

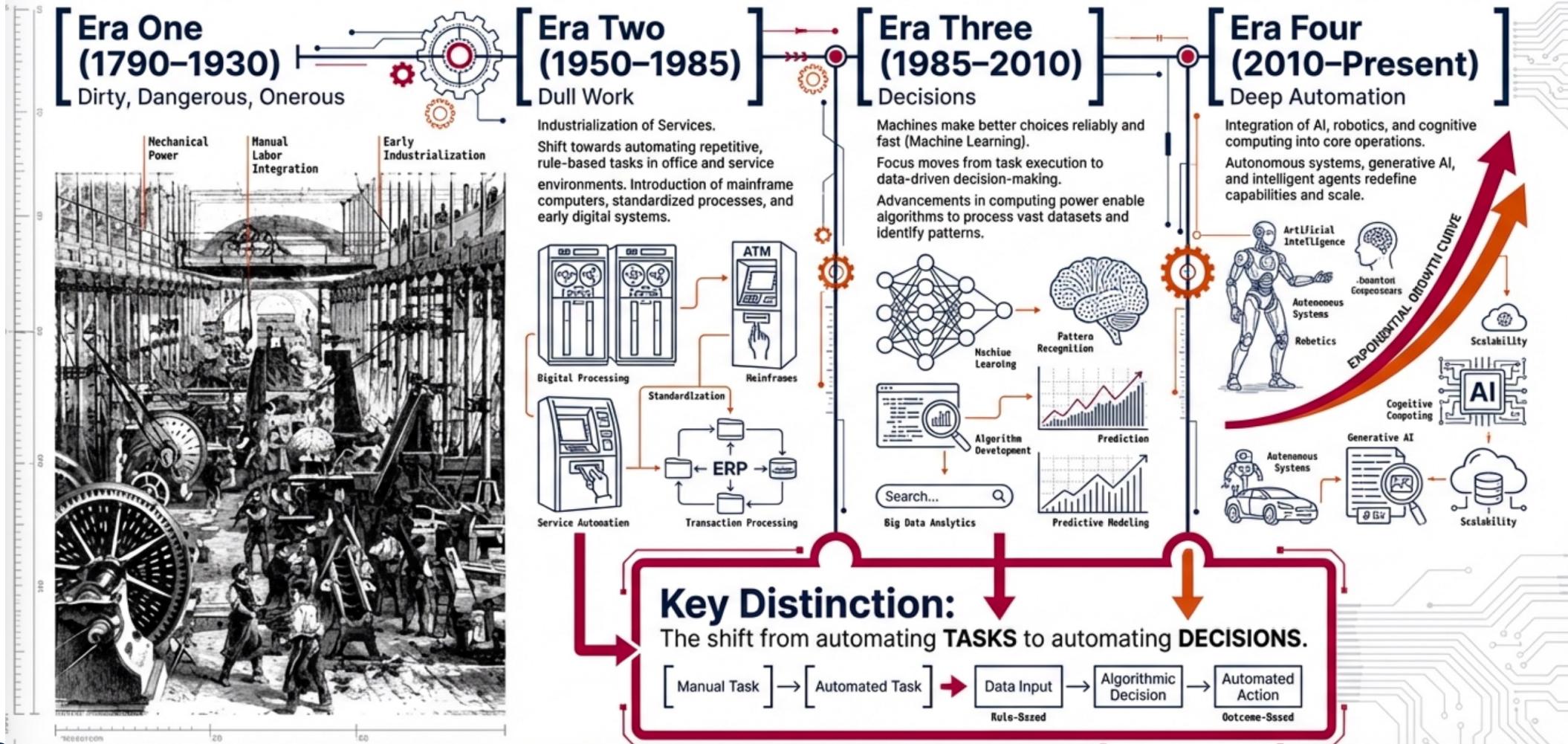


AI&DATA Transformation of F&B Lecture I: Enabling Technology

DESIGNING TOMORROW



The Age of the Exponential: A Timeline of Automation (1790–2022+)





Technology is an enabler

But (alone) it's not enough

120 years ago American factories began to electrify their operations, igniting the Second Industrial Revolution

Productivity did not increase in those factories for the following 30 years

Nowadays productivity in office works (e.g. administrative tasks) grow less than in the production side even if the pervasivity of the technology is higher.

POSSIBLE REASONS?

?

What is productivity?

How it is impacted by Tech and Why it is important?

$$\text{Productivity} = \text{Output} / \text{Input}$$

Technology



- **Efficiency:** doing the same with less
- **Effectiveness:** doing new (more) with the same



- Labor productivity measures the output per worker in a period of time (e.g. a hour, a year).
- Growth in labor productivity is usually associated with growth in revenues, wages and living standards within an economy

The tech enablers

List of emerging (or already emerged, or that could already be seen as commodity) technology to watch

- Cloud computing & next Gen ERP
- Robotics & Additive Manufacturing
- Internet of Things
- Augmented Reality

→ The new commodities

- Big Data & Analytics
- Machine Learning & Artificial Intelligence
- Blockchain

→ Game Changer

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Cloud computing

What is and why is important for F&B?

- Cloud computing refers to the delivery of computing resources (such as storage, computing power, and software) over the internet.
- Instead of having to invest in and maintain their own physical servers and infrastructure, businesses can access these resources on-demand from a cloud provider.
- This can lead to cost savings, as businesses only pay for the resources they actually use, and can scale up or down as needed.
- Cloud computing also allows for greater flexibility and collaboration, as employees can access the same data and applications from anywhere with an internet connection.
- It's everywhere and it's no more a real "choice" (e.g. the on premise version of some SW is or is planned to be no more available in the near future)
- A back to the past jump in term of "ICT" architecture
- Concerns regarding security still remain (even if are not justifiable)

Cloud computing

What is and why is important for F&B?

- Cloud computing refers to the delivery of computing resources (such as storage, computing power, and software) over the internet.
- The global cloud computing market size reached USD 781B in 2025 and is projected to reach USD 2.9 trillion by 2034, at a CAGR of 15.7%.
- North America dominates with 52% market share in 2025. Amazon Web Services leads with 32% of the public cloud market.
- Cloud computing enables greater flexibility and collaboration, with employees accessing data and applications from anywhere.
- It's everywhere and it's no more a real 'choice' - by 2026, edge data centers expected to grow to 1,200 (vs 250 in 2022)
- Businesses are optimizing cloud infrastructure for AI - focus in 2026 is on AI optimization
- Europe balances digital-transformation with data-sovereignty rules (hybrid architectures)

Cloud computing

What is and why is important for F&B?

- Cloud computing is transforming the Food and Beverage (F&B) industry by offering scalable, flexible, and cost-effective solutions to manage operations, enhance customer experience, and optimize supply chains for example:

Digital Twins for Supply Chain Optimization

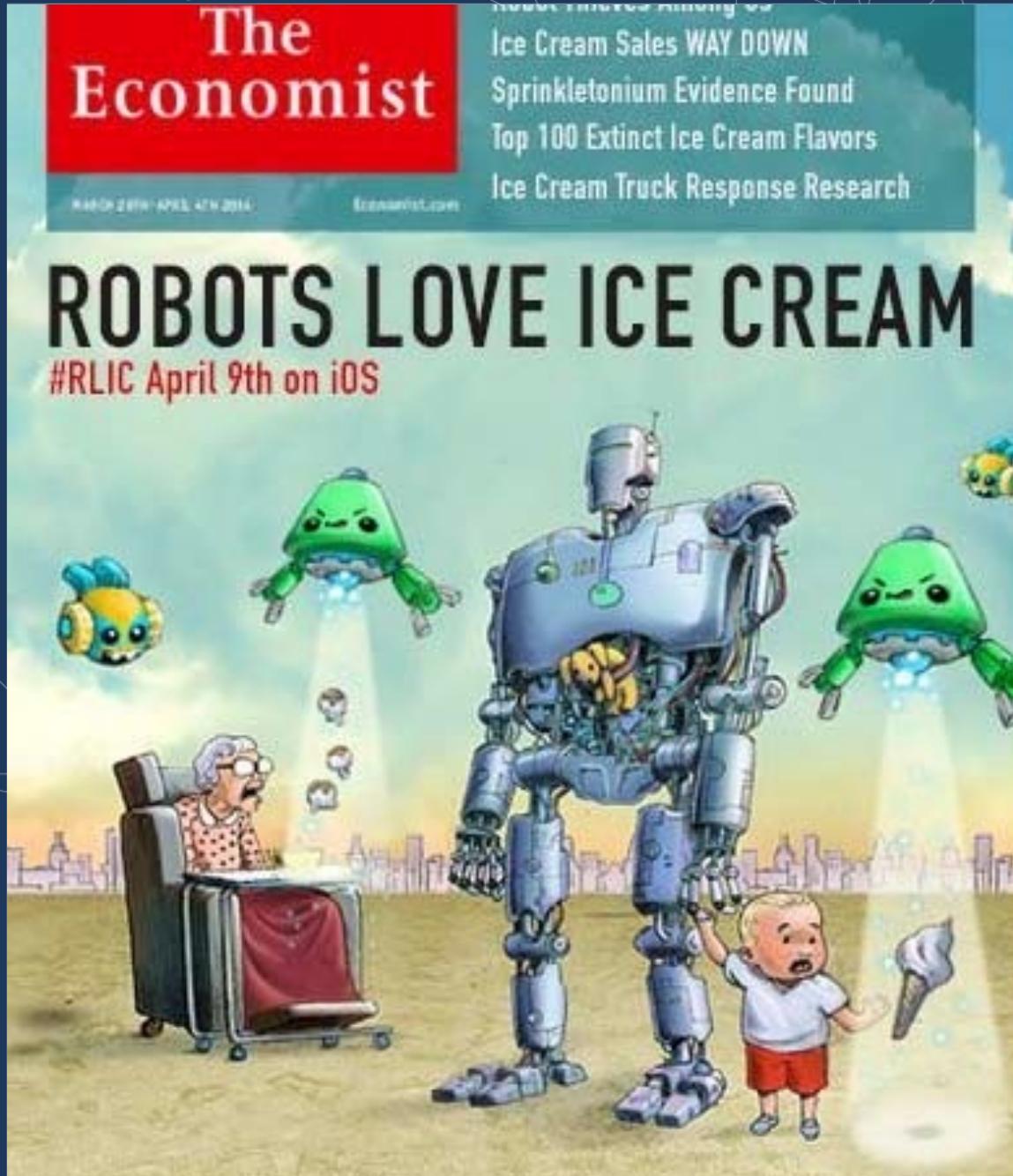
The concept of digital twins, which involves creating a virtual replica of the physical supply chain, is gaining traction in the F&B industry. Hosted on cloud platforms, these digital twins can simulate different scenarios, predict the outcomes of various decisions, and identify the most efficient supply chain configurations. This approach enables F&B companies to make data-driven decisions to improve delivery times, reduce costs, and enhance supply chain resilience.

Personalized Customer Experiences

Cloud computing allows F&B businesses to collect and analyze customer data to offer personalized experiences. From customized menus based on dietary preferences and past orders to targeted promotions and loyalty programs, cloud platforms enable companies to engage customers in a more meaningful way. This personalization can lead to increased customer loyalty, higher spending, and differentiation in a competitive market.

Smart Kitchen Management

Cloud-based smart kitchen management systems are revolutionizing how F&B operations are run. These systems can monitor kitchen equipment in real-time, manage inventory, automate procurement, and ensure food safety compliance. By optimizing kitchen operations, F&B businesses can reduce operational costs, minimize food waste, and improve service speed and quality.



Robotic & Additive Manufacturing

- Imitation of humans - now with humanoid robotics 'right around the corner' (NVIDIA CEO)
- Collaborative workforce (cobots) - 31% of F&B manufacturers investing in robotics in 2025
- Robot installations in U.S. F&B sector up 21% in 2024 (IFR World Robotics 2025)
- New applications: Drone picking, autonomous delivery, AMR technology at larger plants

Robotic & Additive manufacturing

What is and why is important for F&B?

- Additive manufacturing, also known as 3D printing, refers to a process of creating a physical object by adding successive layers of material.
- Additive manufacturing can be used to produce a wide range of objects, from small components to large structures, and can be applied to a wide range of industries, including aerospace, healthcare, and consumer goods.
- Additive manufacturing allows for faster prototyping, more efficient use of materials, and the ability to produce complex geometries that cannot be produced using traditional manufacturing techniques.

In Food and Beverage there are several applications that we can discuss

- Customized food production: Additive manufacturing can be used to create customized food products that are tailored to individual dietary needs and preferences.
- Food waste reduction: Additive manufacturing can be used to reduce food waste by creating products using only the exact amount of ingredients needed.
- On-demand production: Additive manufacturing can be used to produce food products on-demand, reducing lead times and inventory costs. FoodTech market projected to reach \$350B by 2025.

Robotic & Additive Manufacturing

NEWS RELEASE 24-AUG-2021

Raising the steaks: First 3D-bioprinted structured Wagyu beef-like meat unveiled

Researchers at Osaka University use 3D-bioprinting to create structured cultured meat like the complex texture of Wagyu beef, which may provide an environmentally friendly and sustainable method for producing cultured meat alternatives

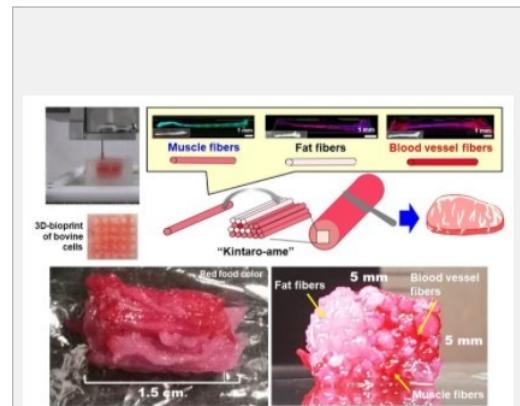
Peer-Reviewed Publication

OSAKA UNIVERSITY



Print Email App

Osaka, Japan – Scientists from Osaka University used stem cells isolated from Wagyu cows to 3D-print a meat alternative containing muscle, fat, and blood vessels arranged to closely resemble conventional steaks. This work may help usher in a more sustainable future with widely available cultured meat. Wagyu can be literally translated into “Japanese cow,” and is famous around the globe for its high



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More on this News Release

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OSAKA UNIVERSITY

JOURNAL
Nature Communications

FUNDER

DOI
[10.1038/s41467-021-25236-9](https://doi.org/10.1038/s41467-021-25236-9)

KEYWORDS

APPLIED SCIENCES AND ENGINEERING

BIOCHEMISTRY

BIOMECHANICS

Robotic & Additive Manufacturing

DayTwo offers a personalized nutrition service based on analyzing your gut microbiome to predict how different foods affect blood sugar levels, aimed at improving health and managing conditions like diabetes. The process involves a medical sample and results in custom dietary recommendations through an app.

Updated on January 31, 2024 • 14 min read

DayTwo Review: Unlock The Secrets of Your Gut Microbiome

Written by [Ada Sandoval](#)

[7 sources cited](#)

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Key Takeaways

- Pros include personalized recommendations; cons need blood test for accuracy - [Jump to Section](#)
- Provides a microbiome report and a personalized diet plan to regulate blood sugar - [Jump to Section](#)
- Results include detailed reports and diet changes to improve gut health - [Jump to Section](#)
- The test is accurate, using advanced sequencing for gut microbiome analysis - [Jump to Section](#)
- DayTwo offers in-depth blood sugar control guidance compared to other tests - [Jump to Section](#)
- DayTwo is ideal for diabetes and weight loss through diet management - [Jump to Section](#)
- The cost ranges from \$349 to \$499, but exact pricing requires company contact - [Jump to Section](#)

Robotic & Additive Manufacturing

Home > Food Tech

A major highlight from the CES 2024 event is the introduction of Chef Moto by Moley Robotics, a robotic chef capable of preparing and cooking elaborate meals from scratch.



10 Top Trends and Innovations from CES 2024

IVONNE KINSER | JANUARY 15, 2024



Barilla Continues to Develop Pasta 3D Printer, Envisions Gourmet Customization



[Image: Spadellatissima.com]

"When the project was first launched, the time needed to make the pasta was much longer – it was 20 minutes to print one piece of pasta and today we can print four pieces in about two minutes," Fabrizio Cassotta, R&D research manager for meal solutions at Barilla, told just-food. "We are now working to improve the time to print; our target is to print one full plate of pasta in two minutes."

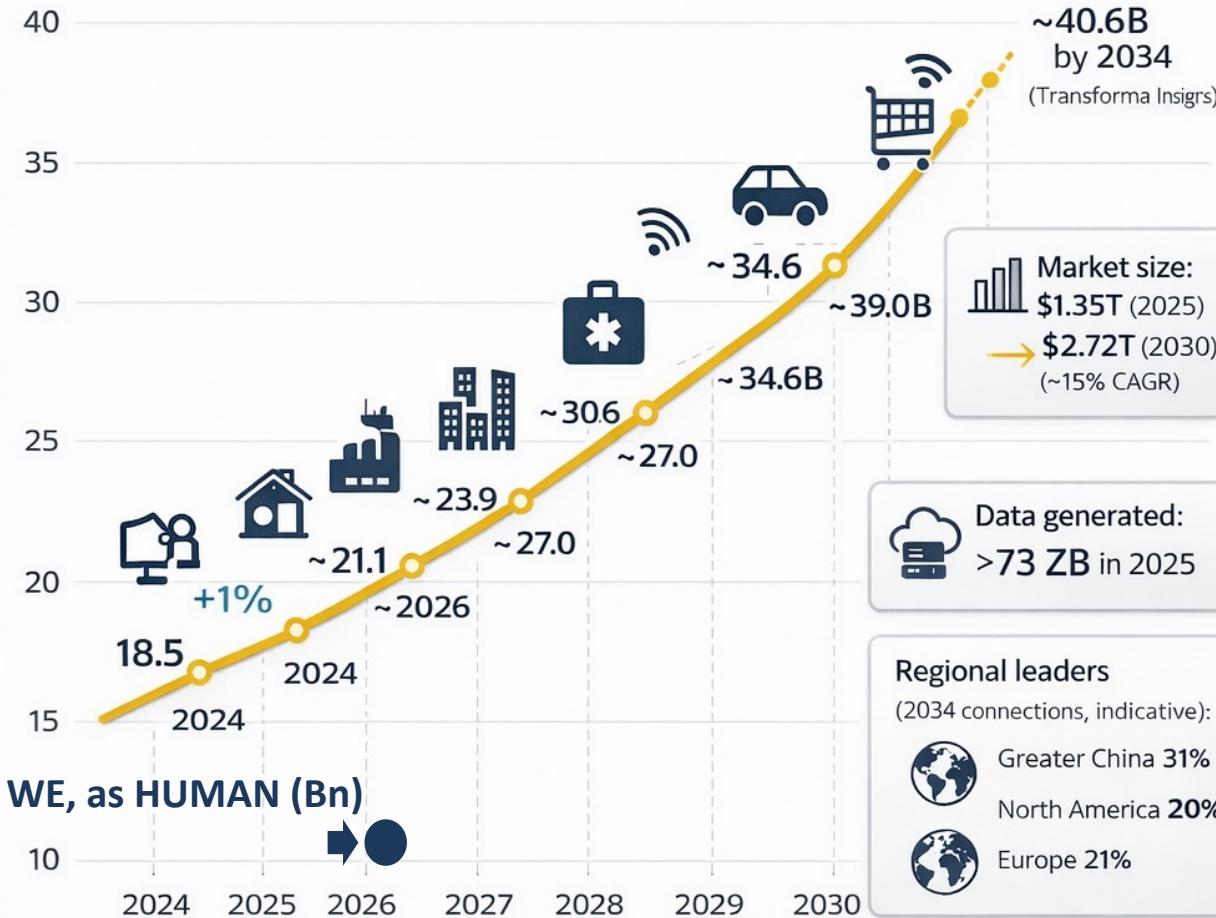
"All of these experiences will help us better understand the limits of personalisation because there will probably be some limits," continued Cassotta. "We cannot forget that 3D printing technology is still very new and we are the first company in the world to print 3D pasta prototypes. So it has been a real challenge to transform the standard 3D printing technology and apply it to pasta making."



www.spadellatissima.com

Active Connected IoT Devices

(IoT Analytics definition)



Internet of Things

Our language is already “merely interesting”

- Every product can communicate with computers
- Information can be captured and go where it can produce more value
- Smart connected products enable business model innovation
- New challenges in designing products and services
- Nothing really new (i.e. barcode scan) .. What is new is the dimension of the phenomena

Internet of Things

What is and why is important for F&B?

Here there are a few example of how IoT is used in the food and beverage market segment is in different areas:



Food safety and quality control

IoT technologies in the food and beverage industry are used to monitor and control food safety and quality.

Sensors track conditions like temperature and humidity during the food's journey from production to delivery, helping prevent spoilage and ensuring safety standards are met. For example, IoT sensors in transport vehicles maintain optimal conditions for food preservation, reducing the risk of contamination and ensuring consumer safety.



Supply chain management

Food and beverage companies can use IoT technology to track the movement of goods from suppliers to warehouses to retail locations, and forecast future demand. This allows the company to have a real-time view of their entire supply chain, which can help them to make more informed decisions about ordering and production, and to identify and address any bottlenecks or inefficiencies.



Enhanced Agricultural Practices

Utilizing IoT devices such as soil sensors and drones, smart farming integrates enhanced practices for sustainable agriculture. This includes precision monitoring of soil moisture and weather patterns. Additionally, vertical farming, integrated within structures like skyscrapers, employs IoT systems to control light, nutrients, and water supply. This optimized environment boosts yield per square foot, marking a significant advancement in agricultural efficiency.

Augmented Reality



- Connected IoT devices growing 14% to reach 21.1 billion globally in 2025
- Projected to exceed 25B devices in early 2026, heading toward 40B before 2030
- IoT market: USD 1.35 trillion (2025) to \$2.72 trillion by 2030 (15% CAGR)
- Greater China leads with 6.9B connected devices, followed by North America (4.3B)
- IoT devices expected to generate over 73 zettabytes of data in 2025

Augmented Manufacturing

What is and why is important for F&B?

- Augmented Reality (AR) is a technology that enhances or augments a user's perception of the real world by overlaying digital information, such as images, text, and sounds, onto the user's view of the real world.
- AR can be experienced through a variety of devices such as smartphones, tablets, smart glasses, and head-mounted displays.
- AR can be used in a wide range of applications, including education, entertainment, healthcare, manufacturing, and retail.
- AR can be used to enhance the user's understanding of a product or service, to provide interactive and engaging information, and to simulate real-world scenarios in a safe and controlled environment.

In Food and Beverage there are several applications that we can discuss

- Virtual food product testing: Augmented reality can be used to simulate the taste, texture and appearance of a food product before it is actually produced, allowing for faster and more accurate product development.
- Training and education: Augmented reality can be used to train employees on food handling, preparation and packaging techniques in a safe and interactive way.
- Marketing and customer engagement: Augmented reality can be used to enhance the consumer experience, by providing interactive and engaging information about a product or brand.

The tech enablers

List of emerging (or already emerged, or that could already be seen as commodity) technology to watch

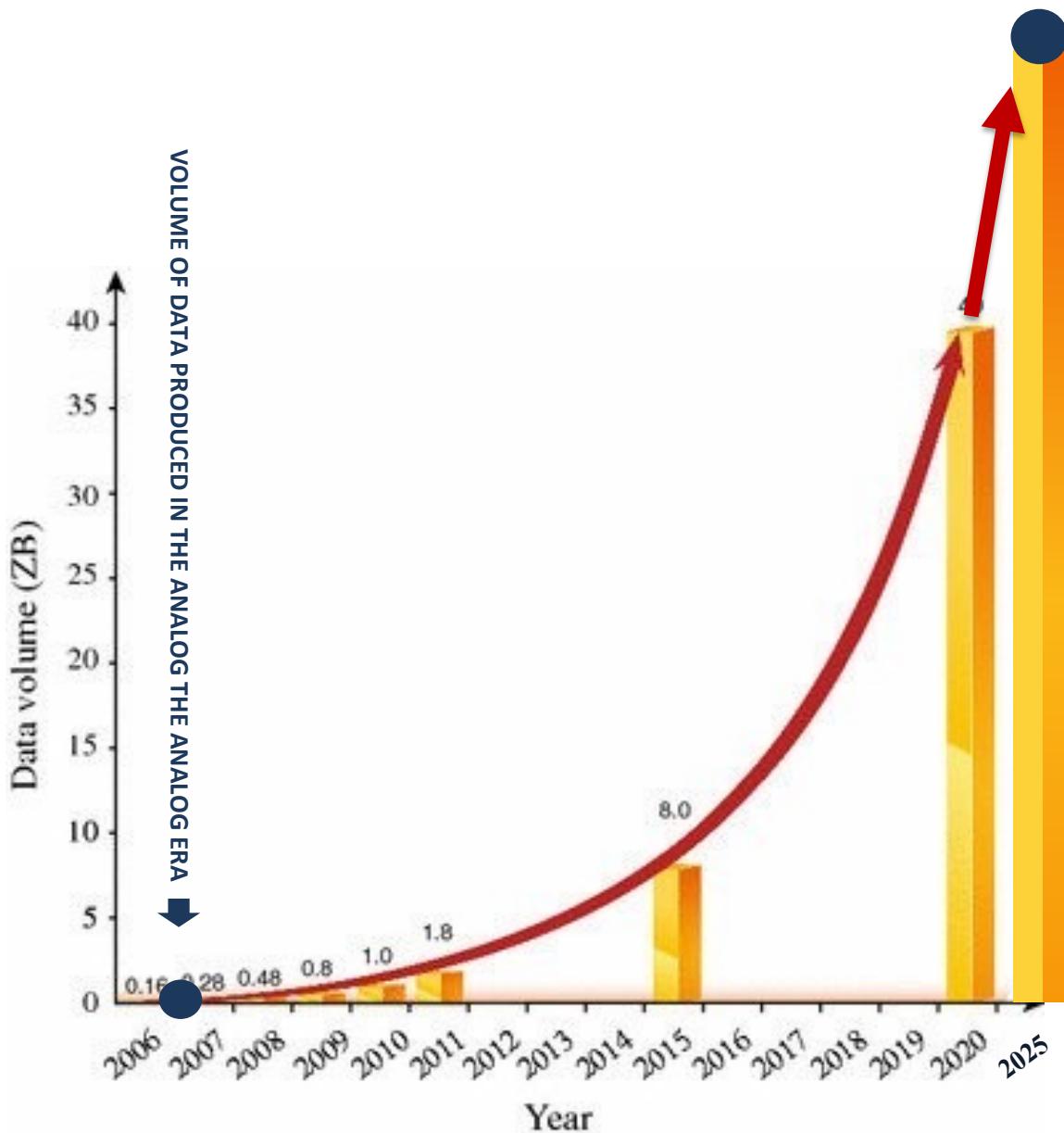
- Cloud computing & next Gen ERP
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→ The new commodities

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→ Game Changer

221ZB in 2026!



Big Data

It's big beautiful or not?

Trends

- Cheaper and smaller sensors
- Processing power and memory increase and are becoming faster
- The communication infrastructure can handle more information
- Declining storage costs
- Ubiquity
- More usable interfaces

New Frontiers

- Observing product in use
- Associations and pattern recognition

Multiple domains of application

- Predictive maintenance
- Customer profiling
- Image recognition

Big Data & Synthetic data

What are and why are important for F&B?

- **Big data** refers to the large, complex, and diverse data sets that are generated by businesses, organizations, and individuals. These data sets can come from a wide variety of sources, such as social media, IoT devices, and transactional systems, and can be structured, semi-structured, or unstructured. The volume, velocity, and variety of big data can make it difficult to process and analyze using traditional methods, which is why specialized tools and techniques, such as Hadoop, Spark, and machine learning, are often used to extract value from big data.
- On the other hand, **synthetic data** refers to data that is artificially generated by machines, rather than being collected from real-world sources. This data can be used to train machine learning models, test algorithms, or create simulations. Synthetic data can be particularly useful in situations where real-world data is difficult or impossible to obtain, such as in certain scientific research or when working with sensitive data. Synthetic data can also be useful in situations where the real-world data is not enough to train a model, in this scenario synthetic data can be generated to augment the real-world data.
 - In summary, big data refers to the large, complex and diverse data sets that come from real-world sources, while synthetic data refers to the data that is artificially generated by machines for specific purpose such as training or testing.

Big Data & Synthetic data

What are and why are important for F&B?

- Big Data analytics market: USD 348B (2024) to USD 962B by 2032 (CAGR 13.6%). Global data volume: 181 ZB in 2025, 221 ZB projected for 2026 - 40 ZB of additional data produced annually. Nearly 30% of global datasphere consists of real-time data. Tools like Hadoop, Spark, and ML extract value from big data.
- Synthetic data: artificially generated by machines for training ML models or testing. Critical when real-world data is difficult to obtain or insufficient. By 2026, GenAI and RAG moving from prototypes to standardized enterprise patterns
- Over 97% of businesses have invested in Big Data, yet only 40% use analytics effectively. 65% of organizations have adopted or are investigating AI for data analytics.

Big Data & Synthetic data

What are and why are important for F&B?



Market segmentation

Big data revolutionizes the food and beverage industry by analyzing customer purchasing behavior. Retailers and manufacturers utilize data on product preferences, purchase frequency, and pricing to optimize inventory management and pricing strategies. For instance, a grocery chain leverages customer purchase history to stock popular products and identifies purchasing patterns to tailor marketing campaigns and in-store promotions.



Optimize supply chain efficiency

Food and beverage companies can track and analyze data on suppliers, inventory, and transportation to identify bottlenecks and inefficiencies in the supply chain. By identifying these issues and implementing solutions, companies can reduce costs and improve their ability to quickly respond to changes in demand.



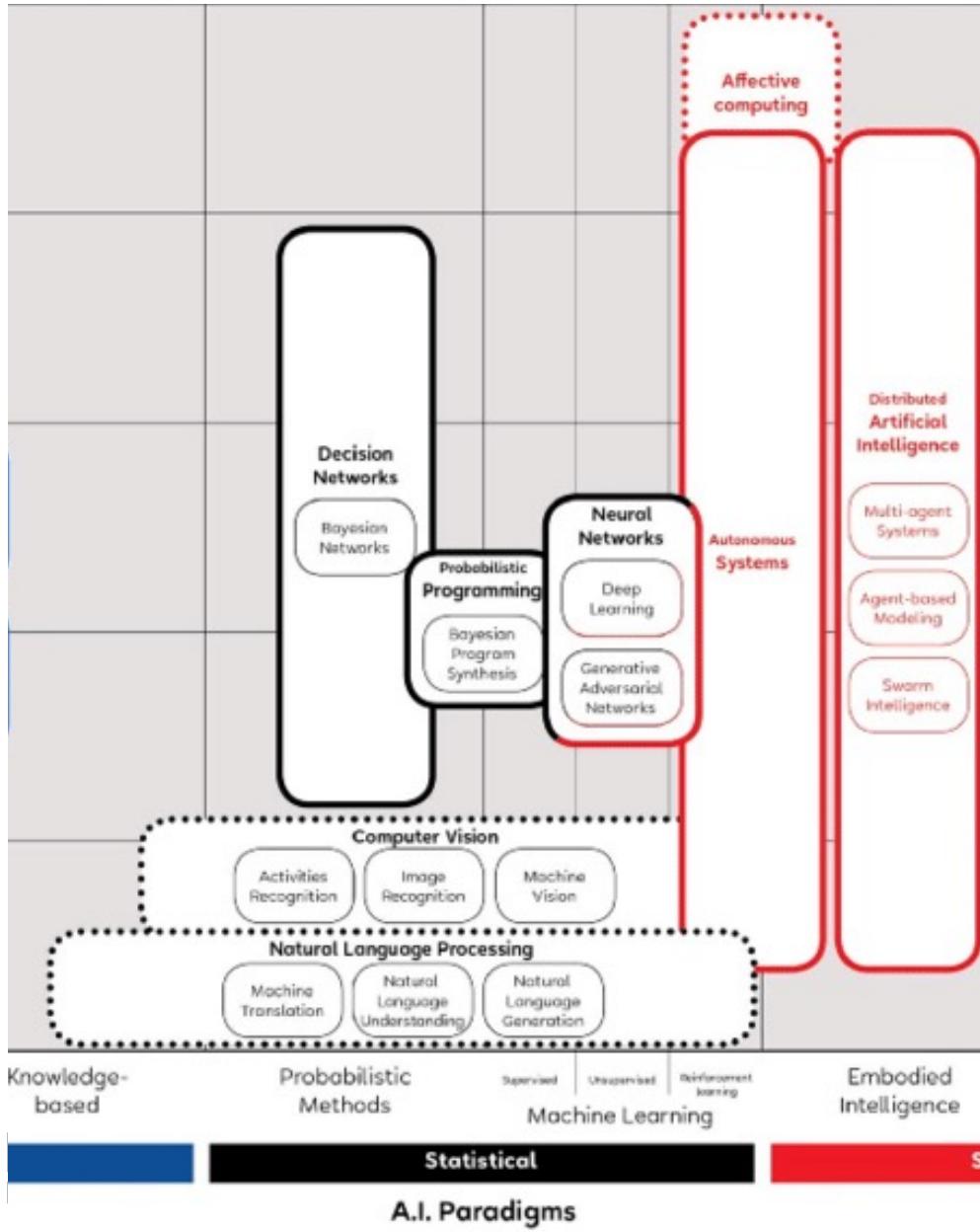
Dynamic Pricing Models

In the food and beverage industry, Big Data analytics enable dynamic pricing models that respond to real-time demand, competitor pricing, and market trends. By leveraging this data, F&B companies can adjust prices dynamically to maximize sales and profits. This approach optimizes pricing strategies, ensuring competitiveness and responsiveness to changing market conditions.

Machine Learning & A.I.

Science Fiction or reality?

- Algorithms can produce for themselves the rules programmers cannot specify
Implications for labor, liability, ethics
- Brute force vs Machine learning: the classical example of the difference between DEEPBLUE (1997) and ALPHAGO (2016)
- AI in F&B market: USD 13.4B (2025) to USD 67.7B by 2030 (CAGR 38.3%) 71% of organizations regularly use GenAI; 92% of Fortune 500 have adopted AI
- 83% of F&B manufacturers planning to increase AI investments in 2025
- AI agents: 40% of enterprise apps will include task-specific AI agents by end of 2026 (Gartner)



Machine Learning & A.I. (un) fortunately is becoming a reality

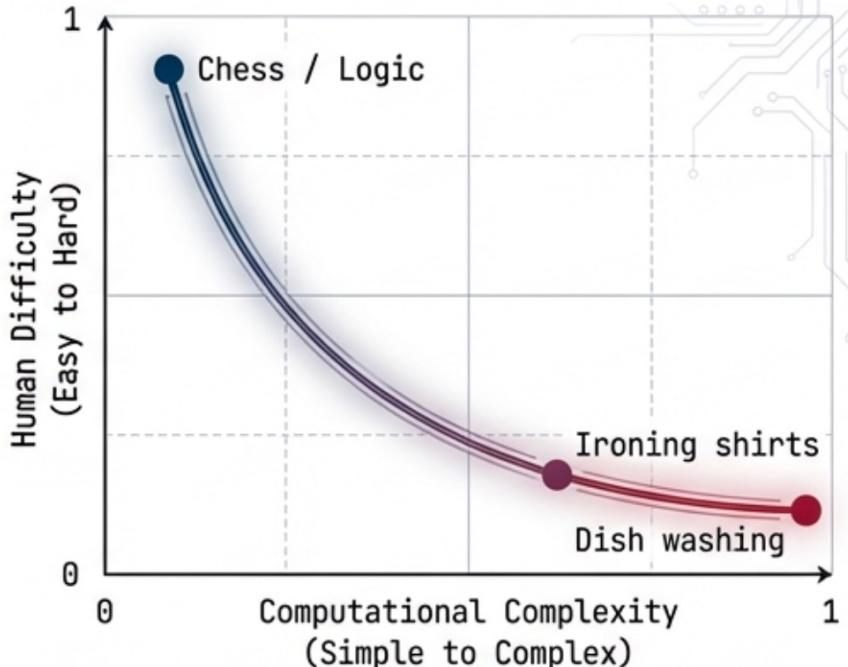
- What's happening to AI in the last year is explainable with some paradoxal view:

"Human knowledge of how the world functions and capability are, to a large extent, beyond our explicit understanding"

- The **Polanyi paradox** is a concept proposed by the philosopher Michael Polanyi in his book "Personal Knowledge: Towards a Post-Critical Philosophy." The paradox refers to the idea that, while we may claim to be able to know something objectively, our own personal biases and assumptions inevitably play a role in shaping our understanding and interpretation of that knowledge.
- In other words, the paradox suggests that **true objectivity is impossible**, as we can never fully separate our own subjective experiences and beliefs from our understanding of the world. This can be seen in a variety of fields, from scientific research to political decision-making, and has important implications for how we approach knowledge and understanding.

The Moravec Paradox

Skills vs. Computational Resources



Sensorimotor skills are computationally complex but human easy.
Abstract thought is computationally simple but human hard.

Machine Learning & a.i. The END OF THE Moravec Paradox ?

High-level reasoning requires very little computation, but low levels sensorimotor skills require enormous computational resources - but humanoid robotics may be 'right around the corner'
(Jensen Huang, NVIDIA CEO, 2025)

Machine Learning & A.I.

(un) fortunately is becoming a reality

- The Moravec Paradox is a concept proposed by the roboticist Hans Moravec, which states that while it is relatively easy for computers to perform tasks that are difficult for humans, such as complex calculations and logical reasoning, it is much more difficult for computers to perform tasks that are relatively simple for humans, such as recognizing objects or navigating through a physical environment.
- In other words, the paradox suggests that tasks that are easy for humans to perform, such as recognizing speech, visual perception, and common sense reasoning are computationally complex, while tasks that are difficult for humans such as complex mathematical calculations, are relatively simple to compute.

Machine Learning & A.I.

Reality check

Task that machine cannot do and cannot learn

Abstract tasks

- Inductive reasoning
- Intuition
- Creativity
- Judgment
- Persuasion

Manual

- Sensorimotor skills
- Manipulation
- Situational adaptation

Task that machine could afford doing

- Task that provides clear feedback with clearly definable goals and metrics
- No need for detailed explanation of how the decision was made
- No long chains of logic or reasoning that depend on common sense or on background knowledge unknown to the algorithm
- The phenomenon being learned is stable over time (otherwise retraining needed)
- Distribution of future test examples is similar to the distribution of training example
- A tolerance for error exists!

Machine Learning & A.I.

Reality check – 2026 statements

- **AI WILL NOT REPLACE HUMANS, WILL PROBABLY REPLACE HUMANS THAT WILL NOT USE AI**
- **FROM BEING ABLE TO DO SOMETHING TO BEING ABLE TO ASK 'SOMEONE' TO DO IT - AI AGENTS EMERGE (40% of apps by 2026)**
- **ENTERPRISE AI: FROM \$1.7B TO \$37B SINCE 2023 - NOW 6% OF GLOBAL SaaS MARKET**
- **EU AI ACT: FULLY APPLICABLE AUG 2026 - AI LITERACY REQUIRED SINCE FEB 2025**

Machine Learning & A.I.

What are and why are important for F&B?

Types of AI, listed and explained by AI itself

- **Reactive Machines:** These are the most basic type of AI, which are designed to react to specific situations in a pre-programmed way. They do not have the ability to form memories or learn from past experiences.
- **Limited Memory:** These types of AI can take into account past experiences and use them to inform future decisions. This allows them to learn from their surroundings and adapt to changing conditions.
- **Theory of Mind:** This type of AI is able to understand and represent the mental states of other agents, and can be used to model social interactions and communication.
- **Self-Aware:** This type of AI is capable of self-awareness, and is able to understand its own mental states and emotions.
- **Generative Pretrained models:** This type of AI is trained on a large dataset, and then fine-tuned on a smaller dataset to generate new data. They are trained to generate new examples that are similar to the examples it has seen before, like images, text, and music.

Machine Learning & A.I.

What are and why are important for F&B?

- **Predictive Maintenance:** AI can be used to predict when equipment in a food and beverage factory is likely to fail, allowing for proactive maintenance and reducing downtime.
- **Quality Control:** AI-based image recognition systems can be used to inspect food products for defects, ensuring that only high-quality products reach consumers.
- **Supply Chain Optimization:** AI-based algorithms can be used to optimize logistics and distribution, reducing costs and improving efficiency.
- **Personalization:** AI can be used to personalize the food and beverage products and services to individual customers, such as recommending products based on their preferences and dietary restrictions.
 - **Nestle:**
 - has used AI-based algorithms to optimize their supply chain and logistics
 - uses a digital twin of their supply chain to simulate different scenarios and optimize their logistics, reducing costs and improving delivery times.
 - has cut down the average project duration from 33 months to as low as 6-9 months in some categories by streamlining its R&D process.



BlockChain

Trust at discount price

- It is a shared, trusted, public ledger that everyone can inspect, but which no single user controls.
- Bitcoin's blockchain ledger prevents double-spending and keeps track of transactions continuously.
- The spread of blockchains is bad for anyone in the "trust business" => centralised institutions which are deemed sufficiently trustworthy to handle transactions (e.g. banks, clearing houses and government authorities)

In the food and beverage industry

- The ability for consumers to identify high quality food is currently prohibited by information asymmetry: lemon market => consumers adversely selecting lower quality (or unsafe) food in the absence of high quality information relating to food quality.
- Through the use of a QR code and a smartphone, customers can scan a package at the Point of Sale and receive a full and complete history of their food's journey from Farm to Fork
- Companies can no longer rely on generalized terms such as "healthy" or "organic" in order to signal value => The blockchain provides a method of substantiating these previously unsubstantiated claims
 - Blockchain in agri-food: highest adoption rate (41.7%) among digital tools for transparency and traceability
 - Walmart uses blockchain for real-time food origin and quality monitoring - from logistics to shelf

Geek Feta cheese case: BC-based traceability profitable when consumers pay premium for traceable products

Takeaways

Complementary technologies (e.g. no value from IoT, without Big Data&Analytics)

- Automation logics in decision-making: 71% of organizations regularly use GenAI (2025)
- Higher performance: businesses report 24.7% productivity increase, 15.7% cost savings with AI
- The work of managers changes: Chief AI Officer roles now in 61% of enterprises
- EU AI Act fully applicable Aug 2026 - governance and compliance become strategic priorities
- For some tasks automation is not worthwhile but if the cost will fall there will be no reasons for not adopting widely