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Research Note

Illusion or reality? Building a metaverse community focused on value creation in the agricultural sector

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ABSTRACT

Obsolete models, lack of professionalisation and an environment characterised by continuous changes have turned out to be a dangerous mix that has ended up stopping or slowing down the development of the agricultural sector. It is now necessary to design and carry out initiatives that counteract this trend, especially initiatives based on innovation and the use of technology. This article aims to analyse the implications of the new ways of working to be used in spaces created under the umbrella of a new technological order known as metaverse. Through the creation of a community of metaverses, capable of promoting interaction, collaboration and communication between the different agents involved in the value chain of the agricultural sector, the aim of this research is to create an integrated and collaborative trusting environment that allows consensual, well-founded and robust business decisions focused on cost savings and the optimisation of quality and productivity. This research seeks to benefit all agents involved in the agricultural sector value chain. By placing producers at the centre of the system, the approach described in this study aims to avoid the current imbalances between the interests of different agents, while promoting an innovative and sustainable agricultural sector committed to meeting the challenges of today's society.

1. Introduction

In the face of uncertainty and change, the need for organisational effectiveness to seize the opportunities offered by technological advances has led to irreversible changes in the way people work. At the same time, companies are undergoing a profound internal restructuring for two key reasons: people's increasing empowerment and the unstoppable process of business digitalisation.

Remote working or e-working shares some features with the existing concept of telecommuting, namely the use of technology, remote spaces, employer-employee contractual agreements, and flexible work time (Eurofound and the International Labour Office, 2017). However, there are key differences. According to Nilles (2007, p. 1), e-working implies "any form of substitution of information technologies (such as telecommunications and computers) for work-related travel: moving work to the workers instead of moving workers to the work". E-working emphasises the "location independent aspect directly", whereas teleworking more on "travel substitution aspects". Hence, e-working has replaced the old concept of teleworking (Messenger et al., 2017).

Businesses must create new knowledge- and technology-centric work environments built around sustainability. Creating such environments requires agile answers to many questions, some of which have not yet even been asked. It also means leaving unanswered some questions from the past. Of course, when discussing such issues, the so-called past is in fact recent history.

Rapid technological progress has led to Industry 4.0, where a set of smart, responsible, and flexible interconnected industrial ecosystems are built (Srivastava et al., 2022). Industry 4.0 places a greater focus on promoting flexibility and efficiency than on driving sustainability and human well-being (Xu et al., 2021). In contrast, Industry 5.0 (I5.0) seeks sustainable, resilient, and human-centric production systems and services (Breque et al., 2021). In parallel, Society 5.0 (S5.0) places the focus of technological development on human beings, offering people valuable solutions for their lives (Mavrodieva & Shaw, 2020). Accordingly, S5.0 is a human-centric society that balances economic progress with the resolution of social problems through an integrated system spanning

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cyberspace and the physical world. Whereas common practice in the information society of the past was for humans to analyse information collected from the Internet, in S5.0, people, things and systems are connected in cyberspace so that the optimal results (obtained, for example, through artificial intelligence) feed back into physical space. This process brings new value to I5.0 and S5.0 in ways that were previously unthinkable. Part of Industry 5.0 and Society 5.0 is the "metaverse (MV) economy", which is at the heart of the initiative proposed in this article.

Given the novelty of the MV as a concept, it has several definitions, all from the last few years. The word "metaverse" derives from the root "meta" (beyond) and "verse" (from universe). It describes a virtual environment that exists in parallel to the physical world (Tlili et al., 2022). According to Lee et al. (2021), in the MV, the virtual and the real interact and evolve together through value-creating social, economic, and cultural actions. In the eyes of Kye et al. (2021), the MV is a form of 3D virtual reality (VR) where people go about their daily routines and economic interactions using avatars to represent reality.

The MV has become a key enabler of the three Industry 5.0 values. The first value relates to *human-centricity*. The MV enables human-centricity not only because humans and machines work together but also because devices can be employed to model user needs and respond to them more effectively. Devices are designed so that consumers can act as co-producers of their own products and services (Sigala, 2010; Page, 2011). The principle of no-one left behind is upheld, with inclusive workspaces (Park et al., 2021) that motivate, engage, and ensure the diversity of individuals (Seigneur & Choukou, 2022). The second value relates to *sustainability*. The MV promises to drive sustainability, environmental protection, and health, helping break down mental and behavioural barriers to climate action (Liu et al., 2022). The MV even supports the achievement of SDGs 4, 8, 9, and 13 (Tlili et al., 2023). It also creates safer, more innovative, and more creative work environments by enabling testing without causing irreparable harm to people or the environment. For example, the MV can be used to test the algorithms for driverless vehicles (Pamucar et al., 2022). Finally, the third value relates to *resilience*. The MV has the capacity to create opportunities for resilient industries that are not disrupted by increasingly common unexpected events, as was the case of sectors such as the traditional tourism (Choi & Kim, 2017) and fashion industries during and after COVID-19 (Gursoy et al., 2022).

Despite the many undeniable positive aspects of the MV, it also presents major short-term challenges. These challenges are mainly related to regulation (Li et al., 2022), security and ethics (Njoku et al., 2022), design (Gursoy et al., 2022), health (Hu et al., 2022), sustainability (Kshetri & Dwivedi, 2023), and the role of virtual currencies in the financial governance of the MV (Vidal-Tomas, 2023). They may even call into question its future viability.

Combining applied and basic research, this paper aims to explore the implications of new ways of working in business spaces created by using the new technological phenomenon that is the MV. It therefore analyses the potential of the MV from a management perspective. The paper focuses on the design of alternatives to promote value creation in the primary sector (specifically, agriculture) through interaction, collaboration, and communication to redress the imbalances of the past and anticipate situations that could affect this sector and the sustainability of the planet in the future. Obsolete models, a lack of professionalisation, and a continuously changing environment create a dangerous mix that has led to imbalances and misalignments between the interests of different parts of the agricultural value chain. This situation has curbed development in this sector. The use of technology as proposed in this paper presents a transformation in ways of thinking and acting, under the conviction that a radical shift in mentality is the only way to trigger the actions and behaviours capable of achieving the desired changes. Thus, the rapid development of technological tools – such as monitoring and control systems for agricultural machinery and equipment (23% of the use of new technologies), crop and land mapping services (19%) and crop and land monitoring systems (14%) – creates new possibilities for the agricultural sector, enabling the management of data and knowledge for issues such as growth, development, tolerance, resistance, architecture, physiology, ecology, performance, and other basic quantitative parameters (Li et al., 2014). Information on other aspects such as air temperature, CO_2, light intensity and soil humidity can also be gathered (Taşan et al., 2022), allowing the creation of effective data-driven knowledge models for decision making and prediction. Therefore, digitalisation is moving the agricultural sector towards "precision agriculture", which, based on the use of advanced technology, is aimed at better managing natural resources and combating climate change. The knowledge generated at this point must be the lifeblood of the decisions adopted by the other agents involved in the agricultural sector value chain.

The remainder of the article is structured as follows. The next section has three subsections that describe the conceptual model. The following section has seven subsections that develop the proposal for action.

2. Conceptual framework

2.1. New ways of working

New ways of working (NWW) are a set of management practices that affect the physical workspace, technology, organisation, leadership, and work culture (Gerards et al., 2018). The demands of globalisation, the climate emergency, and major global, political, and economic imbalances call for urgent, sustainable-growth-oriented responses that affect new ways of working. Recent events that have had profound social, economic, political, and health implications such as the COVID-19 pandemic have merely served to accelerate an ongoing process of transformation that has shaken the traditional paradigms of social life.

E-working refers to the use of technology in work performed outside the confines of the company at any time or place (Grant et al., 2013). Analysis of the positive and negative implications of e-working continues to fuel an intense debate (Grant & Clarke, 2020). With e-working, companies have found a way to cut operational and staffing costs (Watterson, 2020). However, it means that they are forced to design sophisticated protocols for work performance and organisational information and knowledge protection (Segbenya & Amerley-Okorley, 2022). The worker perspective has been the subject of less analysis. For employees, positive aspects include autonomy, flexibility, satisfaction, and productivity (Rahman & Arif, 2021). Meanwhile, negative aspects relate to issues such as work-life balance (Raghuram & Wiesenfeld, 2004), stress, attitude, emotions (Greenhaus & Beutell, 2002), loneliness, work-leisure separation (Sardeshmukh et al., 2012), domestic violence, communication overload, work intensification (Grant et al., 2019), and demotivation. Motivation changes when working remotely. Self-determination theory (Deci & Ryan, 2002) is applicable in this context. This theory emphasises the power of internal control over externalities. That is, employees who are intrinsically motivated are usually more satisfied and perform better (Bono & Judge, 2003). Accordingly, e-working arguably leads people to act in a more mature way, where individuals (rather than managers) must discover their own ways of first thinking and then acting to achieve their goals in a self-efficacious way.

A positive e-working experience covers four dimensions (Grant et al., 2019):

1. Self-efficacy. According to social cognitive theory (Bandura, 1986), which is built on the concept of human agency (Bandura, 2006), self-efficacy refers to personal judgements and abilities to manage personal resources to achieve goals (Bandura, 2001). It is important to consider time and context when analysing self-efficacy (Bandura, 2006). Therefore, e-self-efficacy is different for remote or virtual work contexts. The integration of social cognitive theory with self-determination theory (Sweet et al., 2012) led to the creation of

the digital resilience competency framework (Grant & Clarke, 2020). This theoretical framework highlights the need to develop competencies to promote people's well-being, productivity, and engagement. It is highly applicable to e-working, where procedures are blurred, tasks depend on individual skills and initiatives, and scope for supervision is limited. The framework proposes five e-skills from the perspective of e-self-efficacy (Tramontano et al., 2021): personal and knowledge skills, trust, self-care, social exchange, and emotional skills. The last two are particularly relevant to this research. They are responsible for keeping the intense social and emotional demands of e-working in check.

2. Relationship with the organisation. E-management relies on a strategy based on communication, trust, openness (Kowalski & Swanson, 2005), and commitment. Thus, the easy task of creating a trustful e-working climate and the more challenging task of maintaining it require a combination of communication, trust (Golden & Raghuram, 2010), and autonomy (Richardson, 2010). Designing long-term goals, sharing goals (Van der Meulen, 2017), and catering to the needs and preferences of all those involved (Grant et al., 2013) are factors that ensure high levels of satisfaction (Sousa-Poza & Sousa-Poza, 2000) and well-being at work (Bentley et al., 2016).
3. E-worker well-being. Identifying the variables that promote e-worker well-being, as well as those that can threaten it, is important so that they can be avoided. For example, work intensification, loneliness (Grant et al., 2013), and the fact that home and work share the same physical space (Kossek et al., 2009) are factors linked to mental health problems (Bakker et al., 2013) and stress, as well as lower levels of workplace well-being (Hartig et al., 2007). Rooted in the transactional model of stress (Lazarus & Folkman, 1984), the concept of technostress refers to the negative physical, psychological, or behavioural effects arising from situations where the demands exceed the work resources (Cooper et al., 2001) that people can provide in highly technological settings (Tarafdar et al., 2019). For years, three characteristics of work environments have led employees to suffer technostress (Ragu-Nathan et al., 2008). First, people have an enormous growing dependence on information and communication technologies (ICTs), which are constantly being updated. Second, this dependence on ICTs creates a mismatch between the necessary and real knowledge to perform different tasks. Third, ICTs have changed (and will continue to change) the work environment and culture through, for example, remote supervision, multitasking, social isolation, and abstraction of work (Zuboff, 1988). The behavioural effects of technostress are tangible and traceable (Morales et al., 2017), whereas the psychological effects may go unnoticed (Weinert et al., 2020). Therefore, it is important to establish mechanisms to flag and prevent them.
4. Work-family balance. This concept is defined as the ability of workers to set effective boundaries between directly and indirectly work-related activities. The flexibility associated with e-working reduces work-family conflict and promotes workplace well-being (Lewis & Cooper, 2005), job and family satisfaction (Wheatley, 2012), organisational commitment, and family performance (Carlson et al., 2009). A lack of work-family balance can lead to serious health and personal relationship problems (Eddleston & Mulki, 2017). These problems stem from being unable to enjoy free time, having to do more work in (officially but not in practice) shorter hours, and being permanently online in the "on call, always on" culture (Chesley, 2014) to compensate for higher levels of flexibility (Chesley, 2010).

2.2. The metaverse

Ritterbusch and Teichmann (2023) studied 28 definitions of the MV across seven fields of study (Arts and Humanities; Business, Management, and Finance; Computer Science; Engineering; Environmental Sciences; Medicine; and Social Sciences). Computer Science offered the most definitions (17). Engineering (1), Environmental Science (1), and Medicine (1) supplied the fewest. The two definitions from the perspective of Business, Management, and Accounting are listed in Table 1 (p. 12371). This paper presents one of the most comprehensive definitions of the MV: "Metaverse, a crossword of 'meta' (meaning transcendency) and 'universe', describes a (decentralised) three-dimensional online environment that is persistent and immersive, in which users represented by avatars can participate socially and economically with each other in a creative and collaborative manner in virtual spaces decoupled from the real physical world" (p. 12373). According to this definition, the MV creates the opportunity for a new virtual and real economy where businesses (Park & Kim, 2022) and the corresponding interactions between economic agents create a near-infinite world of possibilities.

Several bibliometric studies and systematic literature reviews of the MV have almost futilely attempted to build the theoretical foundations of a constantly changing concept and orient future research trends (Abbate et al., 2022; Damar, 2021; Feng et al., 2022; Richter & Richter, 2023; Ritterbusch & Teichmann, 2023; Shen et al., 2023). Table 2 summarises how the MV has been characterised in previous research.

Despite its opportunities, the MV still has unresolved issues that require further research:

1. Regulation. There is no solid foundation to develop regulations and performance standards, especially regarding connectivity between different MVs to build an ecosystem of connected MVs (Li et al., 2022).
2. Security and ethics. The personal and financial information of users and companies may be compromised (Njoku et al., 2022) by the high degree of diversity, decentralisation, and freedom (Al-Sartawi, 2020).
3. Technology. The software and hardware involved in the MV must be able to cope with the development of systems that have, for now, been becoming increasingly complex (Pamucar et al., 2022) and expensive (Park & Kim, 2022).
4. Design. There must be effective interaction mechanisms and plans to provide immersive user experiences (Gursoy et al., 2022).
5. Accessibility and health. Physical and mental health risks negatively affect the implementation of the MV (Hu et al., 2022).
6. Digital literacy. A lack of understanding or awareness of the technologies involved in the MV hinders its effective implementation (Gunasekeran, 2018).
7. Sustainability. Making users stay in the MV and guaranteeing high Internet connection speeds are measures that ensure the sustainability of the MV (Njoku et al., 2022). However, other issues such as high energy demands and CO_2 emissions are also relevant (Kshetri & Dwivedi, 2023; VentureBeat, 2022).

Table 1
Definitions of the term MV.

AUTHOR	DEFINITON	CitQ
Boulos and Burden (2007)	"…Four emerging technologies make up the so-called metaverse, a digital domain equivalent to the atom-based domain of our physical lives. These technologies are: mirror worlds (digital representations of our own atom-based world); virtual worlds (digital representations of any space, imagined or real); lifelogging (the digital capture of information about people and objects in the real or digital worlds); and augmented reality (sensory overlays of digital information on the real or even virtual world)".	64
Papagiannidis et al. (2008)	"…Focus is on the business activities and commercial applications that virtual worlds can host and the wider implications of these virtual environments, often referred to as 'metaverses'".	165

Table 2
Characterisation of the MV in previous studies.

CHARATERISTICS	DETAILS
Eight perspectives (so far) for application (Narĩn, 2021)	Definition and properties, education, art, gaming, religion, culture, health, industry.
Five functional traits (5Cs) (Mykyoung, 2022)	Canon: time and space are not fixed; they are created and developed by users and developers Creator: participants can act as users and creators at the same time. Currency: contents can be produced, distributed, and consumed using digital currency. Continuity: economic and social life is a continuum, so it influences and is influenced by the real world. Connectivity: the connection with the real work is forged by sharing information through links that transcend time and space.
Four identifying characteristics (Dionisio et al., 2013)	Realism: Is the MV realistic enough to create successful immersive experiences? Ubiquity: How can the MV be accessed? Does user identity remain intact when moving around the MV? Interoperability: Can digital assets and users move through different ecosystems without interrupting their immersive experience? Scalability: Does the MV architecture enable many users to connect without compromising their experience or the efficiency of the system?
Three technology waves or phases (Shen et al., 2023)	First: globalisation of multisensory stimuli. Second: integration of latest generation technology applications. Third: improved version of cyberspace from the creation of a digital world in parallel to the physical world.
Four types of technology (Elon University, 2006; Tlili et al., 2022)	Augmentation vs. Simulation + External vs. Intimate = Augmented reality uses location services and interfaces that process and superimpose virtual 2D or 3D information on the real world to make it appear in 3D (e.g. creating smart environments based on location networks such as in Pokémon Go). Lifelogging enables people to record, organise, store, and share information about their lives (health, leisure, hobbies, etc.) to observe, communicate, and model their behaviours based on everyday experiences (e.g. using augmented reality for Facebook, Instagram, etc.). A mirror world simulates the appearance, structure, and information of the real world, not simply replicating it but using the MV to merge with and expand the real world (e.g. virtual maps using GPS technology such as Google Earth and Google Maps). A virtual world creates the feeling of being there by designing backgrounds, personalities, and institutions for social or economic purposes by applying 3D technologies and virtual communication tools (e.g. creating avatars that interact virtually). + Mixed reality is the evolution and maturation of augmented reality by including interactive features in VR. Extended reality or cross reality refers to a group of immersive technologies that span electronic and digital environments where data are represented and projected.
Eight types of enabling technologies and six characteristics of the MV ecosystem (Lee et al., 2021)	Enabling technologies: Extended reality; User interactivity; Artificial intelligence; Blockchain; Computer vision; Internet of things and robotics; Edge and cloud computing; Future mobile networks. Characteristics of the MV ecosystem: Avatar; Content creation; Virtual economy; Social acceptability; Privacy and security; Trust and responsibility.

While the growth of the MV is unstoppable, some authors have argued that fashion comes before reality (Vidal-Tomás, 2023) and that technology companies have created the MV with weak arguments to justify its use (Kim, 2021). These companies have been accused of wanting to run before they can walk (Jones, 2022). Some authors are even sceptical about whether people will ultimately want to access and invest time in the MV (Mogaji et al., 2023). Many unknowns must be resolved. Issues related to technical, economic, and financial aspects may have a more direct, faster, and more plannable solution. However, those related to the human side of the MV are likely to have a more complex, involved, and unpredictable solution. They represent a challenge that requires more attention and study.

2.3. *The human dimension of the metaverse*

The combination of the human dimension and the MV requires an ethical perspective to analyse the influence of technology on social and human values such as health, well-being, work, freedom, democracy, knowledge, privacy, security, and self-fulfilment. The dimensions of corporate social responsibility (CSR) must be consistent with such an ethical perspective (Papagiannidis et al., 2008). Although the MV may drive the economy, it must be balanced with environmental, social, and ethical concerns (Lea, 2022) or, in other words, with the principles of sustainability. The MV does not suggest that machines should replace humans, but merely that they can help them to be better, creating so-called *superhumans* capable of achieving better outcomes. Moving work environments to the MV is a milestone for the near future, but almost everything in that regard remains to be done (Koohang et al., 2023). Therefore, organisations must design new strategies from a human perspective to help establish guidelines for the virtual world.

2.3.1. *The "almost" (= already achieved)*

There are three "almosts" or areas that have already been developed in relation to the human dimension of the MV (Purdy, 2022):

1. Immersive forms of collaboration. Keeping remote workers engaged has become a major challenge for companies. Meetings in flat 2D environments do not work. It is thus useful to use MV-based platforms. Human employees and their avatars can go in and out of virtual offices, meeting rooms, or networking rooms in real time and can receive help from virtual helpdesks. Experiences can be fully immersive if holographic capsules, glasses, hats, or tactile gloves are also used to interact with three-dimensional virtual objects and experience sensations such as movement, texture, and pressure (Dwivedi et al., 2022). In addition to human employees and their avatars, the MV also includes a variety of digital colleagues in the form of highly realistic human-like AI-powered bots. They act as advisors and do much of the heavy lifting so that human employee avatars can focus on production and tasks that add the most value. Emotions are the next frontier in the MV to create digitally

responsive humans that can sense, interpret, and make sound decisions. These digital humans are highly scalable. They do not need to rest. They can be in several places at once. They are also prepared to do the most repetitive, boring, and dangerous jobs without complaining. However, they result in an overdependence on automation and lead to a battery of low-skilled human workers who are unable to perform new job roles.
2. New job roles. As the three-dimensional economy gathers pace, new ways of understanding work and new jobs emerge. Just as the Internet has created jobs that were unthinkable years ago (digital marketing managers, social media consultants, and cyber security professionals), the MV will also create such jobs. For example, *meshers* or 3D template developers, avatar conversation designers, digital asset managers, virtual real estate agents, and *holoporters* to enable movement between different virtual worlds offer massive potential for smart businesses.
3. The acceleration of learning and skills acquisition. The MV has caused a revolution by drastically reducing the time required for training, thus increasing process effectiveness. In the MV, any object (manual, machine, or product) can become interactive. With 3D screens, the entire training process can be led step by step. Worker avatars can learn through role-playing exercises and simulations in realistic, safe, inclusive training scenarios. Meanwhile, bots unblock, encourage, set scalable goals, and support training or problem-solving processes. Rooted in gaming, games in the MV become the learning activity itself. Learning systems based on immersive gamification prove more effective than traditional training by visually demonstrating concepts and work practices, using learning by doing, and asking learners to solve problems using quest-based methods.

2.3.2. The not so "almost" (= challenges)

The MV is still in its infancy, although it will gradually be implemented in the near future. In addition to obstacles related to hardware and software infrastructures, energy consumption, and the integration of virtual worlds, other barriers arise from the development of regulations to manage participants (human employees and their avatars, digital humans, and digital bots). There is a certain level of agreement on four aspects that must be addressed in the short term:

1. Portable skills. This challenge involves certifying MV-acquired skills that can be used in other MVs or the physical world, through a more fluid definition of skills that ensures quality and provides security to workers and employers.
2. Hybrid action. This challenge relates to allowing employees to move between the physical, online, and 3D environments using MV technologies (avatars, VR headsets, haptic gloves, augmented reality glasses) and, more recently, VR locomotion technologies or electrocardiogram (ECG) electrodes to decode neural signals and control objects with the mind.
3. Reverse intergenerational learning. Those from the younger generation, who are born into a socially connected 3D gaming environment, can, should, and know how to help those from the older generation become skilled in MV technologies.
4. Democracy and freedom. To protect the MV from the efforts of some companies to gain control of it, the MV should be made more open (open source software and standards) and should force interoperability (seamless connections) between different virtual worlds.

The MV has changed expectations about why, where, and how to work, providing new opportunities for companies to recapture spontaneity, interactivity, and fun, while still ensuring flexibility and productivity. The MV can only succeed if it is implemented as a tool for participation and experience, not supervision and control. Nevertheless, business leaders can start imagining, dreaming, and creating the workspaces of the future, today.

3. Proposal for action

3.1. General motivation

A future where all companies go native in the MV seems far off and is probably unreasonable to expect at this stage. However, what is not only reasonable but also unavoidable is introducing the MV into the day-to-day operations of the company and integrating the operations of the company with the MV. One way of achieving this goal is to combine physical, remote, and virtual work to generate maximum value from each one. Adapting the concept of globalisation, the term meta-globalisation can be coined to refer to the strategy of dividing the operations of meta-global companies into parts by placing each one in the space (physical, remote, or virtual) where maximum value is generated. This philosophy forms the basis of an initiative that hinges on three fundamental axes: (1) where? Primary sector (agriculture); (2) where to? Value creation (goal); and (3) doing what? Interaction (human dimension).

1. Where? The choice of the agricultural sector is justified for three reasons. First, it is vital in that it meets people's primary needs, influences other sectors, ensures life on earth and the survival of humanity, affects human interference in the natural balance of the planet, manages the uses of natural resources, and holds status as a business activity since Neolithic times. Second, the sector has suffered disregard and neglect, especially in developed countries. Many people and companies have abandoned agricultural work, creating regional imbalances that have led to the simultaneous overcrowding of some areas and the emptying of others. Third, many agricultural products are commodities that are in global demand, are present in international markets, and can act as financial assets.
2. Where to? If properly executed, value-based management (VBM) can align overall business aspirations with management processes to focus attention on key value drivers. The aim of creating value justifies why companies redesign their strategies, especially if they operate in increasingly competitive and globalised environments such as the agricultural sector. Regardless of the strategy, companies must be able to achieve the approval of the market and ensure sustainable growth. The VBM perspective, which is valid for all sectors, is particularly relevant in the agricultural sector because of the enormous economic and social implications of all the links in the agricultural sector value chain.
3. Doing what? The value chain in the agricultural sector involves many business agents that must know how to integrate their information and action systems. Given the characteristics of the products in this sector, operations must be immediate. Therefore, truly collaborative structures focused on cost savings and quality optimisation are needed. This approach, which seems obvious in theory, has been unsuccessful in practice. Serious misalignments, especially in recent times, between the interests of operators in the value chain have led to numerous problems and unclear statements that reveal a lack of harmony between actors, weaken the sector, and cause confusion in the media. In this third axis, technology and virtual environments can play a fundamental role.

3.2. Specific motivation

The specific motivation for this research should be analysed in terms of the current situation and the intended ideal scenario.

3.2.1. Current situation

General analysis of the current situation leads to the following conclusions:

1. Fewer and fewer people want to work in this underappreciated sector with little social recognition.

2. Fields are being repurposed for new uses such as solar farms or the planting of cereals for biofuels, which have environmental impacts.
3. Farmland and natural resources (land and water) are being over-exploited for economic (profit-making) and demographic (ever-growing population) reasons. The most developed countries are resorting to value creation through technology and the reduction of production (SDG 15).
4. Climate change is a reality that threatens life on earth, particularly the survival of the agricultural sector. Natural disasters and water shortages are causing million-dollar losses that require measures for environmental protection and natural resource sustainability, climate-smart agricultural practices, the integration and synergy of those involved, and participation in the implementation of innovative tools and practices for prevention and response.
5. Prices in the sector are spiralling. The rise in agricultural prices is increasingly being explained by not only an increase in demand but also a decrease in supply.
6. There are huge differences between the prices for producers and end consumers. Reasons include the spread of supply coupled with the high concentration of demand, especially in terms of distribution and agro-industrial companies; the entry of products from countries with lower labour costs and less strict quality standards; and price- rather than differentiation-based consumer purchasing decisions.
7. There are conflicting interests between those involved in the agricultural value chain. These conflicting interests hinder collaboration and communication and lead to conflicts that distract the sector from its goal of getting stronger and becoming more attractive through research and development (R&D).

3.2.2. Ideal scenario

It is easier to describe (but not necessarily to achieve) the ideal scenario. This scenario consists of the following four aspects:

1. Contribute to SDG 2 (Zero hunger), SDG 12 (Responsible consumption and production), and SDG 15 (Life on land). Support SDG 6 (Clean water and sanitation) and SDG 13 (Climate action).
2. Ensure effective management of natural resources (land and water) to secure the sustainability, security, and peace of the planet.
3. Correct and prevent the negative effects of regional imbalances resulting from migration from rural areas to cities.
4. Ensure that no person or company is left behind in the race for progress. The aim is to avoid a situation of several worlds moving at different speeds because of disparities in resources, capabilities, or opportunities.

3.3. The goal

This situation means that the goal of this initiative is highly specific, namely to build a community of interconnected MVs related to the agricultural sector. Based on innovation, training, interaction, collaboration, and communication, this MV community should be capable of solving and preventing current problems and anticipating future needs.

There are three reasons why such problems, which have not been solved in the physical world, could be solved in a virtual environment:

1. Working in the MV requires easy, continuous interaction, collaboration, and communication. In theory, this feature seems to be the key driver of success in the context of the present study. So far, collaborations have predominantly been between economic agents of the same type (producer with producer, distributor with distributor, transformative company with transformative company, etc.). The aim is to unify the perspectives of different agents into a single viewpoint that is accepted by all and that can be explained by the principles of value generation and sustainable growth. Hence, a community of MVs rather than a single MV is needed to enable interactions between them. This situation introduces complexity and opportunities in equal measure.
2. The MV must safeguard freedom and democracy as two core principles so that it cannot be appropriated for the interests of a few large technology companies. Smaller companies with fewer resources must democratise the MV by designing scalable experiences to compete on equal terms with larger companies that possess more resources. In other words, no one can be left behind. It is crucial not to return to a situation "where the weakest start the race for progress years after the strongest. The ability to run must decide the fate of companies, not when they are placed in the starting box".
3. Power must be transferred between agents. The power is currently on the side of companies (industry and distribution). The aim is for this power to shift to producers, which naturally must become the heart of the system. The maxim that land is the source of everything is the prerequisite for all other processes to make sense. This approach, which makes business sense, also (crucially) makes sense from the perspective of sustainability and the natural balance of the planet. Such a power shift entails major operational changes, as well as further-reaching changes in perspective and mindset.

These reasons justify the creation of a space for interaction within the MV for the agricultural sector, highlighting the importance of the human dimension. The human dimension is the glue, the cement, and the oil that greases all the machinery to ensure that everything works correctly and to prevent it from stopping. To use a simile "the human dimension is like the string of a music box that, when turned, gets all the dancers (and there are many) to take action in an orderly and coordinated way".

3.4. Action strategy

The relationship between the MV and the world of gaming explains why this project is structured the way it is. Just like a game, the project is structured in levels. Each level must be completed before moving on to the next one. This structure is well suited to this project, which, given its complexity, has action phases that must be well evaluated before advancing to the next stage. Reaching the highest level means that the process of building the MV community is complete. At this stage, the concept of meta-globalisation discussed earlier makes sense. Throughout the process, the elusive yet exciting human dimension is crucial to ensure that the goals are met.

3.4.1. Level 1

A set of producer companies in the agricultural sector (A1) linked by type of product, specialty, or related interests create a space for interaction and decisions in the MV "AgriVerse" (Kang et al., 2023). This space should help create collaborative relationships based on complementarity and mutual responsibility. Transparent, honest, continuous communication between those involved should create a work environment where the priorities are trust, freedom, and competitiveness. Aspects related to production, finance, technology, resource management, and environmental interaction must be decided by consensus among those involved at this level (A1). Crucially, future lines of action must be outlined and justified from an innovation and technology-use perspective to ensure the survival of not only A1 but also the sector and the planet. These reflections are applicable to any other level(s) in which a metaverse(s) is also created. Therefore, they will no longer be repeated. Level 1 is complete when A1 create the MV[1].

3.4.2. Level 2

A set of knowledge-providing companies (A2) linked by specialty, goals, or related interests create a space for interaction and decisions in the MV. The need for new knowledge on agricultural technology, innovation, and operations that applies to A1 leads to the inclusion of universities and other research centres as key partners in the process. This measure is essential to achieve the goals associated with climate-smart agriculture. The demands of climate-smart agriculture are context-specific (place and time). They therefore require expert analysis and advice on the measures that will work given certain conditions. Hence, stable collaborative relationships between A1 and A2 must be built, promoting synergies to optimise the use of natural resources and comply with the principles of smart and sustainable agriculture. The knowledge generated between A1 and A2 is the lifeblood that feeds the decisions and actions of A1 and other agents. Level 2 is complete when A2 create the MV[2].

3.4.3. Level 3

Once MV[1] and MV[2] have been created, they must interact. Thus, A2 that share common interests and that are linked to A1 by type of product, area, or related interests create a space for interaction and decision in the MV. Level 3 is complete when A1 and A2 create the MV [12].

3.4.4. Level 4

A set of agro-industrial companies (A3), distribution companies (A4), consumer associations (A5), financial institutions (A6), and public administrations (A7) linked by specialty, goals, or related interests create spaces for interaction and decisions in the MV. At this stage, A1 should establish processes of interaction with other agents in the system. The knowledge acquired in Level 2 should inform these processes. In other words, A1 should become the originator of interaction, collaboration, and communication actions with other companies, associations, entities, or administrations. This situation ensures that the principle of first things first, the transfer of power to the first link in the chain, and the principles of equality, freedom, and justice inform the decision processes. The interactions (between two to seven agents) must revolve around A1 (the heart of the system). A1 must evaluate, coordinate, and monitor the purposes and interests of the other agents. In the agricultural sector, the need for immediate response is coupled with the complexity of relationships between different types of agents. Therefore, the proposed model, which describes continuous, urgent interactions between diverse agents, can only succeed if it shifts towards more agile, free, and flexible action scenarios. Level 4 is complete when A3, A4, A5, A6, and A7 create MV[3], MV[4], MV[5], MV[6], and MV[7].

3.4.5. Level 5

Once all the MVs have been created, interactions between them must be established. In this level, A3 with common interests and links to A1 (and A2) in terms of type of product, specialty, or related interests create a space for interaction and decisions in the MV. Level 5 is complete when A1, A2, and A3 create the MV[123].

3.4.6. Level 6

In this level, A4 with common interests and links to A1 (and A2 and A3) in terms of type of product, specialty, or related interests create a space for interaction and decisions in the MV. Level 6 is complete when A1, A2, A3, and A4 create the MV[1234].

3.4.7. Level 7

In this level, A5 with common interests and links to A1 (and A2, A3, and A4) in terms of type of product, specialty, or related interests create a space for interaction and decisions in the MV. Level 7 is complete when A1, A2, A3, A4, and A5 create the MV[12345].

3.4.8. Level 8 (with special bonus)

Completing this level represents a special bonus. In this level, A6 with common interests and links to A1 (and A2, A3, A4, and A5) in terms of type of product, specialty, or related interests create a space for interaction and decisions in the MV. Level 8 is complete when A1, A2, A3, A4, A5, and A6 create the MV[123456].

3.4.9. Level 9 (with special bonus)

Completing this level represents a special bonus. In this level, A7 with common interests and links to A1 (and A2, A3, A4, A5, and A6) in terms of type of product, specialty, or related interests create a space for interaction and decisions in the MV. Level 9 is complete when A1, A2, A3, A3, A4, A5, A6, and A7 create the MV[1234567].

Table 3 and Fig. 1 outline the framework for building the community of MVs. This proposal is not science fiction. In fact, many people are already adopting a virtual life. It is suspected that by 2030, people will spend more time in the MV than in real life (Singh, 2022). Businesses must therefore take a step forward to participate in this new space and capitalise on the endless possibilities it offers.

Table 3
Action plan for the construction of MVC-Carrot.

L1	**MV [1]**	**"A" to**	**"A" from**
	Training and guidance on technology and interaction tools to create MV[1]	A1	Specialised technology firms
	Feedback: Results of training and guidance on technology and interaction tools to create MV[1]	Specialised technology firms	A1
L2	**MV [2]**	**"A" to**	**"A" from**
	Training and guidance on technology and interaction tools to create MV[2]	A2	Specialised technology firms
	Feedback: Results of training and guidance on technology and interaction tools to create MV[2]	Specialised technology firms	A2
L3	**MV [12]**	**"A" to**	**"A" from**
	Adoption of decisions on stable training and guidance on technology, innovation, and climate-smart agriculture	A2	A1
	Feedback: Results of stable training and guidance on technology, innovation, and climate-smart agriculture	A1	A2
L4	**MV [3] , MV [4] , MV [5] , MV [6] , MV [7]**	**"A" to**	**"A" from**
	Training and guidance on technology and interaction tools to create MV[3], MV[4], MV[5], MV [6], MV[7]	A3, A4, A5, A6, A7	Specialised technology firms
	Feedback: Results of training and guidance on technology and interaction tools to create MV[3], MV[4], MV[5], MV[6], MV[7]	Specialised technology firms	A3, A4, A5, A6, A7
L5	**MV [123]**	**"A" to**	**"A" from**
	Adoption of decisions on agro-industrial products and processes	A3	A1, A2
	Feedback: Results of agro-industrial products and processes	A1, A2	A3
L6	**MV [1234]**	**"A" to**	**"A" from**
	Adoption of decisions on product distribution	A4	A1, A2, A3
	Feedback: Results of product distribution	A1, A2, A3	A4
L7	**MV [12345]**	**"A" to**	**"A" from**
	Adoption of decisions on consumer needs	A5	A1, A2, A3, A4
	Feedback: Results of consumer needs	A1, A2, A3, A4	A5
L8	**MV [123456]**	**"A" to**	**"A" from**
	Adoption of decisions on investment and finance	A6	A1, A2, A3, A4, A5
	Feedback: Results of decisions on investment and finance	A1, A2, A3, A4, A5	A6
L9	**MV [1234567]**	**"A" to**	**"A" from**
	Adoption of decisions related to the public domain	A7	A1, A2, A3, A4, A5, A6
	Feedback: Results of decisions related to the public domain	A1, A2, A3, A4, A5, A6	A7

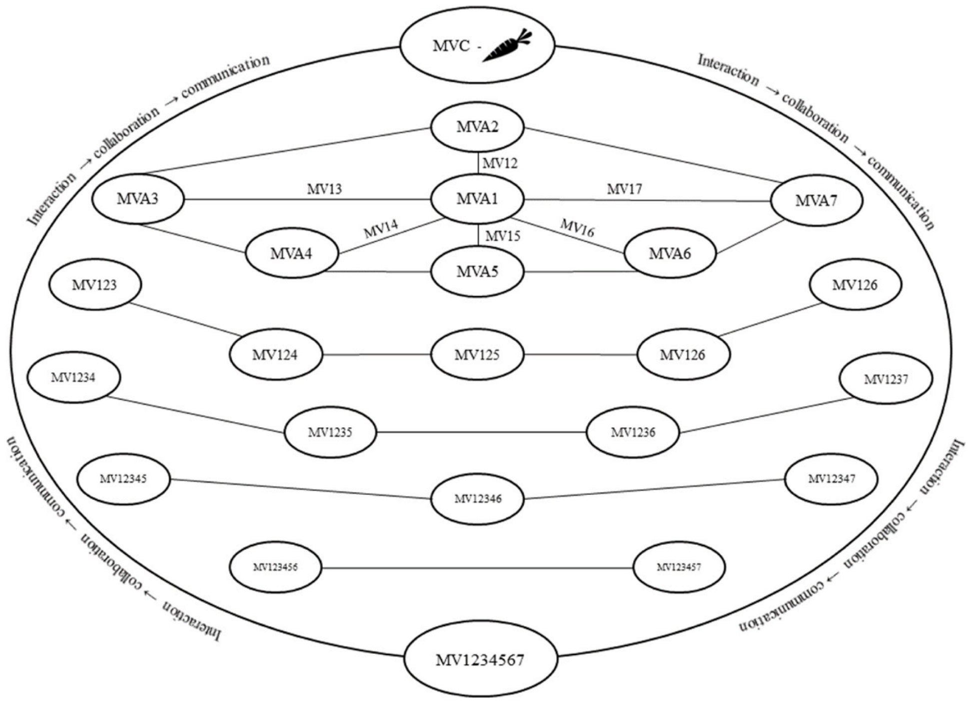

Fig. 1. MV community construction process.

3.4.10. Key considerations for the proposal for action

The following considerations are important in relation to the proposal for action:

1. Levels 8 and 9 are bonus levels. The reason is that they might not have been included in the initial proposal given their lack of a strictly direct relationship with operations in the agricultural sector. However, they will need to become involved in the project at some point, so it was considered helpful to include them in the initial proposal.
2. The levels appear in a logical and understandable order. However, in reality, progress does not have to occur in that order (especially for Levels 4 to 9).
3. Starting a project such as this one requires substantial funding from public and private initiatives. However, the radical changes in mindset required to discover and seize the opportunities provided by the MV, together with the need to safeguard its defining features (free and democratic), justify this public funding.
4. Once these nine levels are complete, the reward is the creation of a community of MVs that use technology (augmented reality, mixed reality, and virtual worlds) to promote interaction, collaboration, and communication between different MVs of agricultural sector agents. The project deserves a name, and it has been denoted *Interactive community: A carrot in the metaverse (MVC-Carrot)*.
5. This proposal is the first phase of a scalable project that should continue by linking the MVC-Carrot with other MV communities related to this or other sectors. Such a process would make sense of what is known as the “MV economy”.

3.5. Method

This project calls for the combined use of applied and basic research rather than using them sequentially or in isolation. The idea is to use applied research under the three-step approach of measurement → intervention → measurement. Accordingly, at each level, analysis of the initial situation is needed to provide a basis for designing the most suitable intervention. In the intervention phase, direct actions should target training and/or innovation (Levels 1, 2, and 4) or decision making in the intensive processes of interaction, collaboration, and communication (Levels 3, 5, 6, 7, 8, and 9). Regardless of their nature, interventions must be consistent with the aim of the project, the technological, informational, or economic scope of the agents, and the measurement instruments. It is then necessary to measure the impact of the interventions.

In fact, basic research is relevant at the initial and final measurement phases of each level. The model must be divided into sub-models (by level and phase), with the results providing guidance to meet the overall aim. Basic research can be used to analyse the relationships between variables. These variables, as well as their form of measurement, can be gathered from an exhaustive review of the literature. Given the novelty of the topic, some study variables and/or measurement scales may not exist. In such cases, the new variables must be adapted, created, and empirically validated. Different methods can be used, depending on the aim of each model or sub-model. Example techniques include regression models, structural equation modelling (Bentler, 1988), qualitative comparative analysis based on fuzzy logic (Woodside, 2016), and panel data analysis (Bastos & Pindado, 2013) if data on the study variables are available over long enough periods (as the project progresses through its different levels).

3.6. Implications for research and practice

3.6.1. Implications for research

This study advances knowledge on the application of new technologies in work environments. Specifically, it proposes the creation of a MVC that, through interaction, collaboration and communication, can resolve and prevent problems derived from mismatches in the interests of the agents involved in the agricultural sector value chain. Despite the results of recent studies, there are still many uncertainties surrounding the MV, mainly in relation to the implications of the “MV economy”. More research on issues related to security, regulation, ethics, health, and sustainability is needed to understand all possibilities offered by the MV. Thus, it is vital to analyse the implications of working in the MV for people’s health, the rules followed to carry out safe economic transactions, the ethical principles that should govern operations in the MV and the extent to which the great sustainability promise of the MV is true. Furthermore, it is crucial to explore the implications of operating in the MV in a sector such as agriculture, which is a key driver of wealth around the world and is heavily responsible for the use (or misuse) of natural resources. Further research is needed to understand how to build a MVC in the agricultural sector and how to design intelligent decision and prediction models capable of answering questions related to planning, processing, packaging, storage, distribution, sales, and consumption.

3.6.2. Implications for practice

The MVC-Carrot aims to create value in the agricultural sector. This initiative is highly applicable in reality. The aim of solving past problems and preventing new problems highlights the need to create a space for permanent interaction between agricultural sector agents, with producer companies at the heart of this space. It should be geared towards training/innovation, information exchange, and coordinated and consensual decision making. This need, which has been apparent for some time, has not yet been addressed. To achieve this goal, smart technologies and knowledge management are key allies to improve production processes and facilitate interaction, collaboration and communication between all the agents involved. Important positive effects relate to the monitoring of damage to the environment, which can be aided by simulation models that are trained and updated with real-time data. Furthermore, new and old (undocumented) knowledge can (and should) be collected, transmitted and valued through technological tools to be incorporated into intelligent decision and prediction models. Thus, it is vital to avoid any type of barrier to the creation and transmission of scientific knowledge, building decentralised knowledge platforms between producers and other related agents (agro-industrial companies, distribution companies, consumer associations, financial companies, and public companies) to perform tasks and make decisions that require different types of knowledge about product characteristics or process sustainability. Including all stakeholders in the community ensures that all interests and points of view are considered. It does not guarantee success, but it does mean that decision scenarios are as realistic as possible. Concepts as "contract farming" make complete sense in this context, allowing customers to access high-quality products at the desired time, and farmers to sell without worrying about any other problem. Based on smart technologies, the MVC-Carrot aims to create trustful, integrated, and collaborative environments that strengthen ties between actors, save costs, improve productivity and quality, and enable consensual, well-informed, sound business decisions.

4. Conclusions

The design of this initiative leads to four main conclusions. First, the construction of free and democratic (virtual) environments must ensure that no one is left behind in the race for progress. Second, merely changing the environment where people and companies operate is important but not enough. It is also crucial to change the mindset to transfer power between agents and place the land (i.e. producer companies) at the heart of the system. Third, effective interaction, which is already critical in business practices in the physical world, is even more important in the virtual world. The human dimension is the key to achieving this effective interaction. Fourth, the technologies involved in the MV should not conceal the real aim of their use, which in this case is interaction, collaboration, and communication.

Author contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by all authors. The first draft and previous versions of the manuscript was written and commented by all authors. All authors read and approved the final manuscript.

CRediT authorship contribution statement

M. Ángeles López-Cabarcos: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization. **Juan Piñeiro-Chousa:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization.

Declaration of Competing Interest

None.

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