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The Role of Blockchain Technology in Developing E-commerce: A Case Study of Carrefour - United Arab Emirates

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Abstract: This study, through descriptive analysis supported by numerical statistics, aims to demonstrate the role of blockchain technology in developing and facilitating e-commerce processes, particularly in the areas of electronic payment and data protection, and in accelerating revenue generation. This is achieved by addressing concepts related to e-commerce and the applications of blockchain technology in its operations, understanding the close relationship between them in the economic sphere. The study is further supported by a case study of Carrefour in the UAE. The study concluded with several key findings, most notably improved company revenues, an increased share of e-commerce, and a larger customer base due to enhanced data security, despite the challenges inherent in both e-commerce and blockchain technology.
Keywords: E-commerce, blockchain; international payments, data protection

Résumé : Cette étude, par une analyse descriptive étayée par des statistiques, vise à démontrer le rôle de la technologie blockchain dans le développement et la facilitation des processus de commerce électronique, notamment en matière de paiements électroniques et de protection des données, ainsi que dans l'accélération de la génération de revenus. Pour ce faire, elle aborde les concepts liés au commerce électronique et aux applications de la technologie blockchain dans ses opérations, en mettant en lumière leur étroite relation dans la sphère économique. L'étude est également étayée par une étude de cas menée auprès de Carrefour aux Émirats arabes unis. Elle conclut sur plusieurs points clés, notamment l'amélioration des revenus de l'entreprise, l'augmentation de sa part de marché dans le commerce électronique et la croissance de sa clientèle grâce à une sécurité des données renforcée, malgré les défis inhérents au commerce électronique et à la technologie blockchain.
Mots-clés : Commerce électronique, Blockchain, Paiements internationaux, Protection des données

Introduction: The various developments in the field of information and communication technology, and the emergence of e-commerce, have led to many challenges that may hinder its development and continuity, including weak trust, fraud risks, and data and information security issues. In this context, blockchain technology emerged in 2009 as an electronic platform for

trading Bitcoin. With the growth of online shopping and e-commerce platforms, and the emergence of electronic payment challenges, many global institutions and e-commerce companies have adopted blockchain technology to facilitate and enhance the efficiency of e-commerce transactions. This has become one of the most important technological developments and modern innovations, providing a decentralized environment for recording transactions in an encrypted and distributed manner, thus promoting transparency, security, and trust in electronic transactions.

The importance of the study lies in highlighting the role that blockchain technology has played in developing e-commerce by facilitating electronic payment, protecting data, improving returns, increasing the share of e-commerce and its expansion. This is done by focusing on a case study of Carrefour in the United Arab Emirates, which has experienced a qualitative leap in several aspects.

The problem: What role does blockchain technology play in the development of e-commerce? Answering this general problem requires addressing the following questions: - What challenges has e-commerce faced? And what are the requirements for its success?

- How has blockchain technology contributed to the development of e-commerce?
- Has Carrefour in the UAE achieved the desired results from its use of blockchain technology?

To answer the questions and address the issues raised, the research paper was divided into the following sections:

1- E-commerce: Requirements and Challenges
2- The Role of Blockchain Technology in Developing E-commerce
3- A Case Study of Carrefour in the United Arab Emirates

1- E-commerce between requirements and challenges:

1- E-commerce and its forms:

E-commerce is a business model that includes transactions or processes of buying and selling products or services via the Internet through various smart devices, relying on electronic stores dedicated to shopping, payment, selling and buying, and completing everything related to the purchase process, such as paying money and receiving the product and information related to the process, through the Internet (Mustafa Binqib, 17/02/2023), without an intermediary, eliminating all barriers and distances and saving effort and time.

E-commerce is a business model that includes transactions or processes of selling and buying products or services online through various smart devices, relying on electronic stores dedicated to shopping, payment, selling and buying, and completing everything related to the purchase process, such as paying money, obtaining the product and information related to the process, through the Internet (Mustafa Binaqib, 17/02/2023), without an intermediary, eliminating all barriers and distances and saving effort and time

In technical terms, e-commerce is defined as the process of buying and selling goods and services or transferring money and data via the Internet;

The Organisation for Economic Co-operation and Development (OECD) defines e-commerce as: the buying and selling of goods and services carried out via digital communication methods through platforms specifically designed to send and receive electronic buying and selling requests, supported by digital payment mechanisms.

The World Trade Organization defines it as an integrated set of processes for producing, distributing, marketing, selling, and delivering products electronically (WTO 2018). The European Union, however, defines it as "business activity conducted electronically," including the digital processing of data such as text, audio, and images (EU 2023).

It is also defined as the delivery of information, products or services, and payments via telephone lines, computer networks, or any other technological means, with the aim of improving the efficiency and quality of service delivery(R. & Kalakota R et Whinston, 1997)

The idea of e-commerce dates back to the idea of electronic exchange in the seventies and eighties when companies and suppliers used electronic data exchange via private networks to transfer commercial documents and financial transactions; The concept of online shopping became easier with the emergence of the internet and the World Wide Web in the early 1990s, as companies created websites to showcase their products, offered electronic payment options and online banking applications, and expanded their customer base.

During the period between 2010 and 2020, commerce via smartphones and social commerce through social media grew, especially after the COVID-19 pandemic and the emergence of direct sales platforms known as social commerce. This expanded further after 2020 with the development of smart technologies, supply chains, and multi-channel stores to connect online sales. Today, e-commerce utilizes artificial intelligence, data analytics, smart supply chains, and multi-channel stores to connect online sales, making the consumer experience safer. The development of e-commerce can be illustrated in the following table:

Table 1: The Evolution of E-commerce

Time period	idea	The New	innovation
1980-1980	Exchange of raw data	The emergence of electronic data exchange systems between companies and commercial documents	Michael Aldrich's invention of telephone shopping in 1979
1990-2000	The emergence of websites, the internet	Amazon launched in 1995 and adopted e-commerce	First secure transaction via SSL protocol
2001-2006	Market maturity	Search Growth: GOOGLE ADWORDS	The emergence of the global payment gateway PAYPAL

2007-2019	Smart expansion	Trade over the phone	Launching social media platforms: iPhone - Alibaba
After2020	Corona pandemic	Reliance on social commerce heavily	Direct shopping from online stores
From 2020 to the present day	Market expansion and payment tools	Using artificial intelligence with the internet	Using advanced blockchain technologies, data analysis, and automation

Source: Prepared by researchers based on https://commerce.amwaly.com/blog , Https://mawdoo3.com and the type of trade varies depending on the parties involved. Among the forms of e-commerce are:

-**Business-to-Business (B2B)**: This type of trade is similar to retail trade.

- Business-t**o-Consumer (B2C)**: This encompasses all electronic transactions between companies and mimics the trade between producers or suppliers and wholesalers in traditional commerce.

- Consumer-to-business (C2B) e-commerce: In this case, products and services are offered by consumers to businesses, such as an interior designer or photographer. - Consumer-to-consumer (C2C) e-commerce: This process takes place between consumers through an intermediary, such as an online platform, where consumers offer their services or products to other consumers.

- Business-to-government (B2G) e-commerce: This encompasses all transactions conducted online between businesses and government institutions, such as tax services and social security services.

- Consumer-to-government (C2G) e-commerce: This includes various electronic transactions between businesses and government entities across different sectors, such as distance learning, paying for healthcare services, booking medical appointments, and social security services.

Among the advantages of e-commerce are: global reach, as e-commerce activities know no spatial or geographical boundaries, in addition to the consumer avoiding additional costs.

The importance of e-commerce can be viewed from several perspectives:

- For the consumer: It reduces effort and time, as the consumer only needs to open their phone and shop in the store with an easy experience. They can also rate products before purchasing, choose their shipping location, and benefit from offers and points when the store uses a points and rewards system.

- For the economy and society: It facilitates access for customers from everywhere, creating an open market, in addition to providing new job opportunities.

1-2- Requirements for the Success of E-commerce:

Among the requirements for the success of e-commerce are:

1-2-1 Choosing the right products and customers: Both the products and the potential customers or audience are among the most important elements of e-commerce success, ensuring demand is met at a competitive price. This helps achieve the sales targets set in the market research plan.

1-2. -2. Professional Design and Branding: The design of the online store serves as a gateway to attract customers, taking into account the store's logo, choosing a suitable layout and name, and ensuring easy accessibility for customers through various marketing and sales channels.

1-2-3. Utilizing Various Appropriate Marketing Methods: Digital marketing methods are numerous, including interactive advertising, affiliate marketing, email marketing, social media and mobile marketing, viral marketing, messaging, public relations, search engine marketing, and public relations.

1-2-4- Providing Multiple Payment Methods: Choosing successful payment methods is essential to ensuring the success of e-commerce businesses. These methods are numerous and include:

- PayPal: A popular payment method and a choice for most online stores;

Credit and Debit Cards: An important and preferred payment method for shoppers, whether local cards issued by banks or international cards issued by major corporations such as Mastercard and Visa...

1-3- Measuring E-commerce Indicators: E-commerce indicators are divided into two main types: macroeconomic indicators and e-commerce performance indicators.1-

1-3-1 Macroeconomic Indicators:

These indicators are used to assess a country's ability to adopt and develop e-commerce. UNCTAD studies confirm that the "digital divide" is not only about phone ownership but also about infrastructure. If "technological readiness" is high but "financial inclusion" is low, the market will remain dependent on cash on delivery, which hinders the growth of large companies and increases operating costs. These indicators are also known as digital readiness indicators or the e-commerce enabling environment (World Bank Findex database), and they are:

1-3-1-1 Financial and Monetary Inclusion: This measures the extent to which individuals and businesses have access to formal financial services and the ease with which they use digital transactions and payment systems. Key metrics include:

- The percentage of adults with bank accounts and the penetration rate of e-wallets. A minimum penetration rate of 90% is required.

This is the case in countries advanced in e-commerce (World Bank Findex database).

1-3-1-2 Logistics Infrastructure: This refers to the efficiency of transportation and delivery through supply chains, ports, and last-mile delivery (the quality of parcel delivery to homes). One of the most important metrics is the Logistics Performance Index (LPI) issued by the World

Bank. A score of 3.5 out of 5 or higher on this index is preferred to indicate high logistical readiness.

1-3-1-4- Cybersecurity and Regulation: This measures consumer confidence in the protection of their personal and credit card data, and the availability of laws to protect digital consumer rights. Countries in Tier 1 are considered the most secure for digital commerce (International Telecommunication Union - ITU)

1-3-1-5-Digital Readiness and Internet Access: This includes internet speed, its cost relative to income, and the coverage of 5G networks. Among the most important metrics are: - Broadband Penetration: It is preferable for internet penetration to exceed 80% of the population as a minimum to support e-commerce (UNCTAD reports on the digital economy).

1-3-2- Performance Indicators in E-commerce Stores: These indicators help store owners measure the success of their marketing plans and make informed decisions by analyzing various e-commerce store metrics using tools, programs, and applications such as Google Analytics and Google Search Console.

1-3-2-1- Sales and Revenue Indicators: These indicators are related to business activity, and their effectiveness depends on the accuracy of data from government agencies and the digital analysis tools used. We define:

- Gross Merchandise Volume: Measures the total value of sales during a specific period before deducting expenses.
- Customer Acquisition Cost: Measures the total cost of acquiring a new customer.
- Average Order Value or Median Value: Measures the average amount a customer spends per order.
- Customer Lifetime Value: The total expected revenue a customer will generate for the store throughout their relationship with the store.

1-3-3-2- Marketing and Customer Service Indicators: These indicators help evaluate the effectiveness of advertising campaigns and customer attraction:

- Number of Visits: This refers to the number of visits to the online store during a specific period. The higher the number, the better, and therefore, efforts should be made to convert a larger percentage of these visitors into customers by increasing the conversion rate.
- Customer Acquisition Cost: This is the amount spent on marketing to acquire one new customer.
- Return on Advertising Spend: This measures the effectiveness of advertising campaigns in generating direct revenue.
- Bounce Rate: This is the percentage of visitors who leave the site after viewing only one page without any interaction, relative to the total number of sessions. A high bounce rate indicates a problem that needs to be addressed.

2-2-3- Conversion Indicators: These are the indicators that measure the store's ability to convert a visitor into a subscriber:

Conversion Rate: This measures the percentage of visitors who completed the purchase process out of the total number of site visitors.

- Shopping Cart Abandonment Rate: This indicator expresses the percentage of potential customers who abandon their shopping cart after adding products to it, and it must be as low as possible;

2-2-4- Customer Service and Retention Indicators: These metrics measure the store's ability to retain customers and the effectiveness of improving the customer experience through ease of use of online stores or e-commerce platforms, longer shopping periods, and streamlined shipping processes, in addition to attracting and retaining customers:

- Repeat Purchase Rate: The percentage of customers who made more than one purchase within a specific period.
- Net Promoter Score: Measures customer satisfaction and the likelihood of them recommending the store to others.
- Return Rate: The percentage of returned orders, a strong indicator of product quality.

2-2-5- Operational Performance Indicators: These relate to the efficiency of the work behind the scenes (logistics):

- Order fulfillment time: The time elapsed from the moment the customer clicks the "buy" button until the shipment is dispatched and delivered.
- Delivery rate: The percentage of orders delivered compared to the total number of orders.
- Inventory accuracy: Measures how well the actual inventory matches what is displayed.
- Confirmation rate: The percentage of orders confirmed by the customer after placing the order.

The above can be summarized in the following table:

Table 2: E-commerce Indicators

indicator	measurement	Reasonable ratio
Macroeconomic indicators		
Financial and monetary inclusion - Percentage of adults with bank accounts, - Percentage of e-wallet penetration	Access to and ease of use of financial services for individuals and businesses	Over 90%
Logistics Infrastructure - Logistics Performance Index (LPI) issued by the World Bank	Transportation and delivery efficiency from	Achieving a rating of 3.5 out of 5 or higher on the LPI index
Cybersecurity and the legislative environment	Personal data protection	"Category 1" countries
Technical readiness and internet	Limits of diffusion	More than 80%

access: Broadband		
Performance indicators		
Sales and revenue indicators	Commercial activity	
Total volume of goods	Total sales before expenses over a period of time	The bigger the better...
Average order value	Average amount spent per order	The smaller the better
Customer acquisition cost	Total cost of acquiring a new customer (marketing and advertising)	The smaller the better
Customer lifetime value	Total revenue expected from a customer throughout their relationship with the store	The bigger the better
Customer service indicators	Evaluating the effectiveness of advertising campaigns and customer attraction	
Customer acquisition	The amount spent to acquire one new customer	
Return on advertising expenditure	The effectiveness of advertising campaigns in generating direct revenue	
Average value of demand	The percentage of visitors who leave the website after viewing only one page without any interaction	30% - 40%
Average value of demand	The average amount a customer spends per order	
Conversion indicators.	Percentage of visitors who completed the purchase process	2% - 3%
Abandon the shopping cart	Percentage of users who added products to their cart but did not complete the checkout process	Less than 65%
Conversion rate	Percentage of visitors who completed the purchase out of the total number of website visitors	1% to 3%
service indicators	The store's ability to retain customers	
Repeat Purchase Rate	Percentage of customers who made more than one purchase within a specific period	25% or more
Net Promotion Points	Measures customer satisfaction and the likelihood of them recommending the store to others	

Product Return Rate	Percentage of returned orders	Acceptable percentage 20%
Operational performance indicators	It measures the efficiency of work behind the scenes	
Delivery rate	Percentage of orders delivered compared to total orders	95% or higher
Order fulfillment time	Time taken for shipment to reach the customer	Between 2-3 days
Inventory accuracy	Correspondence of actual inventory to what is displayed in the online store	Over 99%
Confirmation rate	Percentage of orders confirmed by the customer after placing the order	Over 99%

Source: Prepared by researchers based on Shipping Bo. (n.d.). E-commerce KPIs- Stape. (2025). ,Commerce KPIs
- UNCTAD reports on the digital economy2024

2- The Role of Blockchain Technology in Developing E-commerce

2-1- Blockchain Technology: Definition and Characteristics:

Blockchain technology is a distributed digital database consisting of a series of blocks containing transaction information. These blocks are recorded in an encrypted, secure, and immutable manner. It relies on a decentralized system that allows for the recording and verification of transactions without the need for an intermediary, thus contributing to reduced costs and increased efficiency. The blockchain space has witnessed significant developments with the entry of many new platforms into the market, especially with the creation of modern cryptocurrencies protected by cryptographic processes. Hashes, blocks, nodes, miners, wallets, digital signatures, and protocols are among the key concepts that comprise blockchain technology.

The following table illustrates the most important characteristics of blockchain technology:

Table 3: Blockchain Technology Characteristics

Property	description
Transparency	All parties can view transactions
Cost Reduction and Efficiency	This reduces the need for external intermediaries, minimizing time and financial costs
Decentralization	It does not rely on a central entity to manage transactions
Reliability	Once a transaction is recorded, it cannot be modified or deleted
Enhanced Security	Transactions are secured using encryption technologies that are immutable, making hacking or data forgery extremely difficult.

Independence	Network control is managed by users or nodes, eliminating the need for a central authority.
Traceability	Every transaction can be traced on the chain, facilitating verification of the complete history of any transaction
Smart Contract Compatibility	Smart contracts can be set up and executed on the network as self-executing contracts
Acceleration	In transaction execution
Improved Supply Chain management	During product tracking from source to consumer
Backup	Data is replicated across all nodes in the network, reducing the chances of data loss
Programmability	Specialized software can be used to meet specific needs

Source: prepared by researchers based on: Farah Murad: Explaining Blockchain Technology and Dilip Kumar: What is Blockchain Technology and How Does it Work?

The blockchain technology works in several steps:
- Transaction initiation: A transaction is created, such as a financial transfer, contract execution, or data recording;
- Transaction verification: Instead of a bank checking the balance, for example, a network of computers (nodes) verifies the transaction using cryptographic algorithms to ensure its validity;
- Blocking: The transaction is added to a block once verified;
- Block closure: Once completed, the block is closed using cryptographic hashing and added to the previous block, creating an unbreakable chain of records. Each new block strengthens the security of the entire system, making hacking virtually impossible.

2-2- Blockchain Applications in E-commerce:
The technology is used in many fields, and its use is expected to expand:
2-2-1- Cryptocurrencies or Digital Currencies: Cryptocurrencies, such as Bitcoin, are among the most prominent areas where blockchain technology is used in cryptocurrency exchange. This reduces traditional bank transfer fees and speeds up international transactions.
2-2-2- Electronic Wallets: Funds are transferred after knowing the recipient's wallet address. The transaction is recorded on the blockchain after being verified through computer calculations and remains stored on the network. This gives blockchain the advantage of complete transparency, eliminating intermediaries and avoiding additional fees. Users also control their personal data, reducing the risk of central data breaches.

2-2-3- Intellectual Property Protection: Works become non-fungible by encrypting them and linking them to a unique number via blockchain technology. This method preserves intellectual property even after the
work is purchased, as these tokens are considered non-fungible assets or possessions. The number of buyers of digital works based on non-fungible tokens increased by 66% in 2020 (Ziad Youssef, august 2021,)

2-2-4- Smart Contracts: Smart contracts are a protocol or software code on the computer that simplifies the mechanisms of conducting the contract and preserves it on the blockchain network. Smart contracts are not limited to large commercial transactions, but can be applied to the simplest types of transactions. The contracts are characterized by transparency and security and rely on a set of code instructions to make the transaction free from fraud and deception. They are self-execution of contracts and payments when the conditions are met automatically, such as sending payment to the supplier immediately upon confirmation of receipt of the shipment and without human intervention.

2-2-5- Supply Chain Tracking: Tracking the product journey from the factory to the end consumer, ensuring product authenticity (especially for luxury goods) and preventing counterfeit products;

2-2-6- Loyalty and Rewards Programs: By creating token-based loyalty point systems that are tamper-proof and unshakable, these systems are easy to manage and exchange.

2-3- Challenges of Blockchain in E-commerce:

Blockchain technology is considered one of the most challenging technologies:

2-3-1 Scalability: This is one of the most prominent challenges facing this technology and network. Data necessitates resorting to other solutions such as lightning networks and the Sharing Protocol by dividing data into segments that can be processed separately, while achieving higher transaction speeds than those currently available

2-3-2- Security Concern: Although blockchain is inherently secure, it remains vulnerable to a range of potential security risks, such as cyberattacks and software vulnerabilities. The solution lies in developing robust security protocols with encryption, implementing best security practices among users, and developing multi-layered defense systems that include regular network audits and penetration testing.

2-3-3 Regulation and Legislation: Regulatory and legal challenges are among the most prominent obstacles and limitations facing the expansion of blockchain use. This necessitates that business owners engage with regulatory bodies to establish a clear legal framework that supports innovation.

2-3-4 Public Acceptance and Adoption: Widespread acceptance of blockchain technology enables strategic partnerships with the public and private sectors to encourage innovative applications in various fields, such as
supply chain management, financial services, and even e-voting and education initiatives, in order to increase public adoption.

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3-Case study of Carrefour in the United Arab Emirates:

The United Arab Emirates is a leading country in adopting and implementing blockchain technology by following financial technology strategies, digital transformation and employing e-commerce, as it has moved from the experimental stage to the stage of full institutional adoption. Statistics indicate that the blockchain market will grow to approximately $8.9 billion in 2025, with projections of a 35% compound annual growth rate (CAGR) to reach $72.6 billion by 2032. The country's e-commerce market was valued at $8.8 billion in 2024 and is expected to reach $13.8 billion by 2029, driven by blockchain-based digital payment technologies.

Blockchain technology has emerged as a solution to address the complexities of global supply chains (Majid Al Futtaim, 2021), and Carrefour, which is run by Majid Al Futtaim, is considered one of the leading institutions that has succeeded in transforming this technology from a theoretical concept into an operational tool with the aim of enhancing food security and data transparency**.**

3-1- Introducing Carrefour :

With the rapid and significant transformation of the e-commerce sector in the UAE, the rise in internet usage, and the adoption of blockchain technology since consumer behavior changed, Carrefour emerged as a blockchain-based company under the management of Majid Al Futtaim. Founded in 1995, the company operates over 450 stores in 16 countries, serving more than 750,000 customers daily. Carrefour works to enhance trust and efficiency within the e-commerce ecosystem and supply chains. It is one of the world's largest retail chains, a French company operating in over 30 countries, including the UAE. Carrefour offers e-commerce services through its official website and mobile application and has sought to develop its digital services using cutting-edge technologies, including blockchain

3-2- Carrefour's applications of blockchain technology in e-commerce:

Carrefour began its technological journey in 2018 by joining the IBM Food Trust platform, a global network that relies on Distributed Ledger technology with the aim of addressing the crisis of loss of trust that may arise between the consumer and the producer as a result of the length of supply chains (IBM Newsroom, 2018). The actual transformation began in this year when Carrefour International launched its “Carrefour 2022” food transformation strategy. The strategic decision was to join the IBM Food Trust network. In 2021, Carrefour UAE launched the first blockchain food traceability solution in the region.

The coverage expanded to include not only food supplies but also tracking the carbon footprint of products, incorporating the technology into sustainability standards (UAE Digital Government, 2023). With the rapid adoption of the UAE's blockchain strategy, Carrefour moved from the testing phase to full implementation of its "Carrefour: Quality Line" products by 2025.

Regarding the technical and operational mechanism, Carrefour has adopted a technical system that ensures that every event in the product's lifecycle is recorded as an encrypted "block" that

cannot be modified. When the consumer scans the QR code, this information appears within 2.2 seconds (Carrefour Group, 2022), a process that previously took days in traditional systems (Solaiman & Pearson, 2022). The recorded data includes the following:

- Origin data: Farm location and harvest or slaughter date.
- Cold chain: Temperature monitoring during transport to ensure food safety.
- Certification: Quality certificates and Halal certifications.

Regarding the technology (IBM Food Trust system): Carrefour relies on a distributed ledger protocol where every transaction in the supply chain is recorded in encrypted blocks:

- Authentication at source: Farmers upload harvest data and health certificates.
- Logistics control: Container temperature and transport speed are automatically recorded via blockchain-linked sensors.
- Final verification: Consumers receive tamper-proof, verifiable information via a QR code.

The development of blockchain technology at Carrefour has gone through three phases:

- Foundation Phase (2018): Joining the IBM Food Trust global network as a founding member, establishing an international standard for food traceability.
- Phase of Application: Starting to track sensitive products (such as meat and poultry) to ensure their compliance with health and environmental standards.
- Phase of Regional Expansion (UAE): Majid Al Futtaim Group brought this experience to the UAE, connecting local farms to the digital platform, making Carrefour the first retailer in the region to allow customers to access origin data via smartphones.

The organization relies on a distributed ledger system that ensures:

- Absolute transparency: Immediate and accurate recording of the product's journey from farm to shelf with data that cannot be altered or deleted.
- Logistical efficiency: Rapid tracking of product routes and expiration dates, reducing waste and enhancing quality control.
- Building trust: Enabling consumers to self-verify quality and origin by scanning QR codes.

In seconds, they can access: the date of birth/harvest; temperature data during transport; halal and quality certificates; farm location; and processing details.

The development of Carrefour using blockchain technology in e-commerce can be represented by the following table:

Table 4: The evolution of blockchain use in Carrefour's foreign trade

years	Innovation	Using blockchain in e-commerce	Property
2018: Phase One	Carrefour launches the first blockchain trial in the food sector	The first blockchain application in Europe on the “Overn Chicken” product within the quality chain (FQC) by tracking the product’s history and details from farm to customer via a numbered QR code on the packaging	Trust and transparency

2018: Phase Two	Carrefour continues its Quality Lines initiative	Expanding the use of blockchain to a total of 8 product lines within the 2022 transformation plan	
2019	Expanding the blockchain network to more than 10 products: Carrefour Quality Line	Blockchain Ten is installed as a "transparent data layer" behind every digital product in e-commerce, linking complete tracking data via QR code to the website or store application	Transparency with non-alterable
2020	Norwegian salmon added to the blockchain network	The e-commerce product model leverages immutable data within the e-commerce interface to display the product journey before purchase	increased trust, security, and transparency
2021	Using the IBM Food Trust platform to track Carrefour chicken and other products in the Middle East	Blockchain supports supply chain data.	
2022	Carrefour announces the implementation of blockchain technology across all Carrefour Quality products	verifying the e-commerce system directly via blockchain	Transparency and cost reduction
-2022 2021	The Food Trust network expands its product range and geographical coverage	The use of blockchain via IBM Food Trust has expanded to include more than 100 products, such as organic food and baby products, within the objectives of the "Carrefour 2022" plan	Credibility, trust, and high efficiency
2022-2023: Phase One	Strengthening E-commerce with Blockchain Advantages	Blockchain technology has been integrated into e-commerce systems to improve digital supply chain management: online inventory tracking	Delivery speed, data accuracy, and product quality
2022-2023: Phase Two	Academic Studies on Blockchain Applications in E-commerce	Carrefour is considered an example of integrating blockchain into e-commerce platforms (simplified smart contracts) between the producer and the customer, even if Carrefour has not announced the full use of smart contracts	Transparency
2023	Expanding the use of	There is no official news about the use	Digital trust

	blockchain technology to track Carrefour Quality products on a wider scale within Europe and the Middle East	of blockchain in payments or smart contracts, despite product tracking through e-commerce interfaces and applications	
2024	Utilize food tracking platforms (such as IBM Food Trust) while adding new products to the network	Blockchain remains a "transparent data layer" behind the product, from which information is taken that is visible to customers when they purchase the product online or via mobile application	Trust and digital transparency
2025	Carrefour's focus is on the digital transformation of e-commerce (express shopping, express delivery, artificial intelligence)	There is no evidence of blockchain being used in electronic payments or digital contracts in e-commerce, despite blockchain data being incorporated into digital software	Trust in the data And transparency on the website

Source: Prepared by researchers based on: Carrefour website, Kaddouri Mohamed, and Belhabib Abdelkamel and -Majid Al Futtaim. (2021). Strategic digital transformation : Beyond food traceability. Corporate Vision 2025

3-3- Results of applying blockchain technology to e-commerce at Carrefour:

Reports issued by Majid Al Futtaim and independent studies indicate valuable results as follows:

-Regarding consumer confidence: Carrefour recorded a 20% increase in sales of blockchain-certified products compared to regular products (Majid Al Futtaim, 2021)، reflecting consumer awareness of quality. Studies related to the Carrefour app showed that 73% of consumers consider "traceability" a crucial factor in purchasing, and customer surveys in the UAE revealed that 75% of shoppers prefer to buy products bearing the "digitally verified track" tag as proof of product quality, which led to increased sales.

-Regarding control and added value: The technology succeeded in reducing food waste resulting from expiration and poor storage by 15% as a result of the accuracy of tracking logistical data. Customers also showed a willingness to pay an increase ranging from 2% to 10% for products that have complete transparency.

- Regarding operational efficiency: Technology has contributed to reducing data verification time and the speed of product recall in health emergencies from days to mere seconds. As for tracking speed, the time required to trace the source of a product has decreased from 7 days in the traditional system to only 2.2 seconds (IBM Newsroom, 2018).

-Reducing waste and improving business performance: Data accuracy has contributed to reducing waste in fresh food by 12% to 15% as a result of real-time inventory management (Carrefour Group, 2022).
- Improved quality of e-services: Technology has proven highly effective at Carrefour UAE by providing accurate and transparent information.
- Rapid crisis response: Tracing the source of contaminated products is now quick, reducing food waste and preventing illness or even death.
- Supply chain efficiency: Reduced paperwork and faster auditing processes between Carrefour, suppliers, and regulatory bodies.

3-3- Carrefour's future prospects: 2026 and beyond:

Carrefour focused on several aspects to consider:

3-3-1-Digital expansion: Carrefour is moving towards an "integrated digital economy" where blockchain is combined with artificial intelligence (AI) to accurately predict demand and reduce food waste by more than 15%, and is also moving towards integrating blockchain into a more complex and comprehensive technological system;

3-3-2-Green Blockchain and Sustainability: Blockchain is now being linked to tracking and focusing on the carbon footprint of each product in Carrefour to support the UAE's sustainability initiatives. The system will allow consumers to see how sustainable a product is and the number of emissions resulting from its transportation, in line with the UAE's goals for climate neutrality 2025 (UAE Digital Government, 2023 Net Zero 2050).

3-3-3-Integration with Artificial Intelligence (AI Integration): It will later work on using big data stored on the blockchain to feed AI models with the aim of predicting crises in supply chains before they occur, and adjusting demand levels automatically to avoid shortages or surpluses.

3-3-4- Smart Contracts: This is done by automating payments to suppliers once the blockchain confirms the arrival of the shipment and its compliance with quality standards, which speeds up the economic cycle and reduces commercial disputes.

3-3-5- Expanding the scope of traceability: By moving from tracking only food products to tracking non-food products (such as clothing and textiles) to ensure quality and apply fair trade standards.

To date, there is no clear evidence that Carrefour uses blockchain for cryptocurrency payments or in its online payment system. Its primary use is for tracking goods and improving the transparency of the e-commerce experience.

Conclusion:

E-commerce has witnessed significant and rapid growth and development worldwide for years, and this growth is expected to increase even further, especially with the introduction of artificial intelligence, machine learning, the Internet of Things, and the use of various technologies, particularly blockchain, the subject of this research. This has led to a more successful customer

experience, continuous sales, and increased profits. Despite the widespread and ongoing role of blockchain in improving e-commerce and the success of buying and selling transactions, some obstacles and drawbacks may exist. However, these do not negate its importance in e-commerce and the unique shopping options and experiences it has provided for consumers, companies, and even the economy and society at large.

Blockchain technology has contributed to the development of e-commerce by enhancing security, increasing trust, reducing costs, and improving the quality of services. The study also proved its role in supporting e-commerce and developing the digital economy. While some see blockchain as only related to digital currencies, Carrefour has proven it to be a vital tool for "information democracy," enabling the average consumer to have the same amount of information as any official, making "food safety" verifiable at the touch of a button.

Blockchain technology has helped improve Carrefour's e-commerce performance, as well as providing transparency and security by tracking products from farm to consumer through a decentralized, tamper-proof ledger. This blockchain data is then displayed directly on e-commerce platforms via QR codes or visual tracking.

Results:

- Blockchain technology has effectively contributed to the development of e-commerce by improving security, transparency, and trust, thus helping organizations enhance their competitiveness;
- Technology has helped increase customer confidence in e-commerce, improve service quality, and boost online sales;
- Experience has shown that the various characteristics of technology have made it a strong pillar for protecting transactions, reducing opportunities for fraud and hacking, enhancing transparency, and supporting transactions that comply with fairness and quality standards.
-Applied studies have shown that blockchain technology has contributed to enhancing transaction security, reducing costs, improving operational efficiency, and increasing transaction speed, making it an important tool for developing and improving e-commerce.
-The application of blockchain in e-commerce has helped develop payment systems and improve the quality of electronic services.
- Blockchain at Carrefour UAE is not just a "technological feature," but a trust-building tool that has transformed the relationship between merchant and consumer into one based on reliable and tamper-proof data.

Recommendations:

- The need to increase investment in this technology, develop digital infrastructure, and encourage institutions to use it and similar technologies such as artificial intelligence and big data;
- Although blockchain is considered inherently secure, it remains vulnerable to a range of risks such as cyberattacks and software vulnerabilities. Therefore, it requires strong encryption

systems, security protocols with best security practices, and multi-layered defense systems that include regular network audits;

-Regulatory and legal challenges are among the most significant obstacles to the widespread adoption of blockchain. It is essential for blockchain companies to engage with regulatory bodies to ensure the development of a clear legal framework that supports innovation while overcoming bureaucratic hurdles.

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