



## The role of blockchain for food safety and market efficiency

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### ABSTRACT

It is well known that the introduction of Blockchain in the agri-food sector represents a digital innovation aimed at increasing business income through the reduction of production inputs (and therefore of production costs expressed at constant prices) and/or the increase of output (increase in the quantity produced and therefore in revenues expressed at constant prices). According to Schumpeter, innovation and entrepreneurship mainly depend on innovative people, their skills and knowledge. In fact, digital innovation is always aimed at increasing the competitiveness of the company and can concern an improvement in technical and economic efficiency. On an existing company structure, efficiency concerns an optimization of the variable production factors to be used in the production process (reduction of variable costs: example quantity of water used; quantity of fertilizers to be used according to seasonal trends; quantity of pesticides to be used) which have repercussions on the structure of the cost of production and therefore positive effects on the net income of the entrepreneur. In the present study after examining the economic theory of innovation, through the theory of value examined why agri-food companies should adopt innovations such as the Blockchain. The study highlights that digital innovations can be implemented by entrepreneurs according to company size and with a view to increasing the value of production and that the affirmation of innovation requires long periods of time.

### 1. Introduction

The industrialization process has certainly transformed our society, especially in the last decades of the last century, creating a widespread well-being, which previous generations could not even imagine. Industrial progress was then joined by technological-information technology, which led to the shortening of distances and the rapid dissemination of information [1,74]. The changes that have taken place in society are also the result of technical progress, that is, the flow of new knowledge that is created and that has accumulated in the Italian economic system. In this regard, it should be remembered that technical progress, which always involves the incorporation of new plants and/or equipment, has also been very intense in the primary sector where it has determined the introduction on the market of new agri-food products and the spread of new production techniques. In the agri-food field, innovation has also manifested itself through the optimization of company resources based on the experience accumulated over the years by the entrepreneur (Learning by doing). Innovation strategy means bringing to the selected market or sector key, pivotal and forward-looking activities regarding the implementation of a new product, service, marketing method, process, etc., which will be able to meet the needs of previously unrecognized buyers. Satisfied or to satisfy her needs in a new way [2,3]. This

aspect appears very important in function of a better organization and optimization of company resources to increase economic efficiency. The effect of innovation translates, with reference to the Cartesian axes, into an upward shift of the production function, and into a rapprochement towards the origin of the axes of the isoquant of production, i.e. the same quantity of product can be obtained with less use of inputs. For a small business, which operates in a competitive market, there is an incentive to make technical innovations as, at least for a certain time, it will be alone to take advantage of it and therefore make extra profits. In this case, the company from a situation in which the minimum average cost is equal to (or above) the marginal revenue can move to a situation where the marginal revenue is greater than the minimum average cost. However, the more or less continuous character with which the technical progress that is implemented by individual companies is manifested ends up blocking the mechanism of freedom of entry into the market which is one of the fundamental characteristics of competitive markets.

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## 2. Literature review

### 2.1. Potential of blockchain in agri-food sector

Technical progress always involves, in an economic analysis of comparative statics, an investment and therefore the entrepreneur will have to correlate it with the size of the company. In a long-term equilibrium situation in which each company has achieved a minimum optimal size, the market supply is given by the quantity corresponding to the minimum optimal size multiplied by the number of companies. And again, there are forms of technical progress that lead to an increase in the quantity produced at company level due to a better organization of resources, both for the creation of high-scale plants that allow a better exploitation of some inputs or that make the process automation. This situation is not absolutely true but always depends from case to case as sometimes for the realization of certain products even the use of small-scale plants, especially in agricultural activities, allows to obtain higher levels of efficiency [4,5]. The increase in company size determined should have no effect on the competitive structure provided that: (a) technical progress is uniform in all sectors; (b) the increase in labor productivity is not caused by more than proportional increases in the size of the company; (c) whether the increase in income due to increases in productivity leads to an increase in the demand for various goods. If these conditions were met in all sectors, the result would be a proportional increase in the overall demand and the optimum quantity produced by each firm, so that the number of firms would remain unchanged [6,7]. However, in reality things are different, with the result that technical progress tends, or at least has tended in the past, to increase the optimum production quantity of individual firms to a greater extent than that in which demand increases [8,9]. The result is a decrease in the number of companies and therefore a push towards concentration. In fact, the companies that innovate more promptly put the others in crisis [10]. But the company that has been successful following technological innovation may agree to absorb the productive unit in difficulty, as the “innovating” company is able, by reorganizing the plants, to enhance its production structure in such a way that no “New” entrepreneur is able to achieve [11,12]. In the business world, this materializes in the fact that the innovative entrepreneur has a far-sighted vision and therefore is able to better organize the production factors and therefore can achieve economies of scope and economies of scale. This allows you to lower production costs and increase profit margins. By reducing the number of companies in the market, the company that has innovated is in a position to be able to intervene on prices by manipulating its offer and also to hinder the entry of new rival companies. The increases in productivity caused by technical innovations translate into increases in purchasing power, which leads to an expansion of consumption. However, from the Engelian analysis of demand we know that the expansion of consumption almost never takes the form of an increase in the quantity of the same: in reality, what changes is the structure of consumption. In particular, the expansion of consumption is directed towards new goods: more is not consumed, but different goods are consumed [13–15]. Thus, product differentiation is born, and with it the possibility that the company increases its market power by isolating its segment both through changes in the characteristics of the product that are considered relevant to consumers even if they are not from a technical point of view, both through appropriate sales development activities (advertising, ancillary services). What are the consequences? The company operating in the agri-food sector innovates by producing differentiated products. Differentiation requires commercial activity to launch the new product on the market which, for the same number of consumers, will appear different from that of rival companies [16,17]. These commercial activities involve costs whose characteristic is that they do not increase proportionally to the business volume of the company. These cases are particular aspects of business activity [18–20]. There are, therefore, huge economies of commercial scale that have nothing to do with changes in production plants: the

indivisibility of research and advertising spending and the indivisibility of the product distribution network are the most important causes of such economies which can lead to the concentration of several companies in a group and can discourage the entry of new companies on the market. It should be remembered that advertising must reach a certain level in order to be effective [21,22]. Financial reasons should not be overlooked either. Large companies and companies already established on the market are able more easily to have access to the financial means necessary to carry out technological restructuring programs and new forms of marketing and this in function of greater ease of access to bank credit (economies financial) [23,24]. The merits of large companies in the global economy are evident on their competitiveness and therefore the blockchain helps to maintain the competitive advantage [25–27]. It follows that the freedom of entry into the market, which is one of the essential conditions for the existence of free competition, is thus violated [28,29]. Another aspect to highlight when it comes to innovation concerns the structure of the markets [30]. In fact, innovative processes tend to be faster in the sectors where you have drifted away from the competition or in those that have drifted the least? To answer this question, it must be pointed out that the innovations are the result of research activity which must be multidisciplinary and concerns the long term. The innovations are the result of investments in research and development which take a long time to complete [31–33]. In the past, the research activity was carried out outside the companies. Currently, an increasing part of the research activity is carried out within companies. In this respect, larger companies are endowed with monopoly powers, ie they are in an advantageous position compared to small companies operating in competitive regimes [34]. It must also be remembered that research activities are subject to risk [35,36].

### 2.2. Blockchain in creating value in agriculture

All this means that the company can have positive results after experimenting with several research projects, however the advantages are achieved in the long term [37,38]. Innovation is always the result of long periods of research [39,40]. Another advantage of a large company is that it is better equipped to take advantage of the unexpected, that is, it can use the result of the research in one way or another in the various production sectors where it operates [41]. Furthermore, the high degree of risk associated with research activities means that these are not financed with borrowed capital but with undistributed profits. This situation places companies that enjoy a degree of monopoly in an advantageous position. Another aspect that is often highlighted in favor of monopolies is that of economies of scale. In fact, the production of any good can be obtained in an economic way only by companies that have a certain production size which is usually quite high. Therefore, in general, from the point of view of potential innovative capacity, large companies find themselves at an advantage over small-sized companies operating in competitive systems. In general, but above all in agriculture, one of the main effects of the introduction of innovations in companies and territorial systems is the growth of productivity and competitiveness which is a synthetic expression to indicate all the different ways in which such growth can take place: from the best allocation of production factors to the diversification of production [42, 43]; from the qualitative improvement of food products to the development of products that can be used for other uses; from reducing the indirect costs of environmental pollution to overcoming the contextual difficulties created by some specific soil and climatic conditions (drought, erosion, salinity, etc.). Of course, not all operational areas in which innovation can be used can be replicated in any context and above all, given a certain condition, not all innovations are capable of generating increased productivity and competitiveness.

### 2.3. Proposed framework for blockchain which can be used as basis for policy

Therefore, one of the first fixed points when it comes to innovation in agriculture, and in the agri-food industry in general, is the awareness of taking into account its complexity. In this regard, we recall that since the establishment of the EEC, technological progress was indicated as one of the most important responses to the necessary increase in agricultural productivity and cost reduction by increasing the efficiency of use of production factors. The emphasis was placed above all on technology and in particular on: mechanization; the use of chemical aids capable of improving soil fertility and defending plants and animals from pathogens; the selection of the most productive varieties and breeds. Thanks to the ample room for improvement possible, due to the reduced technological level of agriculture, in the 1950s and 70s of the last century, innovation changed the face of Italian agriculture and that of developed countries. In the following decades, the technological push has progressively diminished both due to the impossibility of forcing production systems at the same pace and because the agricultural sector has shrunk in terms of economic weight and number of companies. Innovation has maintained its potential for competitiveness for the companies that invested in it, however the gap between “innovative” and “prudent” entrepreneurs has widened with a lengthening of the times for the diffusion of new production. Starting from the nineties of the last century, and with the start of the new millennium, the prospects of agriculture have become further complicated and, if on the one hand new spaces and addresses have opened up, on the other to the sector, in the name of reduction of the environmental impact, an effort was requested to return to the watchwords of tradition (fewer chemical inputs, greater respect for natural processes, diversification and specialization) without however renouncing the positive results of technological progress (efficiency of factors, downsizing costs, good productivity). Even in agriculture, innovation must always be linked to economic reasons (increase in revenues and/or reduction of costs). In fact, the entrepreneur is led to innovate as a function of a possible increase in the company's competitive capacity. But why do agri-food companies adopt innovation processes? To answer this question, we need to refer to economic theory. In fact, the companies that innovate do so to reduce production costs as, for example, has occurred in the last ten years with the spread of electronic scissors (and related binders) for pruning in viticulture, or, as in the past, with the spread of the mechanical milking machine. Process innovation has resulted in economic benefits especially in small family-run businesses operating in a competitive market. The innovation in consideration of the price that companies suffer, and on which they cannot act, in addition to determining a lowering of the average cost, has resulted in an increase in the profit margin. Furthermore, the company that innovates does so to improve the efficiency of the use of production factors such as the transformation of a sprinkler irrigation system to a micro-propagation one. And again, the innovation adopted by the entrepreneur can concern the growth of product quality as occurs when adhering to certain production regulations for products with a designation of origin or typical indication. Finally, innovation can relate to the diversification of company production in order to reduce both the technical risks of agricultural activity and those of the market. So innovation is the result that the entrepreneur finds as a function of a problem that he encounters during the business activity. An innovation can have an incremental character, i.e. it can be an adjustment and actualization of an idea implemented in the past that still works in the basic structure, but needs to increase the possibilities of use or improve the efficiency of the process or be a solution completely new that exploits recently systematized knowledge or intuitions that go beyond the intervention processes usually used. For production processes with low capital intensity, innovation spreads through imitation, that is the effect caused by the verification, by the reference entrepreneurial fabric, of the competitive advantages enjoyed by the company that has it. adopted. The first stimulus to innovate derives from the entrepreneur's

verification of the positive effect of the change on income, be it in terms of increasing revenues at constant prices and/or reducing costs and/or improving product quality. and/or to change the marketing process. In the case of constant income, the novelty to be introduced must in any case be perceived as a solution to a problem deemed important (e.g. adaptation to a standard, response to a pathogen, etc.). The ascertainment of this result is neither simple nor immediate and does not usually emerge from the analysis of the cultivation operation or the production process strictly interested in innovation, but also from the verification of the technical and economic interconnections with other cultivation practices and from its compatibility with the strategic approach that the entrepreneur has given to the company. The introduction of an innovation is generally an investment - of various kinds, but still a commitment of resources - and as such it is connected to a risk that the entrepreneur assumes in which the probability of failure should be minimized. To accelerate their transfer [44,45]. Another aspect to take into consideration for a good diffusion is the context in which the potentially beneficiary companies are inserted [46,47]. If an innovation is the result of a relationship activity, even its application can be strongly conditioned by the relationships and connections that the company has, or could have, with public and private subjects and by the geographical, economic and social characteristics of the territory in which it is located. Innovation contributes to corporate and territorial competitiveness [48, 49]. The blockchain is a tool aimed at improving corporate competitiveness [50,51]. For those companies that adopt it, it is an innovation that helps create a competitive system [52]. Within the agri-food system, the application of technology blockchain would allow greater efficiency in the management of the agri-food chain [53]. In fact, in business management, managers should know the demand for products and should know what, when and how much to produce in the interest of satisfying the consumer's needs and with a view to making the company competitive [75,76]. The technology blockchain in the context of the design of a food supply chain represents a “something” more than and therefore a competitive advantage in fact ensures the perfect information in transactions along the agri-food chain ensures the continuity of business operations and avoids threats deriving from any purchases of raw materials that do not comply with quality standards and also acts as a guarantee for downstream customers on the quality of agri-food products [77].

### 3. Discussions

As mentioned, we know, a particular aspect of innovation in the agri-food sector concerns the so-called agriculture 4.0 which represents the set of precision technologies of interconnected agriculture which, through the cross-analysis of environmental, climatic and cultural factors, allows to establish the irrigation and nutritional needs of crops, disease predictions, identify weeds before they occur, save time and inputs, optimization of production times, affect the quality of products and working conditions. According to data from the Smart AgriFood Observatory, in Italy in 2018 only 1% of the agricultural area used was cultivated with the logic of agriculture 4,0. Among the reasons that hinder the spread of agriculture 4,0 we can include the small size of the company, the difficulties in making investments, the resistance to implement associative forms of management by individual companies. In fact, these types of agriculture, although in general have positive effects on the technical-economic efficiency of the company structure, the small size of the company and the fragmentation of the land bodies, which are still present in Italian agriculture today, hinder the spread of technological progress. In general, to increase diffusion, some conditions must be met, first of all the extension of broadband and extra-broadband even in rural areas to ensure the interconnection of the agri-food chain. In addition, entrepreneurs need sensitivity, competence and propensity to invest. However, it should not be forgotten that the spread of innovations in the agri-food sector concern the problems of adapting the business structure that may affect a part of the company (partial

adaptation) or the company as a whole (total adaptation). In these cases, the entrepreneur is led to implement innovation processes if he really knows “in advance” the results of the innovation process. In other words, in small family-run businesses it is difficult for the entrepreneur, with his own resources, to implement innovation processes as he does not have the necessary capital and above all because he cannot wait for “the time of innovation” to recover the investment and start generating revenue. In this respect, it will be medium-large-sized companies that will make investments in innovative processes, or companies that operate in certain contexts of associations and supply chain structuring [54,55]. A particular aspect of technical progress is digital innovation which indicates a vast range of technological [56,57], organizational and managerial changes whose aim is to improve the application of digital technology to the economic system [58,59]. The so-called blockchain is part of digital innovation [60,61]. The Economist defines the blockchain as “the trust machine” that is the trust machine, to emphasize the possibility that, within a distributed and decentralized architecture where everyone can verify the information, nobody has the exclusive power of control over the information. It is an important aspect to increase the transparency of product information and therefore to increase the efficiency of the market [8]. Based on these characteristics, the blockchain is seen as a tool capable of supporting, for example, the fight against corruption or counter illegal trafficking [9]. However, it should be noted that in order to control and protect agri-food products, from their genesis to the time of meeting with the final consumer, there is no tool that in itself is an absolute guarantee [61–63]. Technology is a useful device but it cannot change all those conditions which, together [64,65], are necessary to achieve the desired goal, that is to guarantee the quality of the food product [66,67]. In other words, the blockchain does not completely eliminate the problem of information asymmetry that is present in the agri-food markets. However, it represents a starting point for improving the market failure with positive effects on the companies operating in the market [68–70]. The blockchain therefore it is a means to regain competitiveness in the market [71,72].

#### 4. Conclusions

As we have highlighted, innovation represents the strength of the company's competitiveness and is the result of investments that have been made both at company and territorial level. Innovation is the result of the contribution of various knowledges, requires a long time for its implementation and is characterized by uncertainty. The innovation strategy defines the long-term objectives, the ways and the scope in which innovations (product, process or organizational) will be used to create a strategic advantage [73]. Schumpeter was the economist who emphasized the importance of innovation in capitalism. In fact, technological and organizational changes are the main cause of long-term economic growth and the creation of business and local value. Schumpeter defined “creative destruction” to describe the way in which products (new products and replacement of old ones) and process innovation cause a dynamic process of renewal but also a process of destruction with old ways falling into disuse, leading to the exit from the competitive market of many companies. At the agri-food company level, the creation of value, which derives from the implementation of digital innovation processes, requires some necessary conditions. The entrepreneur, first of all, must be an “innovator” according to his “mission” which is to create agri-food products to be destined for the market. The company must have a financial capacity that allows it to make an investment. In the absence of self-financing, the company should have access to credit and therefore a banking system is needed that is able to provide loans at competitive interest rates. Furthermore, in order to adopt adequate digitalization processes of the agri-food chain, the input data for raw materials and all the information on the relationships that the company has with the competitive environment are required. All this highlights that digital innovation processes applied to agri-food can determine a condition for creating value both for the individual

company and for the surrounding area provided that there are companies willing to innovate. If these conditions are met, then those conditions are established for which we can extract “value” from the economy of innovation. Since these are always long-term and cumulative processes, at the beginning an innovation has low returns, subsequently, if it is successful, the returns increase and then flatten out. In fact, investments in the first phase of the business are risky and most fail. An innovation is successful as a function of market penetration. If consumers respond well, that is, a demand for the product is determined, then economic value can be extracted from innovation. All this highlights that the value of innovation depends on use. In particular, for agri-food products, innovative digital processes can have a positive effect in creating the value of the entire agri-food chain where companies that are connected by supply relationships (agricultural company, wholesaler and retailer with equal contractual power) operate. and that derive from contractual relationships between the various stages of the supply chain. The single agricultural company that is not part of certain well-established marketing circuits will be unlikely to extract value from digital innovation as it is detached from a competitive context that is necessary to implement the same innovation. Patents are another way to create value from innovation. However, even if most of the innovations are not patented, the entrepreneur can have an advantage in innovating as he is the first to arrive on the market and can enjoy the extra profits that are determined. Ultimately, innovation is uncertain, cumulative, financial and dynamic. Digital innovation is not a solution to all entrepreneurial problems, however it represents a new condition available to the entrepreneur who remains the main actor for innovating and organizing business activities. The issues summarized up to now highlight how the process of adopting an innovation is complex, closely connected with the characteristics of corporate, relational and territorial human capital. Therefore, to conclude, the innovation process can be considered to all intents and purposes a learning process that requires the joint action of different “knowledge” and which produces its effects in the long term. Process and product innovation is the key to the company's competitiveness. Without competitiveness the company cannot stay on the market. It is therefore necessary in agriculture and agro-food to always innovate and adopt those innovations that allow the company to withstand the competition.

#### Declaration of competing interest

I have submitted the manuscript entitled “The role of blockchain for food safety and market efficiency” to Journal of agriculture and food research. I declare not to be in conflict of interest Journal of agriculture and food research. We hope that this manuscript can be taken into consideration for publication in to Journal of agriculture and food research.

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