT framework.

Co-funded by the European Union

Formative Assessment

What challenges may companies face when integrating blockchain into existing food supply chain systems?

Co-funded by
the European Union

Summary and Key Takeaways

TRUST FOOD

SUMMARY

Lesson 7 provided an in-depth examination of blockchain's real-world implementations within the agri-food sector, highlighting its effectiveness in addressing critical challenges such as traceability, safety, and sustainability.

KEY TAKEAWAYS:

- **Practical Blockchain Implementations:**
  Detailed review of blockchain deployment by prominent entities in the food supply chain.
- **Addressing Industry Challenges:**
  Insights on how blockchain technology is delivering tangible solutions for enhanced traceability, increased operational efficiency, and reduced wastage in the food supply industry.

Co-funded by
the European Union

References

1. Patelli, N. and Mandrioli, M., 2020. 'Blockchain technology and traceability in the agrifood industry.' *Journal of Food Science*, 85(11), pp.3670-3678.
2. Xu, X., Lu, Q., Liu, Y., Zhu, L., Yao, H. and Vasilakos, A.V., 2019. 'Designing blockchain-based applications: a case study for imported product traceability.' *Future Generation Computer Systems*, 92, pp.399-406.
3. Lin, W. et al., 2020. 'Blockchain technology in current agricultural systems: from techniques to applications.' *IEEE Access*, 8, pp.143920-143937.
4. Bhusal, C.S., 2021. 'Blockchain technology in agriculture: a case study of blockchain start-up companies.' *International Journal of Computer Science & Information Technology (IJCSIT)*, 13.
5. Patel, A.S. et al., 2023. 'Blockchain technology in food safety and traceability concern to livestock products.' *Heliyon*.
6. van Wassenaer, L. et al., 2023. 'Tokenizing circularity in agri-food systems: A conceptual framework and exploratory study.' *Journal of Cleaner Production*, 413, 137527.
7. Verified Market Reports, (no date). 'Agrifood Blockchain Market Size, Share | Growth Report, 2030.' Available at: https://www.verifiedmarketreports.com/product/agrifood-blockchain-market/ (Accessed: 6 November 2023).
8. Origin Chain Networks, (no date). 'Food Ecosystem.' Available at: https://www.originchain.eu/ecosystem (Accessed: 25 October 2023).

Co-funded by
the European Union

9. TE, 2020. 'Food - the #1 end-to-end food traceability solution.' Available at: https://te-food.com/ (Accessed: 25 October 2023).

10. Ripe.io, Available at: https://www.ripe.io/ (Accessed: 03 November 2023).

11. IBM, (no date). 'IBM Supply Chain Intelligence Suite - Food Trust.' Available at: https://www.ibm.com/products/supply-chain-intelligence-suite/food-trust (Accessed: 03 November 2023).

12. AgriLedger, (2023). Available at: https://agriledger.io/ (Accessed: 03 November 2023).

13. GreenToken by SAP, (no date). Available at: https://www.green-token.io/ (Accessed: 03 November 2023).

14. AgroToken, 'Tokenize your grains and get a loan guarantee.' Available at: https://agrotoken.com/en/ (Accessed: 06 November 2023).

15. Bext360, Available at: https://www.bext360.com/#/home (Accessed: 03 November 2023).

16. Fishcoin Project, 'Blockchain based seafood traceability & data ecosystem.' Available at: https://fishcoin.co/ (Accessed: 06 November 2023).

Co-funded by
the European Union

Further Readings

1. Khan, S. et al., 2023. 'Investigating the barriers of blockchain technology integrated food supply chain: A BWM approach.' *Benchmarking: An International Journal*, 30(3), pp.713-735.
2. Duan, J. et al., 2020. 'A content-analysis based literature review in blockchain adoption within food supply chain.' *International Journal of Environmental Research and Public Health*, 17(5), 1784.
3. Kayikci, Y. et al., 2022. 'Food supply chain in the era of Industry 4.0: Blockchain technology implementation opportunities and impediments from the perspective of people, process, performance, and technology.' *Production Planning & Control*, 33(2-3), pp.301-321.
4. Chen, S. et al., 2021. 'Processes, benefits, and challenges for adoption of blockchain technologies in food supply chains: a thematic analysis.' *Information Systems and e-Business Management*, 19, pp.909-935.

Co-funded by the European Union

THANK YOU

Acknowledgment: The content in this course has been developed as part of the TRUSTFOOD project, which has received funding from the European Union's Digital Europe Programme under Grant Agreement No. 101100804.

Comments and inquiries may be addressed to Andreas Delladetsimas (delladetsimas.a@unic.ac.cy) and Evgenia Kapassa (kapassa.e@unic.ac.cy), University of Nicosia

Co-funded by
the European Union

TRUSTFOOD
Introduction to Blockchain in the Food Supply Chain: Building Trust and Ensuring Safety

Lesson 8: Future Trends

Co-funded by the European Union

Introduction and Objectives

INTRODUCTION & LESSON DESCRIPTION:

- Lesson 8 focuses towards anticipating the progression of blockchain in the food supply chain. This Lesson explores potential trends and advancements, envisioning how blockchain could reshape global food distribution and safety in the upcoming years.

OBJECTIVES:

- Investigate the potential future trends of blockchain in the food supply chain.
- Analyze the possibilities for blockchain to drive innovation and transform global food supply chain.

Co-funded by
the European Union

Key Concepts

- **Emerging Blockchain Trends:** Insight into the latest developments in blockchain for the food supply chain and their prospective impact.
- **Vision for the Future:** Speculation on blockchain's role in enhancing sustainability and operational efficiency in global food systems.

Co-funded by the European Union

Learning Outcomes

By the end of this lesson, participants will be able to:

- Comprehend the up-and-coming trends and the significance of blockchain in the food supply chain.
- Project the influence of blockchain on future global food systems.
- Examine the implications of widespread blockchain adoption for sustainability, regulatory compliance, and consumer engagement.

Co-funded by the European Union

Upcoming Trends in Blockchain for Food Supply Chain (Overview)

- Enhanced End-to-End Visibility
- IoT and Real-time Tracking
- Food Safety Innovations
- Consumer Engagement
- Smart Contracts
- Interoperabi lity

Co-funded by
the European Union

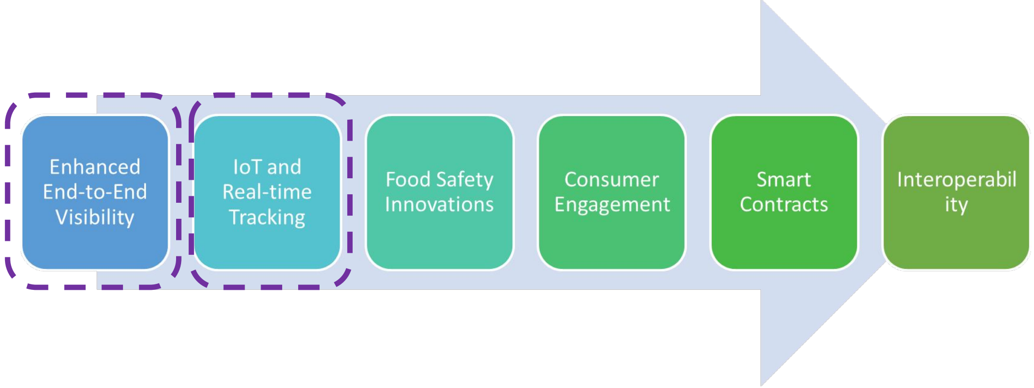
Upcoming Trends in Blockchain for Food Supply Chain (1/3)

Enhanced End-to-End Visibility

- Digital records on blockchain capturing every stage from production to consumption.
- Improved food safety management, waste reduction, and authenticity verification.
- Enhanced management and traceability for food origin and safety protocols.

IoT and Real-time Tracking

- Integration of IoT with blockchain for real-time supply chain responsiveness.
- Smart contracts triggered by sensors to maintain product quality during transit.
- Autonomous responses to conditions ensuring cargo safety and optimal freshness.



Co-funded by the European Union

Upcoming Trends in Blockchain for Food Supply Chain (2/3)

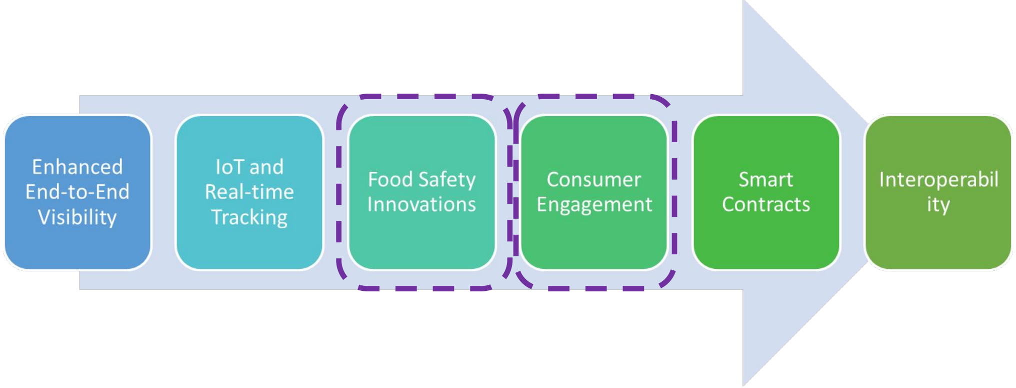
TRUST FOOD

Food Safety Innovations

- Instant verification of organic or fair-trade status through blockchain tools.
- Strengthening of quality assurance protocols, reducing fraud.
- Higher consumer confidence and potential premium pricing for verified products.

Consumer Engagement

- Platforms are emerging that enable consumers to easily access a product's history and origin, which in turn helps them make informed purchasing decisions.
- This trend towards greater consumer engagement demands robust blockchain systems that can provide detailed information.



Co-funded by the European Union

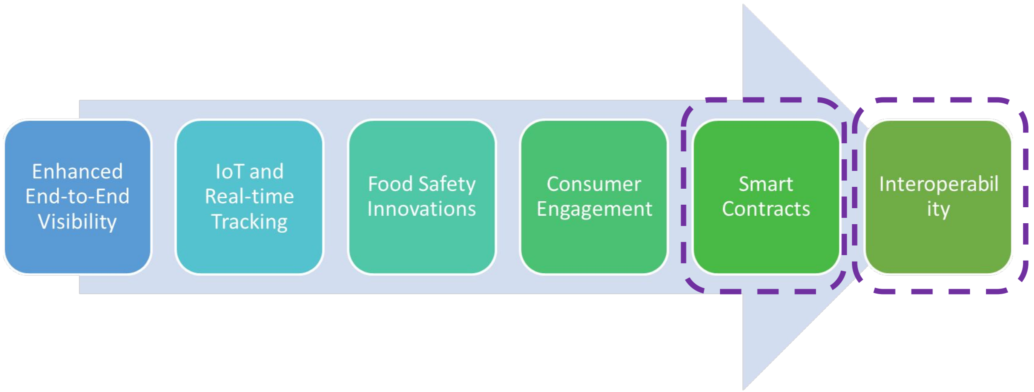
Upcoming Trends in Blockchain for Food Supply Chain (3/3)

Smart Contracts

- Utilizing smart contracts within blockchain to automatically execute agreements when certain conditions are met.
- This can streamline quality assurance processes, ensuring that food safety standards are adhered to without manual intervention.

Interoperability Efforts

- Developing ways to ensure different blockchain systems can work together without friction is a key trend.
- This is important for maintaining a consistent and unified supply chain despite various stakeholders using different blockchain platforms.



Co-funded by the European Union

Consumer Trends and Expectations

- **Provenance as a Service**
  - **Customer Expectations**: Modern consumers demand comprehensive knowledge about the products they purchase, particularly in the food industry.
  - **Integral Value**: Access to a product’s full history has transitioned from a luxury to an essential component in the decision-making process.
- **Impact on Buying Habits**
  - **Influencing Loyalty**: The capacity to trace a product's origin and lifecycle is becoming a pivotal factor in shaping consumer preferences.
  - **Transparency & Ethical Sourcing**: Brands that demonstrate product authenticity and ethical production practices cultivate greater consumer trust and loyalty.
- **Value of Ethical Production**
  - **Market Trend**: An increasing number of consumers are ready to invest more in products with certifications like organic or fair-trade.
  - **Blockchain Verification**: By authenticating these certifications, blockchain technology enhances the product's value, assuring consumers of the integrity and ethical standards of their purchases.

Co-funded by
the European Union

Driving Factors (Overview)

Demand for Transparency and Traceability

Adoption of Blockchain in Agrifood

Growing Awareness of Blockchain Benefits

Co-funded by the European Union

Driving Factors

- **Demand for Transparency and Traceability**
  - **Consumer Verification**: A growing demand among consumers to understand the origins and processes behind their food is driving companies towards technological solutions.
  - **Blockchain Solution**: Blockchain offers transparent, unalterable records, ensuring product histories are clear and secure.
  - **Competitive Advantage**: Brands that comply with these consumer demands see increased market competitiveness.
- **Adoption of Blockchain in Agrifood**
  - **Combating Food Fraud**: Blockchain technology is being adopted in the agrifood sector as a tool to secure the authenticity of food products through traceable supply chains.
  - **Investment Growth**: Companies are increasingly investing in blockchain, recognizing its potential to reduce costs and improve efficiency in complex supply chain operations.
- **Growing Awareness of Blockchain Benefits**
  - **Educational Impact**: Through educational initiatives and sharing success stories, knowledge about blockchain's ability to secure and streamline the food supply chain is expanding among producers and consumers.
  - **Market Shift**: Demonstrated successes in food safety are catalyzing a shift towards blockchain adoption, with stakeholders valuing its contributions to transparency and data integrity.

Co-funded by
the European Union

Impact of Blockchain Adoption

Technological Impact

- Barrier due to technology's complexity.
- Inflexibility of data alteration on the blockchain.
- Challenges in achieving transparency and traceability.

Economic Impact

- Initial high costs for blockchain implementation.
- Potential for increased profits and ROI.
- Efficiency improvements in supply chain management.
- Reduction in costs over time with optimized processes.

Social Impact

- Potential reduction in food fraud.
- Improvements in animal welfare standards.
- Enhanced food security through better traceability.
- Dependency on public awareness for impact realization.

Environmental Impact

- Scalability issues affecting data storage capabilities.
- Environmental benefits versus high energy consumption.

Co-funded by
the European Union

Future of Blockchain in Agrifood Sector (1/2)

- **Adoption Growth:**
  - Increased corporate uptake as competitive differentiator.
  - Boosted transparency and consumer trust.

- **Technological Advances:**
  - Addressing interoperability and energy use.
  - Scalability and sustainability enhancements.

- **Regulatory Evolution:**
  - Clearer regulations for food safety and quality assurance.
  - Encouragement for broader adoption

- **Enhanced Security:**
  - Stronger cybersecurity measures for supply chain integrity.
  - Secure data handling across networks.

Co-funded by
the European Union

Future of Blockchain in Agrifood Sector (2/2)

- **Cost Reduction:**
  - Declining implementation and operational expenses.
  - Greater accessibility for smaller agrifood entities.
- **Integrated Solutions:**
  - Combining with IoT, AI, and machine learning.
  - Advanced supply chain management from production to consumer.
- **Social and Environmental Accountability:**
  - Clearer regulations for food safety and quality assurance.
  - Encouragement for broader adoption.
- **Educational Initiatives:**
  - Training for stakeholders on blockchain uses.
  - Fostering best practices in agrifood industry.

Co-funded by the European Union

Rethinking Our Food Supply Chain

Future Proofing Your Food

Rethinking Our Food Supply Chain - Future Proofing Your Food | Kieran Kelly | TEDxDerryLondonderry
Source: https://www.youtube.com/watch?v=2qSdeVrgN8I&t=122s

Rethinking Our Food Supply Chain

Future Proofing Your Food

Re-Thinking Food: Transforming Food Systems for People and Planet | Frank Eyhorn | TEDxIHEID
Source: https://www.youtube.com/watch?v=4aa6wvJyt1c&t=8s

Co-funded by the European Union

Formative Assessment

How might blockchain technology evolve to better serve the food industry in the future?

Co-funded by
the European Union

Summary and Key Takeaways

SUMMARY

Lesson 8 looked ahead to the potential advancements and applications of blockchain in the food supply chain, offering insights into the anticipated influence of this technology on future food logistics and sustainability.

KEY TAKEAWAYS:

- **Prospective Blockchain Innovations:**

  Participants were informed about possible future trends in blockchain technology in the food supply chain context.

- **Advantages Explored:**

  The lesson anticipated the potential for blockchain to revolutionize global food sustainability, safety, and security.

Co-funded by
the European Union

References

1. Mirabelli, G. and Solina, V., 2020. 'Blockchain and agricultural supply chains traceability: Research trends and future challenges.' *Procedia Manufacturing*, 42, pp.414-421.
2. Zhao, G., Liu, S., Lopez, C., Lu, H., Elgueta, S., Chen, H. and Boshkoska, B.M., 2019. 'Blockchain technology in agri-food value chain management: A synthesis of applications, challenges and future research directions.' *Computers in Industry*, 109, pp.83-99.
3. Kamilaris, A., Fonts, A. and Prenafeta-Boldú, F.X., 2019. 'The rise of blockchain technology in agriculture and food supply chains.' *Trends in Food Science & Technology*, 91, pp.640-652.
4. Yogarajan, L., Masukujjaman, M., Ali, M.H., Khalid, N., Osman, L.H. and Alam, S.S., 2023. 'Exploring the Hype of Blockchain Adoption in Agri-Food Supply Chain: A Systematic Literature Review.' *Agriculture*, 13(6), p.1173.
5. Xiong, H., Dalhaus, T., Wang, P. and Huang, J., 2020. 'Blockchain technology for agriculture: applications and rationale.' *Frontiers in Blockchain*, 3, p.7.
6. Verified Market Reports, (no date). 'Agrifood Blockchain Market Size, Share | Growth Report, 2030.' Available at: https://www.verifiedmarketreports.com/product/agrifood-blockchain-market/ (Accessed: 6 November 2023).

Co-funded by the European Union

Further Readings

1. YouTube, 'Urban Farming: Fixing the broken food system & improving health | Paul Myers | TEDxLiverpool' Available at: https://www.youtube.com/watch?v=5AcjM5BKfRQ (Accessed: 15 November 2023).
2. Xu, Y. et al., 2022. 'Application of blockchain technology in food safety control: current trends and future prospects.' *Critical Reviews in Food Science and Nutrition*, 62(10), pp.2800-2819.
3. Mirabelli, G. and Solina, V., 2020. 'Blockchain and agricultural supply chains traceability: Research trends and future challenges.' *Procedia Manufacturing*, 42, pp.414-421.
4. Zhao, G. et al., 2019. 'Blockchain technology in agri-food value chain management: A synthesis of applications, challenges and future research directions.' *Computers in Industry*, 109, pp.83-99.
5. Wamba, S.F. and Queiroz, M.M., 2020. 'Blockchain in the operations and supply chain management: Benefits, challenges and future research opportunities.' *International Journal of Information Management*, 52, 102064.
6. Niknejad, N. et al., 2021. 'Mapping the research trends on blockchain technology in food and agriculture industry: A bibliometric analysis.' *Environmental Technology & Innovation*, 21, 101272.

Co-funded by the European Union

THANK YOU

Disclaimer: The content provided in this course is for informational purposes only and should not be considered as legal, financial, or professional advice.

Acknowledgment: The content in this course has been developed as part of the TRUSTFOOD project, which has received funding from the European Union's Digital Europe Programme under Grant Agreement No. 101100804.

Comments and inquiries may be addressed to Andreas Delladetsimas (delladetsimas.a@unic.ac.cy) and Evgenia Kapassa (kapassa.e@unic.ac.cy), University of Nicosia

Co-funded by the European Union

Course #6: Introduction to Blockchain in the Food Supply Chain: Building Trust and Ensuring Safety

Lesson 1: Supply Chain Essentials and Challenges in the Food Industry

FORMATIVE ASSESSMENT - QUIZ

Question 1 (Multiple Choice)

Question: What is a primary concern across all stages of the food supply chain?

a. Increasing the speed of delivery
b. Reducing the number of stakeholders
c. Ensuring the safety and quality of food
d. Simplifying the supply chain complexity

Correct Answer: c.

Question 2 (True/False)

Question: The food supply chain involves just three main stages: production, processing, and distribution.

Correct Answer: False

Question 3 (True/False):

Consumers drive the demand that fuels the entire chain by purchasing and consuming the products.

Correct Answer: True

Question 4 (Short Answer)

Question: Name one of the technological solutions mentioned in the presentation that could address supply chain challenges.

Correct Answer: Blockchain

Course #6: Introduction to Blockchain in the Food Supply Chain: Building Trust and Ensuring Safety

Lesson 2: Blockchain Technology Essentials – Part I

FORMATIVE ASSESSMENT - QUIZ

Question 1 (Multiple Choice)

Question: What does SHA-256 in the context of blockchain refer to?

a. A type of blockchain protocol
b. A security feature of wallets
c. A cryptographic hash function.
d. An encryption method for blockchains

Correct Answer: c

Question 2 (True/False)

Question: In blockchain technology, a consensus mechanism like Proof of Work (PoW) or Proof of Stake (PoS) is used to validate and add transactions to the blockchain.

Correct Answer: True

Question 3 (Multiple Choice)

Question: Identify the correct description for each component of blockchain technology:

a. Nodes are individual computers that validate and maintain the blockchain.
b. Blocks are data structures that store a list of transactions.
c. Chains refer to the sequence of blocks, each linking to the previous block's hash.
d. The Consensus Mechanism is the set of rules that network nodes follow to validate transactions.
e. All of the above are correct.

Correct Answer: e

Question 4 (True/False)

Question: Once a block is added to the blockchain, it is impossible to alter its contents without altering the subsequent blocks.

Correct Answer: True

Course #6: Introduction to Blockchain in the Food Supply Chain: Building Trust and Ensuring Safety

Lesson 3: Blockchain Technology Essentials – Part II

FORMATIVE ASSESSMENT - QUIZ

Question 1 (True/False)
Question: Public blockchains are controlled by a single organization and require an invitation to join.
Correct Answer: False

Question 2 (True/False)
Question: Private blockchains are more centralized than public blockchains. Correct Answer: True

Question 3 (True/False)
Question: Consortium blockchains are controlled jointly by multiple organizations.
Correct Answer: True

Question 4 (True/False)
Question: Sidechains are separate blockchains that are linked to a main blockchain and facilitate asset transfer across multiple blockchains.
Correct Answer: True

Course #6: Introduction to Blockchain in the Food Supply Chain: Building Trust and Ensuring Safety

Lesson 4: Role of Blockchain in Optimizing the Food Supply Chain

FORMATIVE ASSESSMENT – QUIZ

Question 1 (Multiple Choice)

Question: Which of the following is NOT a key benefit of applying blockchain technology in the food supply chain?

a. Enhanced traceability of food products
b. Simplified regulatory compliance
c. Increased reliance on paper-based records
d. Improved inventory management

Correct Answer: (c)

Question 2 (True/False)

Question: The immutable nature of blockchain records allows for easy traceability and accountability at every step of the food supply chain.

Correct Answer: True

Question 3 (Multiple Choice)

Question: What does the decentralization of blockchain infrastructure ensure in the food supply chain?

a. Central authority has tighter control over the data.
b. Reduction in the overall cost of transportation.
c. Enhanced security and resilience against data tampering.
d. Increased need for intermediaries.

Correct Answer: (c)

Question 4 (True/False)

Question: Blockchain technology can reduce the amount of time needed to trace the origin of food products in the event of a contamination issue.

Correct Answer: True

Course #6: Introduction to Blockchain in the Food Supply Chain: Building Trust and Ensuring Safety

Lesson 5: Blockchain for trust-building in the food supply chain

FORMATIVE ASSESSMENT – QUIZ

Question 1 (Multiple Choice)

Question: What is the primary role of transparency in the context of blockchain in the food supply chain?

a. It allows for more efficient packaging of food products.
b. It ensures that all stakeholders can verify product details at each step, enhancing trust.
c. It is used to increase the speed of food delivery.
d. Transparency is only important for regulatory bodies, not consumers.

Correct Answer: b.

Question 2 (True/False)

Question: Blockchain's decentralized nature decreases collaboration among participants in the food supply chain.

Correct Answer: False

Question 3 (Multiple Choice)

Question: How does blockchain technology empower consumers?

a. By giving them control over the production process
b. By allowing them to verify the origins, processing methods, and handling of the food products they consume.
c. By providing them discounts on products.

Correct Answer: b.

Question 4 (True/False)

Question: Blockchain technology can verify claims of sustainable and ethical sourcing, thus reassuring consumers of their purchases.

Correct Answer: True

Course #6: Introduction to Blockchain in the Food Supply Chain: Building Trust and Ensuring Safety

Lesson 6: Ensuring Food Safety through Blockchain

FORMATIVE ASSESSMENT – QUIZ

Question 1 (Multiple Choice)

Question: What is a significant benefit of blockchain technology in managing food safety recalls?

a. Increases the time it takes to trace the source of contamination.
b. Reduces the scope and scale of recalls.
c. Decreases transparency in the supply chain.
d. Encourages the use of paper-based tracking systems.

Correct Answer: b.

Question 2 (True/False)

Question: Blockchain technology can ensure the integrity of food safety data through its immutable ledger, which prevents tampering.

Correct Answer: True

Question 3 (Multiple Choice)

Question: How does blockchain technology aid in the rapid identification and resolution of food contamination issues?

a. By slowing down the communication between stakeholders.
b. Centralizing data can be accessed only by select members.
c. By enhancing traceability, allowing for the rapid pinpointing of the contamination source.
d. Complicating the audit process, requiring additional verification steps.

Correct Answer: c.

Course #6: Introduction to Blockchain in the Food Supply Chain: Building Trust and Ensuring Safety

Lesson 7: Exploring Real-world Implementations

FORMATIVE ASSESSMENT – QUIZ

Question 1 (Multiple Choice)

Question: What is a common challenge faced by companies when integrating blockchain into the food supply chain?

a) Decreased transparency of data.
b) The initial cost and complexity of implementation.
c) Overly simplified operational processes.
d) Reduced data integrity and traceability.

Correct Answer: (b)

Question 2 (True/False)

Question: Blockchain integration in the food supply chain can create challenges related to interoperability with existing systems.

Correct Answer: True

Question 3 (Multiple Choice)

Question: Which factor is crucial for the successful adoption of blockchain technology in the food supply chain?

a) Maintaining a centralized database for all transactions.
b) Ensuring that only one stakeholder benefits from the technology.
c) Developing an understanding and skill set among all participants.
d) Avoiding the use of smart contracts to keep processes simple.

Correct Answer: (c)

Course #6: Introduction to Blockchain in the Food Supply Chain: Building Trust and Ensuring Safety

Lesson 8: Future Trends

FORMATIVE ASSESSMENT – QUIZ

Question 1 (Multiple Choice)

Question: What is the expected role of IoT when integrated with blockchain technology in the agrifood sector?

a. To decrease data transparency and traceability.
b. To increase manual processes in food tracking.
c. To enhance real-time tracking and improve supply chain responsiveness.
d. To eliminate the need for smart contracts.

Correct Answer: (c)

Question 2 (True/False)

Question: Blockchain technology is anticipated to reduce the complexity of interoperability among different blockchain systems within the food supply chain.

Correct Answer: True

Question 3 (Multiple Choice)

Question: What are the anticipated benefits of blockchain technology for food safety and quality assurance?

a) Reduced regulatory compliance and consumer trust.
b) Increased food fraud and supply chain inefficiencies.
c) Clearer regulations and encouragement for broader adoption.
d) Higher energy consumption and reduced data security.

Correct Answer: (c)