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Innovation and value creation in agriculture: Results of an experimental analysis of the use of sensors on sicilian vineyards of chardonnay cultivars

Filippo Sgroi

Department of Agricultural, Food and Forestry Sciences, University of Palermo, Palermo 90128, Italy

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ABSTRACT

Innovation represents the company's competitive strength. Without innovation, the company cannot stay on the market. In economic theory, innovation has been strongly expressed as the engine of the development of the enterprise and of the territory. In agriculture, innovation is always an important tool. In this direction, smart agriculture is an innovation that allows the company to remain competitive. This contribution presents the results of an experimental test carried out on Chardonnay vineyard cultivars using sensors that measure soil moisture. Results show that sensors reduce variable costs and improve gross income.

Introduction

The rapid process of industrialization has transformed agriculture, especially since 1950 through the introduction of mechanization on farms. Over time, the reduction of average unit costs allows mechanical production companies to arrive on the market with lower machine sales prices. In fact, at the beginning when an innovation takes place, depending on the high investments, the average unit cost is high and therefore the company that has innovated to recover the investment costs it has made is inclined to sell the product at a high price [1]. As time passes, the innovation is imitated, and therefore, in a certain way, a competition mechanism begins which lowers the selling prices and therefore more companies can afford to buy the good that has been introduced on the market as a result of the innovation [2]. Today, industrial progress has been joined by technological information technology, which has led to the shortening of distances and the rapid diffusion of information. The changes that have taken place in society are also the result of technical progress, i.e. the flow of new knowledge that is created and accumulated in the economic system. Innovation begins with an invention and continues with the development and commercialization of a product for the market. In the European Commission's Green Paper on Innovation in Europe, innovation is defined as the renewal and extension of the range of products and services and related markets; new methods of production, supply, and distribution; the introduction of changes in management, work organization, working conditions, and professional skills [3]. According to economic theory, it is necessary to distinguish between radical innovation and incremental innovation. The first involves a break with existing products or processes and gives rise to new industries or market segments. The second involves improvements to existing processes or products that are increasingly competitive. Incremental innovations far outnumber radical ones. In the context of agricultural enterprises, incremental innovation involves a process of partial adaptation. In particular, we refer to all those production processes where some machines are changed without prejudice to other machines or even the land capital within the agricultural company [4]. It should be remembered that each farm represents a combination of production factors that depend on the climate, soil, and farm machinery. Depending on this combination, every rational entrepreneur should decide on the optimal choice. There is no doubt that innovation is essential for economic growth and development. The crucial question, therefore, becomes how to efficiently organize resources and activities to support a virtuous process of innovation; how to direct investments in research and development, and related human capital, to create wealth and greater well-being. In agriculture, technical progress determines the disposal of old agricultural machines and the introduction of new operating machines that were not previously present on the market which allow for the same inputs to increase output. 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 led to the introduction of new agri-food products on the market and the diffusion of new production techniques [5]. In the agri-food sector, innovation has also manifested itself through the optimization of company resources according to the experience accumulated over the years by the entrepreneur (Learning by doing). This aspect takes on particular relevance in agri-food processes where the entrepreneur, based on his experience,

E-mail address: filippo.sgroi@unipa.it.

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improves the use of production factors with a view to business effectiveness and efficiency. The effect of the innovation translates, concerning the Cartesian axes, in an upward shift of the production function, and a rapprochement towards the origin of the axes of the production isoquant, i.e. the same quantity of product can be obtained with a lower use of inputs. For a small company, which operates in a competitive market, there is an incentive to carry out technical innovations since, at least for a certain time, it will be able to take advantage of them by itself and therefore achieve extra profits. In this case, the firm moves from a situation where the minimum average cost is equal to (or above) marginal revenue to a situation where marginal revenue is greater than the minimum average cost. However, the more or less continuous nature with which the technical progress that is implemented by individual companies is manifested ends up blocking the mechanism of freedom to enter the market which is one of the fundamental characteristics of competitive markets. Innovation can represent a condition of creating a competitive advantage provided that it is not easily imitated by other businesses. As long as the innovation is not imitated, then the company that introduced it enjoys a differential advantage which translates into a higher profit and therefore a condition of corporate profitability.

Technical progress in economic theory

Technical progress represents a condition of growth and competitiveness of the company. Growth is synonymous with the vitality of the company. In order to grow the company, it is necessary to invest in research and development. However, in the Italian agricultural world, considering that the majority of agricultural businesses are modest in size, it is difficult for a company to allocate resources for growth and development. What to do in these cases? Economic Theory teaches us that every investment must be supported by size (in terms of hectares, turnover, number of pieces produced) [5]. In the context of Economic Theory, technical progress can lead to an increase in the quantity produced at a company level; other forms of technical progress concern the better organization of company resources, both the increase in the size of the plants as a function of the increase in demand or the replacement of the plants because with greater automation personnel costs are reduced (this is the case of precision agriculture). In all cases, however, the investment must be correlated to the minimum optimal size that justifies it. This aspect is of considerable importance if one does not want to jeopardize the patrimonial and economic situation of the corporate structure. Productivity increases brought about by technical innovations translate into increases in purchasing power, which lead to an expansion in consumption. From Engel's analysis of demand, however, we know that the expansion of consumption rarely materializes in an increase in its quantity: in reality what changes is the structure of consumption. In the agri-food sector, this aspect is highlighted in societies with high per capita income where as it increases it does not increase the quantity of food products demanded but the service connected to the food. This has manifested itself in developed societies starting from the seventies of the last century and reaches all those economies where per capita income gradually increases. When talking about innovation, a distinction must be made between large and small businesses. In the first case, we are talking about highly capitalized and market-established companies, these companies have easy access to bank credit to make investments in research and development. This situation creates conditions of lack of access to innovations on the part of small businesses which, not having the ease of innovating, are forced to produce, for example, at a higher average unit cost. Talking about the structure of the markets, it is clear that companies operating in oligopolistic markets are more inclined to innovate, even if we must always remember that innovation requires long periods of time to establish itself and is therefore subject to risks. Therefore, in general, from the point of view of potential innovative capacity, large companies have an advantage over small-sized companies operating in competitive and competitive regimes. As Economic Theory teaches us, even in agriculture innovation must always be linked to economic reasons (increase in revenues and/or reduction in costs) [6]. But why do agri-food companies adopt innovation processes? Companies that innovate do so to reduce production costs as, for example, has happened in the last ten years with the spread of electronic scissors (and related tying machines) for pruning in viticulture. This process innovation has brought about economic benefits, above all in small family businesses operating in a competitive market [7]. In addition to causing a lowering of the average cost, innovation can lead to an increase in the profit margin. Furthermore, the company that innovates does so to improve the efficiency in the use of production factors such as transforming a sprinkler irrigation system into a micro-propagation one. Innovation, therefore, is the result that the entrepreneur finds as a function of a problem that he encounters during his entrepreneurial activity. For low capital-intensive production processes, innovation spreads through imitation. The first stimulus to innovate comes from the entrepreneur's verification of the positive effect of the change on income, be it in terms of an increase in revenues at constant prices and/or a reduction in costs and/or an improvement in product quality. and/or a change in the marketing process [8]. The introduction of an innovation generally constitutes an investment - of various kinds, but still a commitment of resources - and as such is linked to a risk that the entrepreneur assumes, the probability of failure of which must be minimized to accelerate its transfer.

Agriculture 4.0 and digital innovation

It is certainly no secret that technology today plays a fundamental role in agricultural innovation. An area that has allowed companies in the sector to adapt their processes to improve efficiency and be competitive in the future. If a few years ago this was a choice that gave a clear advantage in terms of differentiation, today it is practically an obligation to adapt to the legal requirements and specifications required by the markets. Agrotechnology is the field in which technology applied to agriculture is studied, providing a physical and logical infrastructure that helps farmers improve their processes. As? Obtaining a return on investment (ROI) in the short to medium term thanks to a strategic line of innovation that allows them to be one step ahead of their competitors. The use of drones for crop monitoring, remote sensors for precision agriculture, geo-positioning systems to aid localization, improved communications, and advances in renewable energy are innovations that allow us to advance in terms of innovation. This, together with the interest of technology companies in developing agricultural software with the use of techniques such as "Big Data" or "Machine Learning", leads to the consolidation of Agriculture 4.0. Increased food security measures, population growth forecasts, water scarcity, and climate change are all factors of great importance that make this line of technological progress necessary. Something that GAMBÍN keeps an eye on, carrying out internal developments and the implementation of existing tools adapted to its particularities and production needs [9]. Agriculture 4.0 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, forecast diseases, identify weeds before these occur, save time and inputs, optimize production times, affect product quality and working conditions. However, in Italy, these production methods are not widespread. Among the reasons that hinder the spread of Agriculture 4.0 are the limited size of the company which in agriculture translates into a low profitability capacity of the agricultural companies even if they are capitalized; furthermore the lack of cooperation between farmers. The limited size of the company, accompanied by the fragmentation of the land bodies still present in Italy, make the diffusion of innovation difficult. In general, to increase diffusion it is necessary that certain conditions are met, first of all, the extension of broadband and extra-broadband also in rural areas to guarantee the interconnection of the agri-food chain. Furthermore, sensitivity, competence, and

propensity to invest on the part of entrepreneurs are needed. The diffusion of innovations in the agri-food sector concerns the problems of adapting the company structure of partial adaptation or total adaptation. It is convenient for the entrepreneur to adopt an innovation if he knows ex-ante that he will obtain an economic advantage.

Materials and methods

In decision problems, it is customary to indicate the function that describes the entrepreneurial objectives as the objective function [10]. One of the problems that the entrepreneur has is that of reducing costs where, without prejudice to the revenues, the profit can increase; or increase revenues without prejudice to costs. As part of the choices aimed at increasing the profit of the company, the use of sensors applied to the soil can be envisaged to measure the humidity of the same. The use of sensors saves water resources and also the hours of manpower that should be used to monitor soil moisture. The use of sensors is susceptible to evaluations like other recurring decisions on the farm. The fact that this judgment is often required concerning the most convenient way of executing an operation calls into question the substitution between production factors (typically capital concerning labor). To evaluate the convenience of introducing sensors to measure soil moisture, suppose we evaluate the relative convenience between the cultivation of Chardonnay cultivar wine grapes with sensors (A) and that without sensors (B). Assuming that both can be achieved without changing the corporate structure, the fixed costs will be the same whether produced with (A) or with (B), or a combination thereof. Therefore the entrepreneur can express the judgment of convenience in terms of Gross Income on the condition that:

$$RL_{(A)} > RL_{(B)}$$

It would lead to the adoption of technique A. On the other hand it is known that:

$$RL_{(A)} = PLV_{(A)} - CV_{(A)}$$

$$RL_{(B)} = PLV_{(B)} - CV_{(B)}$$

Is that:

$$PLV = \sum p_i Y_i peri = A, B$$

$$CV = \sum_i \sum_j v_j X_j per_j = 1, \ldots, m$$

Results and discussions

The experimental tests to evaluate the economic convenience of using sensors that measure soil moisture were carried out within a farm located in the municipality of Partinico in the province of Palermo. The 10-hectare production facility specializes in viticulture for the production of wine grapes. Among the cultivars present in the company we have Cataratto, Nero d'Avola, Chardonnay, Syrah, Merlot, and Inzolia. Chardonnay was chosen for the experimental test. The land where the vineyard stands is flat with a medium texture. For the test, two parcels of land of 1 hectare each were chosen, where we positioned the sensors in the first, while not in the other. The GSP in the case in question is given by the productivity of the two parcels of land which in our case are equivalent since the morphology of the land, the form of pruning, and the cultivation techniques are the same. In particular, the productivity per hectare amounts to 80 q, while the sale price recorded concerning the year 2022 was equal to 50,00 €/q, therefore it will be that:

PLV (A) = 4.000,00 €
PLV (B) = 4.000,00 €
As regards variable costs, in case (A) costs were recorded as equal to:
CV (A) = 1.800,00 €
CV (B) = 2.200,00 €

Therefore, we have that:
RL (A) = 2.200,00 €
RL (B) = 1.800,00 €

Therefore, the use of sensors applied in the soil to measure soil moisture allows for savings in variable costs and therefore an increase in Gross Income [11–13]. So the application of intelligent agriculture techniques allows you to reduce costs and improve economic results [14, 15]. 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 the corporate and territorial levels. Innovation is the result of the contribution of different knowledge, requires a long time for its realization, and is characterized by uncertainty. 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 enterprise and territory value. Schumpeter defined "creative destruction" to describe how products (new products and replacement of old) and process innovation cause a dynamic process of renewal but also a process of destruction with old ways falling into disuse, resulting in the exit from the competitive market of many companies. At the level of the agri-food company, the creation of value, which derives from the implementation of digital innovation processes, requires some necessary conditions. First of all, the entrepreneur 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 the financial resources, and the availability of cash, that allows it to invest. In the absence of self-financing, the company should have access to credit. In this case, the degree of innovation of the company depends on the market conditions and the interest rate applied by the banks. Therefore the digitalisation of the agri-food supply chain depends on both internal and external conditions of the company. In general, we can highlight that digital innovation processes can only create value if companies are willing to innovate and if business and financial market conditions allow it. Investments in innovations, if they do not fail (given the high risk), are linked to long periods of time, an innovation initially has low returns, subsequently, if it is successful, the returns increase and then flatten out.

Conclusions

In economics, an innovation is successful if it determines demand and therefore creates value. If demand is created then it is possible to extract economic value from innovation. All this highlights that the value of innovation depends on the use of the innovation itself. In the Italian agricultural sector, where the majority of companies are small, innovative digital processes can have a positive effect on the creation of value in the entire agri-food supply chain if they are inserted into circuits that derive from contractual relationships between the different phases of the supply chain. The digital innovation presented in this study allows for economic advantages. The study conducted is very important as it represents an innovation that improves the efficiency of the farm. However, much remains to be done, especially due to the resistance of small entrepreneurs to the adoption of innovations. Innovation in agriculture should be considered as a learning process that requires the joint action of different "knowledge" and which produces its effects in the long term. In other words, entrepreneurs will be led to innovate if knowledge of the innovation spreads and determines real economic benefits. The study is very important for the wine sector but in general for agriculture as it highlights the possibility of saving water and this appears very important in hot arid periods and environments. Furthermore, the possibility of measuring the humidity of the soil with precision instruments allows you not to irrigate according to a calendar but only based on the water needs of the vine and the plant in general.

Ethical

I declare that the drafting of the paper " Innovation and value

creation in agriculture: results of an experimental analysis of the use of sensors on Sicilian vineyards of Chardonnay cultivars" respects international ethical standards.

Declaration of Competing Interest

I declare not to be in a conflict of interest with the Smart Agricultural Technology.

We hope that this manuscript can be taken into consideration for publication in the Smart Agricultural Technology.

Data availability

Data will be made available on request.

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