Article

The Economic Results of Investing in Precision Agriculture in Durum Wheat Production: A Case Study in Central Italy

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Abstract: Today, precision agriculture technologies (PATs) can be considered a tool for the management of the farm which allows the agricultural entrepreneur to optimise inputs, reduce costs, and offer the best quantitative and qualitative agricultural products. In Italy, the number of digital farmers is still low; therefore, it is not yet possible to assess with certainty the actual economic benefits that technologies bring to the farm. To bridge this gap, the paper proposes, through the analysis of a case study, an assessment of the economic efficiency of an Italian cereal farm that has invested in precision agriculture. The results reveal that, unlike what is reported in the literature, after the technological adoption, the farm keeps both the yield and variable costs stable. However, the major benefit is recorded in the decrease in labour costs (-20%) and in the reduction of pesticides (-53%). The increase in the quantity of nitrogen ($+11\%$) and of seed distributed in the field ($+5\%$) indicates that, in the face of a significant increase in total costs due to the capital invested in technology, the farm aims to intensify production rather than reduce agricultural inputs.

Keywords: case study; durum wheat; economic profitability; precision agriculture; sustainability

1. Introduction

In Europe, the cereals sector is not only facing challenges structurally, as well as financially and climatically, which have been responsible for the decline in income experienced by cereal producers in recent years; they include volatility of the market, scarce land availability, and climate change issues. The Italian agricultural context stands out for the presence of traditional low-tech farms, which operate within a political framework, characterised by income support and protected markets. In order to gain profitability and sustainability with an increase in yields accompanied by a reduction in their operating costs, EU grain growers started to digitalise agriculture through the introduction of precision agriculture technologies. This transformation represents an epochal challenge that cannot be taken up by all the farms in the sector because, as already said, it is accompanied by a substantial complexification of farm management.

Thus, this dynamic leads to a progressive exit from the market of smaller farms with the concentration of arable land management into larger production units. It must be clear that the need to increase the production scale depends on the need to invest substantial amounts of financial resources in multiyear assets to fulfil the modernisation required by the market under increasing technical and environmental constraints.

The overall effect of this remarkable process of structural change requires farmers to both invest in technological change and, consequently, train in order to increase their skills in terms of management control [1]. Within the agricultural sector, digital technologies mainly develop through the application of precision agriculture (PA). It emerged in the early 1990s when this technique was only focused on the study and management of spatial in-field variability. There is no broadly accepted definition of PA and starting

from 1990 to date, several definitions were provided. In 2019, the International Society of Precision Agriculture (ISPA) finally provided a comprehensive definition of PA as 'a management strategy that gathers, processes and analyses temporal, spatial and individual data and combines it with other information to support management decisions according to estimated variability for improved resource use efficiency, productivity, quality, profitability and sustainability of agricultural production' [2].

In fact, PA technologies have to be considered as tools to efficaciously manage the farm, their declared objective being to save production inputs with positive effects in terms of productivity, ecological footprint, and saving costs.

The sustainability of resources is crucial for farmers. If the farmer needs to gain a good profit for the long term, he needs to keep performing sustainable farming actions, which include practices of precision farming added with sustainable practices. In this context, applications based on these technologies are proving to have an increasingly central role in tackling the challenges of productivity increase in agriculture required by the global market, with a view of environmental sustainability also focused on the diffusion of the green and circular economy.

However, even if positive effects and sustainable approaches are recognised to PA, the application still remains circumscribed at few farms. In fact, in addition to the cost of investment, the adoption of precision agriculture technologies (PATs) has encountered other difficulties such as additional application or management costs and investment in new equipment, trained employees for the use of technologies and uncertainties found within the farming community, compared to the potential economic and environmental gains from their adoption.

On this premise, we propose an economic analysis case study carried out through analytical accounting with the aim of assessing the economic efficiency of a PA technology investment. Theoretically, the environmental and economic benefits of these technologies are two sides of the same coin.

Nevertheless, in Italy, we are in a phase of adoption of PA technology by pioneering farms. This trend is confirmed by the recent studies [3–5] which refer to the Italian context. Indeed, both studies highlight the fact that high chances for the adoption of PA technologies can be expected mainly from innovative farmers who showed a particularly strong interest in various benefits of PA technologies, such as increases in yields and water and fertiliser savings [6–10]. However, considering that the phenomenon of PA adoption is thus far still at an early stage, especially in the case of small and medium farms [11–14], it is not currently possible to directly observe the economic effect of these technologies.

Thus, consistent with this assertion, the case study we investigate is an Italian farm, situated in the Marche Region in central Italy, considered a pioneer farm in terms of its level of management control skills, its propensity to modernisation, structural change, and willingness to accept the current environmental and market challenges with which the cereal sector will have to deal with. In other words, the case study we propose should be considered a leading farm relative to the farming context under investigation, not a conventional one.

Even knowing that the case study research approach determines a lack of power in terms of generalisability of the research results, it must be considered that the internalisation of PA technologies by Italian farms is a contemporary event, and consequently, the PA cost–benefits analysis must necessarily be carried out through case studies.

A large number of studies report the positive effect of adopting PA technology among farmers [15–18]. According to OECD (2016) [19], a review of 234 studies published from 1988 to 2005 showed that precision agriculture was found to be profitable in an average of 68% of cases. Profitability depends on the extent of spatial variability of soil conditions, the size of a field, and uncertainty about output and input prices.

In particular, most of the studies evaluating the economic efficiency of PA technology, start from the hypothesis that the expected effects of PA adoption include the improvement of the crop operating margin due to the reduction in variable costs and, possibly,

the increase in yields. In addition, in terms of economic benefits, much of the applied adoption research focuses on economic savings from inputs in one growing season and excludes the initial investment costs in machinery and technology of the farming system. Finally, previous studies aimed at evaluating the savings and revenues caused by PA, but only by considering either the average savings from the application of a single technology [20–45].

For this reason, to obtain an accurate analysis of the profitability of precision agricultural technologies, there is a need to apply an economic evaluation, taking into account PA investment in multiyear assets. Based on the assumption that not all farms are able to cope with technological change, this article intends to answer the following research questions:

(1) What is the economic impact derived from the adoption of precision agriculture?
(2) Is there an economic convenience in investing in precision agriculture technologies? What are the effects of the adopted innovations on profitability?

Thus, the paper aims to examine the economic efficiency of an Italian cereal farm managed with precision agriculture technologies for a period of seven years, by describing all the economic changes that occurred before and after the technology adoption. Moreover, the empirical results are compared to the evidence gathered from the Farm Accountancy Data Network (FADN) to increase the robustness of the results extensions and of checks concerning statistical methods and data reliability. Given the importance of profitable and environmentally sustainable farming practices, an economic analysis of PAT adoption is required.

Specifically, the main reasons behind this study are the following:

- Precision agriculture applied to cereal farming is a frontier technology that has been coming to light in Italy for a very short time. Consequently, we believe that with respect to the territory under study it may be useful to provide scientific empirical evidence based on a case study that we consider relevant for being a leading farm in terms of economic results, entrepreneurial skills, and propensity to innovate.
- The study focuses specifically on durum wheat because Italy is among the largest producers of this crop globally. For this reason, we believe that a specific case study on the production of durum wheat is an object of interest at a local, national, and international level.

Finally, understanding PA adoption is necessary in order to develop adequate policies and initiatives which support the adoption of PA technology. As PAT is able to reconcile production requirements and environmental protection, questions arise on how best to support the adoption. The remainder of the paper is divided as follows: Section 2 presents materials and methods, then the results are presented in Section 3, and Section 4 ends with conclusions.

2. Materials and Methods

Using the case study method proposed by [46], we evaluated the economic results of a cereal farm that invested in precision farming technologies. Specifically, a single case study was chosen for application since the farm represents a case study with unusual characteristics, as compared to the national agricultural context, which is characterised by small low-tech farms. In contrast, the farm in question is a large cereal farm, located in central Italy, with a total area of 200 hectares, of which 87 are cultivated with durum wheat.

Additionally, the farm is equipped with a technological package, which includes the following, in line with the subdivision made by [47]:

1. Guidance systems (driver assistance, machine guidance, and controlled traffic farming);
2. Recording technologies, (soil mapping, soil moisture mapping, canopy mapping, and yield mapping);
3. Reacting technologies, (variable-rate irrigation and weeding and variable rate application of seeds, fertilisers, and pesticides).

These technologies were purchased from 2003 to 2019, for a total cost of about EUR 548 000, and they allow the farm manager to collect information to be used to make

informed decisions related to farming practices, including financial and managerial operations [48]. The current precision farming types of machinery are presented in Table 1.

Table 1. Major investments in precision agriculture technologies.

Precision Agriculture Investments for Crop Farming	Type of Technology	Year of Purchase	Replacement Value (EUR)
AGCO challenger ISOBUS-ready tractor	Guidance system	2011	20,000,000
Mazzotti MAF 5400 self-propelled sprayer with GPS guidance system	Guidance system and Reacting technology	2018	20,000,000
Jhon Deere ISOBUS-ready no till seeder	Guidance system	2018	6,700,000
Sulki ISOBUS-ready fertiliser sprayer	Reacting technology	2018	2,400,000
Parrot Drone	Recording technology	2018	500,000
Trimble in-cab terminal and satellite receiver combination for GPS guidance system and variable and rate distribution system	Guidance system and Reacting technology	2019	1,500,000

For the purposes of the case study, we collected information and data concerning the economic sphere of the farm necessary to analyse the profitability of durum wheat. For the economic analysis, we considered the following two distinct periods:

- A pre-adoption phase of PATs during 2013–2017;
- A post-adoption phase in 2018–2019, since the whole farm, by virtue of the investments made, is fully managed through precision agriculture technologies.

It needs to be clarified that the post-adoption phase is asymmetrical, compared to the pre-adoption one. In fact, the economic results of a five-year pre-adoption period (2013–2017) are only compared to two-year of the post-adoption period (2018–2019). The economic analysis was carried out according to the following steps by means of analytical accounting:

1. The definition of an income statement for the period 2013–2019 carried out with the active collaboration of the farm's management;
2. The evaluation of the principal economic indicators;
3. The comparison of the main economic indicators of the case study with the representative medians of these indicators with respect to the FADN sample cereal farm population, representative of central Italy.
4. Break-even and sensitivity analyses.

3. Results

The main results are presented in three main subparagraphs.

3.1. Economic Results

Figure 1 shows the costs, revenues, and prices of durum wheat from seed in the pre and post-adoption period.

Starting from the revenues, they incur a reduction between the pre-adoption period and the post-adoption period, except for the year 2015, when a calamitous event occurred. The decrease in revenues is attributable to cyclical effects that primarily concern the market price (the price of seed grains), but also from the increase in total costs over time which is mainly due to the investments made in PA. Given the competitiveness of the durum wheat market, evidenced by the general tendency to compress the price of commodities, the farm had to necessarily invest in increasingly efficient technologies to maintain a competitive position on the market (technological treadmill). Indeed, the profitability of the cereal

sector strongly depends on the volume of production achieved, on the quality of the seeds, and therefore on the resulting market price. The cereal farm represents an exception since it has been able to implement competitive strategies able to cope with market conditions (e.g., the selling price of the product), becoming, thanks to the qualitative parameters of production, a price-taker on the seed market.
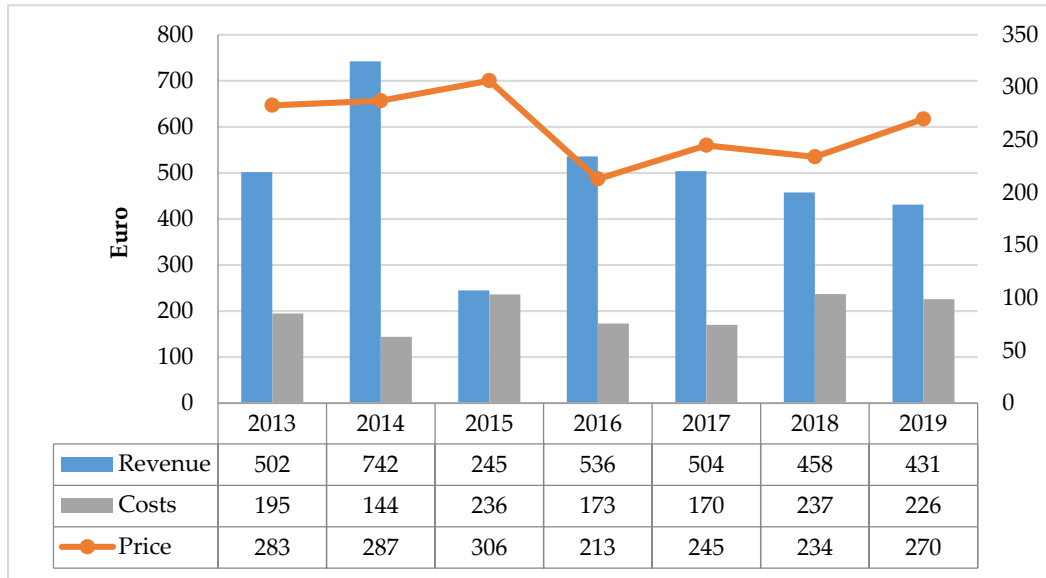

	2013	2014	2015	2016	2017	2018	2019
Revenue	502	742	245	536	504	458	431
Costs	195	144	236	173	170	237	226
Price	283	287	306	213	245	234	270

Figure 1. Costs, revenues and prices of durum wheat from seed.

By analysing the total costs, we observe a growth trend in the post-adoption period. Below, we analysed the different cost items that made up the total costs to understand the reasons for this variation (Figure 2).
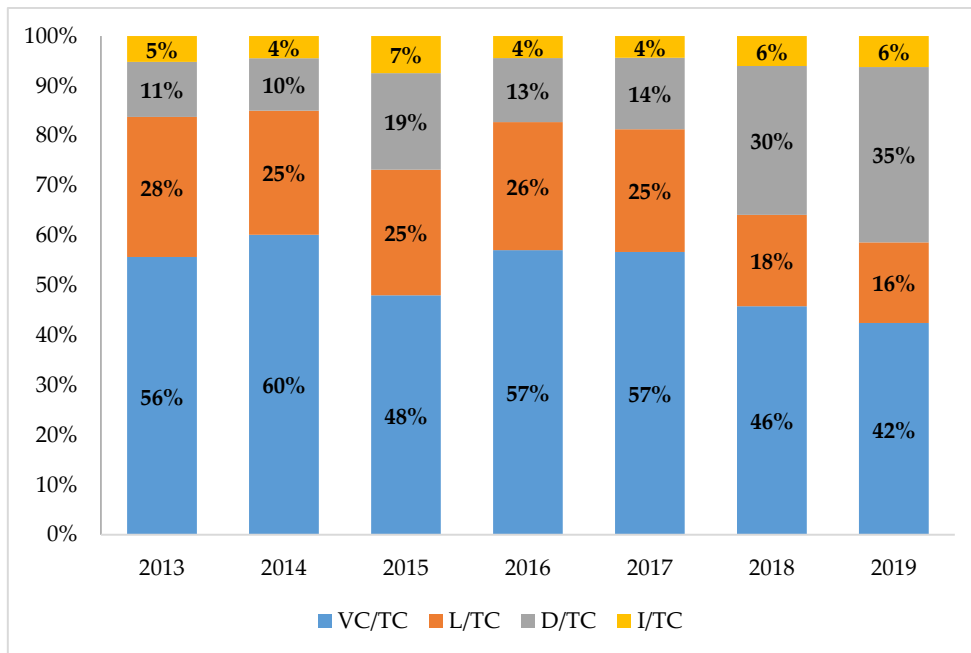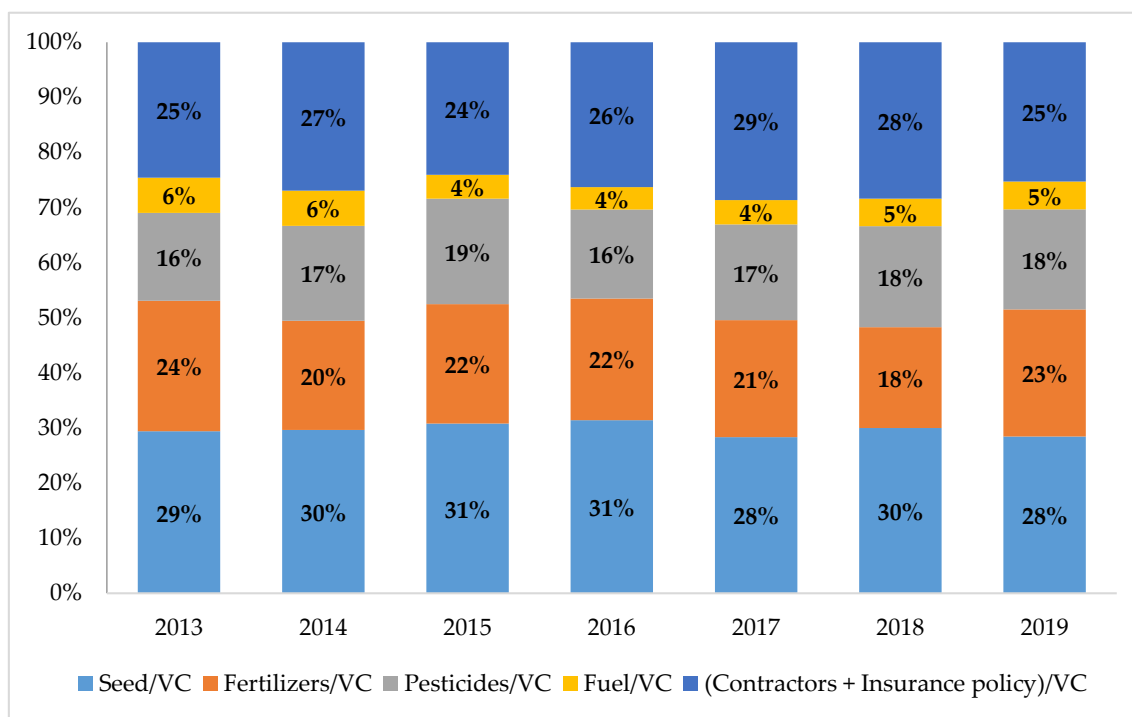

Figure 2. Incidence of the single cost categories as parts of the total costs.

First, in terms of variable costs (VC), they are the cost category that affects revenues most of all. Specifically, Figure 3 further breaks down the individual variable cost items.

Figure 3. Incidence of the single variable cost categories as parts of the total variable costs.

The cost for the seed represents the cost category that mainly affects variable costs (on average about 30%). This shows that seed companies play an important role in the cereal supply chain, capable of influencing the market prices of seeds. It is interesting to note that the cost of fertilisers and pesticides, in the second and third levels of significance, remain stable over time, even after the process of technological adoption. However, by analysing the quantities of inputs distributed in the field, it is revealed that the farm's technological evolution has led to the optimisation of the management of crop inputs in terms of the quantity distributed in the field. The purpose of precision agriculture is not always to reduce the quantities of agricultural inputs consumed; rather, it is above all to optimise their use and generate positive effects in terms of production yields and product quality and, therefore, in terms of revenues. Furthermore, it should be borne in mind that these costs strongly depend on the market price of inputs, which is often volatile and cannot be influenced by precision farming techniques; thus, it is certainly more effective to focus attention on the quantities of inputs used. Although VCs have remained almost unchanged, the volume of inputs distributed in the field has undergone variations (Table 2).

Table 2. Variation in the volume of inputs.

	Seeds (kg/ha)	Fertilisers (kg/ha)	Pesticides (kg/ha)	Fuel (L/ha)
2013–2017 pre–adoption phase	225.39	402	3.81	46.8
2018–2021 post–adoption phase	225	450	2.5	43

In particular, while the quantity of seed distributed remained unchanged, after the introduction of variable rate fertilisation, an increase in the amount of nitrogen added to durum wheat was detected (+11%). These results differ from the literature, which more generally highlights a reduction in terms of distributed nitrogen [49–51]. It should also be pointed out that in the implemented case study, a strategy of distributive efficiency of nitrogen fertiliser, after the automatic resistivity profiling analysis, made it possible

to accurately identify those field areas subjected to nitrogen deficiency, as well as those characterised by excess, so as to intervene in a targeted manner. As regards the quantities of pesticides, it can be observed that there was a decrease in quantities in the post-adoption period decreased (−53%): this decrease is mainly due to the use of precision sprayers. These results are in line with the literature: several authors state that precision agriculture (in particular, variable rate chemical weeding) leads to savings in crop protection products in cereal farming [52,53]. In the post-adoption phase, there was also a decrease in the amount of fuel consumed (−28%). This was possible owing to the new machines purchased, which have a better operating capacity than the previous ones and, among other things, are all equipped with the most advanced satellite guidance systems, which allow for overlaps to be minimised. It should be emphasised that the optimisation of the management of crop inputs discussed above has a very positive effect on the environmental sustainability of precision agriculture as it can result in a reduction in greenhouse gas emissions attributed to agricultural systems.

Returning to the description of the main cost items, it is worth noting that labour cost (L) represents the second most important item from 2013 to 2017, and on average, it affects revenues by 18%; then, after the introduction of the technology, the cost of labour is drastically reduced. This means that the farm, through the use of various PATs, has managed to make the use of the workforce in the wheat production process more efficient, consequently allowing more efficient use of human resources within other farm activities (nursery activity).

Depreciation of capital (D) is the third most important category from 2013 to 2017—it affects revenues, on average, by 16% (minimum value of 6% in 2014 and a maximum value of 31% in 2019). Interest (I) ranks last in importance for the entire period analysed and, on average, affects revenues by 4% (minimum value of 2% in 2014 and maximum value of 6% in 2019). Considering that the capital cost of farm implements equipped with IT capabilities is fairly high, there was a substantial increase in the value of amortisation quotas, derived from the sum of D with I. This increase is due to investments in PA technologies made by the farm in 2018, which allowed the company to innovate. The gap between the total revenue curve and the value-added curve (VA) is the largest because VC represents the main cost category for the entire period analysed. Instead, the absolute minimum difference is observed between the EBIT curve (earnings before interests and taxes, that is, the result before financial charges) and that of net income (NI), because I is the last category that affected the cost for the entire period studied.

In 2019, the EBIT curve is more distant from the VA than in previous years. This phenomenon is due to the substantial increase in D, which occurred because of the huge capital investments made in 2018. By consequence, 2018 was the only year in which it registered a negative operating margin.

3.2. Comparison with FADN

This section provides a comparison of the economic results provided by the case study with the sample farms from the FADN Database (Table 3). Among the datasets of the FADN, we selected two classes of farms: farms with a size >40 hectares; of these, we also considered the most efficient farms as those which make up 25% of this group (40 ha, top 25%). The comparison of the case study data is carried out with the top 25%, considering that the case study is particularly efficient.

Below, we will analyse the individual items in Table 3.

First, regarding the utilised agricultural area (UAA), the case study has on average 87 ha of UAA, showing variations that are not relevant in the period of pre- and post-adoption of technology: pre-adoption (89.3 ha) and post-adoption (82.5 ha). For the period considered (2013–2019), it is important to underline that the total area of wheat cultivated is not constant over time, but it undertakes variations that do not depend on the technologies adopted but rather on the managerial decision on crop rotation and the demand for the product. However, the farm area of the case study is five times larger (82.5 ha) than the

FADN sample (15.2 ha). This implies that, as reported by [54,55], the availability of large-sized fields allows for more efficient depreciation of the machine capital. With regard to the yield, the company recorded a yield of 5.5 (Ton/ha) in the pre-adoption period and 5.4 (Ton/ha) in the post-adoption period, while the FADN companies are characterised by an average yield of 4.7 (Ton/ha). The average yield in 2019 is in line with the historical average (5.6 t/ha against 5.5 t/ha); thus, it can be deduced that the technological evolution implemented in 2018 for the moment has not had direct effects on the quantities produced, but it is expected that at full capacity, the company will reach higher yield levels. This result confirms that the farm is characterised by productivity above the average of Italian cereal farms, even before the introduction of the technology package. As already mentioned in the previous paragraph, farm efficiency can also be found in the managerial choices made in relation to the sale of durum wheat. The table shows that the average price obtained by the case study is on average 262 EUR/Ton vs the 222 EUR/Ton of FADN companies. Indeed, to obtain a better price on the market, the farm does not choose to allocate production to wheat as a food commodity, but it chooses to allocate the product for the production of seeds, thus obtaining a higher average price.

Table 3. Comparison with FADN Database.

Results	>40 ha	>40 ha Top 25%	Case Study	
			Media 2013–2017	Media 2018–2019
UAA durum wheat (ha)	14.3	15.2	89.3	82.5
Crop yields (median) (t/ha)	4.1	4.7	5.5	5.4
Price (EUR/ton)	182	222	262.67	
TC per hectare (median) (EUR/ha)	725. 76	691.74	1062. 49	1329.66
TC per ton (median) (EUR/ton.)	171.4	136.38	194.09	246.44
Variable costs per hectare (median) (EUR/ha)	379.68	341.57	585.99	586.68
Variable costs per ton (median) (EUR/ton)	93.8	74.2	106.38	108.89
Nitrogen (kg/ha)	51.6	46.6	120.38	135.68
Gross Margin (EUR/ha)	350.5	575.81	958.07	837.85
Gross Margin per hectare (median) including EU subsides (EUR/ha)	662.78	928.01	1374.07	1271.78
Incidence labour + capital cost per hectare (EUR/ha)	308.96	299.51	476.5	742.98
EU subsides (PAC) (EUR/ha)	310.62	352.2	416	433.93
Operating Margin per hectare (median) + EU subsides (EUR/ha)	352.16	628.5	897.57	528.8
Operating Margin (EUR/ha)	41.54	376.3	481.57	94.87
EU subsides/Operating Margin + EU subsides (%)	0.88	0.56	0.49	0.92

Regarding the total costs (TC), the case study recorded an increase (+25%) after the post-adoption phase due to investments in digital technologies and thus in the capitalisation of the farm. Adoption of PATs naturally leads to greater expenditures on machinery and equipment because these technologies are capital intensive. By comparing this result with the FADN sample, TC has almost doubled (+48%). Concerning the variable costs, there are no significant decreases in variable costs for the case study before the adoption (586 EUR/ha), while the variables cost of FADN farms amounts to 341.57 EUR/ha.

The increase in variable costs of the case study, compared to the FADN sample, is due to the intensification of agricultural practices after the introduction of technology: indeed, after 2018, both the quantity of nitrogen distributed in the field and the cost of nitrogen increased. In addition, the increase in the quantity of nitrogen (+12%) is in line with the quantity of seed distributed in the field (+5%). The quantity distributed by the case study (135 kg/ha) is more than doubled compared to the distribution made by the FADN farm (46.6 kg/ha). This result highlights how the efficiency of precision agriculture is due to the efficiency of the spatial distribution of the inputs according to the needs of the crop, rather than the savings of the inputs. The efficiency in the distribution of inputs, made possible by the collection of information provided by the precision agriculture technologies, leads to sustainable intensification, thus contributing to the farming efficiency and environmentally friendly farming practices; indeed, the nitrogen input is brought into the field only where needed [56,57]. In order to reach an efficient farming system, the farm decided to adopt an input-intensive system rather than an input-saving one.

Turning to terms of profitability, the farm's gross margin increases by 66%, compared to the FADN sample, attesting that the farm was already efficient in the pre-adoption phase. Paradoxically, the decrease in the gross margin after the adoption of the technology package is manifested by the increase in fixed costs due to the capitalisation of the farm. Consequently, if we subtract the costs of labour and capital factors from the gross margin, we obtain a very low operating margin (94.87 EUR/ha), both with respect to the pre-adoption phase and with respect to the FADN sample.

In summary, in the face of production and management efficiency, including in terms of the market, the investment costs in precision agriculture have a considerable impact in lowering the level of profitability. The operational results, however, must take into account the subsidies of the Common Agricultural Policy (CAP) from which the farm benefits. The subsidies that vary between 416 EUR /ha and 433 EUR /ha allow the farm to retain performance levels of profitability compared to the FADN sample (528 EUR /ha to 628 EUR /ha).

3.3. Break-Even and Sensitivity Analysis

The last part of the analysis concerned break-even and the sensitivity analysis. The break-even point (BEP) analysis was performed for the evaluation of the economic convenience of investments in precision agriculture technologies. BEP is a technique that tends to determine the equilibrium point between total costs and total revenues and that allows us to predict the economic results in correspondence with production outputs (i.e., the quantities produced or sold and therefore, in our case, the yield) or sales price or production costs. Thus, it becomes possible to understand how the variables considered the impact on the farm's economic results.

Adopting precision agriculture technologies by farmers depends on several factors including variation in yields or in the market price. The purpose of this break-even point was to evaluate the minimum yield and price that the company must maintain in order to amortise the cost of the technologies.

Figure 4 relates the BEP of the yield together with the actual yield of the case study. It is evident that the farm yield largely exceeds the BEP in all years except 2018. Indeed, only in 2018 was there was a negative net income (NI) and, to obtain balanced economic results, a yield equal to 5.99 would be necessary, instead of the 5.2 t/ha actually produced, to reach the equilibrium point. In the remaining years, the farm yield was always largely sufficient to ensure a positive NI, since the farm was very efficient from the point of view of the production per hectare. Therefore, it is possible to state that currently there is no need for the agricultural entrepreneur to increase the yield of his productions.
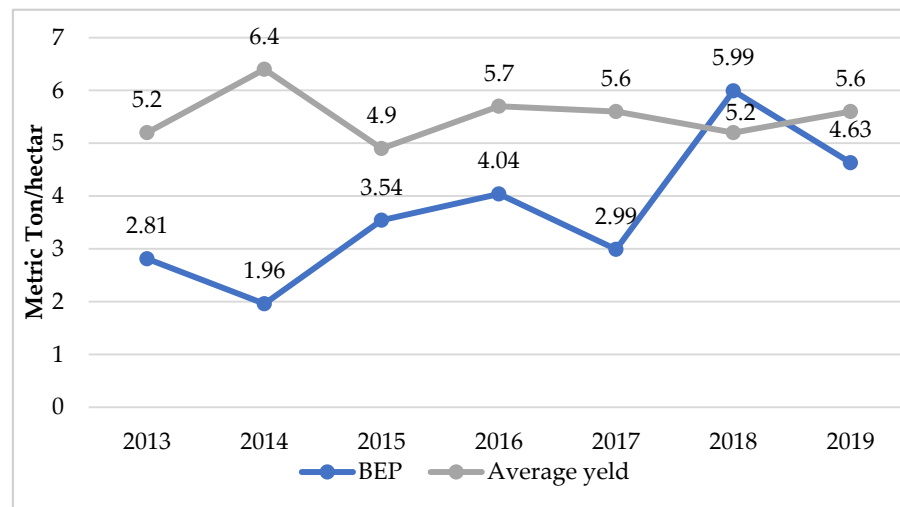
Figure 4. Break-even yield (Ton/ha) of durum wheat on sample farm.

In parallel, Figure 5 shows the trend of the BEP price, together with the actual sale price of the farm. Similar considerations to those made with regard to Figure 5, emerged from this figure. Indeed, only in 2018 did the BEP exceed the actual price (EUR 252.05/ton against EUR 234.00/ton), as it is the only year in which there was a negative NI. However, contrary to what was stated about the BEP yield, by virtue of the increase in the quality of the product, the entrepreneur would like to reach an increase in the sale price of durum wheat from seed.
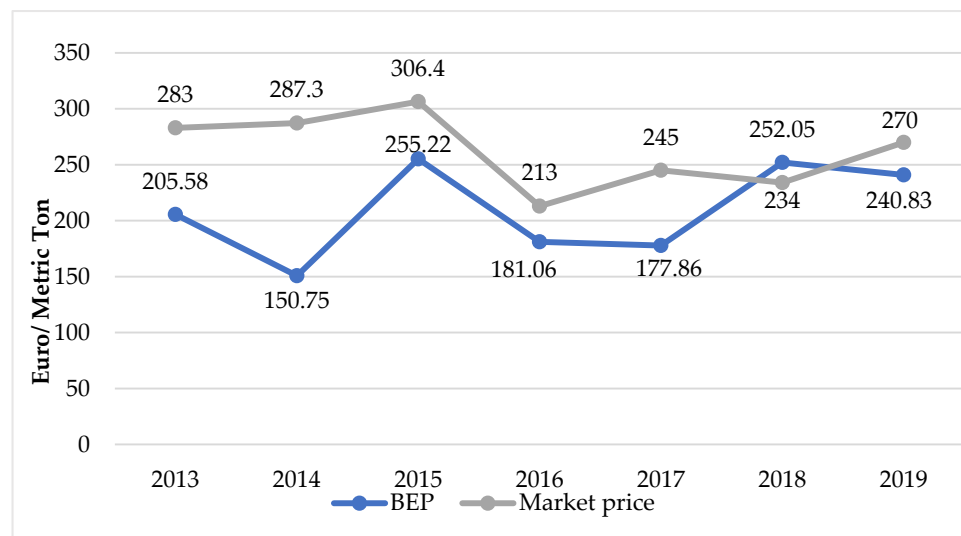
Figure 5. Break-even price (EUR/Ton) of durum wheat on sample farm.

In summary, the farm is in a profitable position in the existing yield and price obtained in the study area. The research concludes with a sensitivity analysis conducted on the results of the income statement of the post-innovation period (2019) in order to assess the economic and financial effectiveness of the innovative investments made in 2018. The sensitivity analysis, in general, allows series of alternatives to be taken into consideration, understood as entrepreneurial choices, with the aim of identifying which parameters can be modified in such a way as to achieve the set economic objectives.

The results of the sensitivity analysis make it possible to examine the effects of the innovations introduced on the profitability of the post-innovation period and, above all, indicate which levers can be realistically acted upon to possibly improve this profitability.

For the following analysis, the effects were evaluated with regard to four parameters: yield, sales price, variable costs, and farm size. The sensitivity analysis revealed the extent to which the production yield, the selling price, or the cultivated area should be increased, or variable production costs be decreased in order to raise the NI up to a level that at least equalises the target profitability (Table 4).

Table 4. Durum wheat sensitivity analysis.

	Yield (Ton/ha)	Market Price (EUR/Ton)	Cost of the Product Unit (EUR/Ton)	Size (ha)
Actual Amount (2018–2019)	5.	252.00	97.78	82.5
Target Amount	6.03	298.96	54.45	131.82
Variation	+11.6%	+18.6%	−44.31%	58.78 %

The table shows that if we sought to obtain an NI in the post-adoption period greater than or equal to that of the pre-adoption period, we would have to reach a production yield of approximately 6.03 t/ha (compared to 5.4 t/ha effective) or a sales price of approximately EUR 289.96/t (compared to the actual 252.00 EUR/t) or variable costs of approximately EUR 54.45/t (compared to EUR 97.78.29 /t effective), and a cultivated area of approximately 131.82 ha (compared to the actual 82.5 ha). Therefore, it is clear that in the "post-innovation" period, the desired positive effects of innovation in terms of profitability require more than one year to manifest themselves. It is conceivable that the new PA technologies introduced within the farm can lead, over time, to an increase in the sale price (following the increase in product quality) and/or to reduce the variable production costs (owing to the optimisation management of crop inputs). Instead, the production yield depends almost exclusively on varietal and pedoclimatic factors, while an extension of the cultivated areas is difficult to hypothesise since the dynamics of the land market hinder its implementation (although the current farm structure, especially in terms of work and capital, could also support an increase in the scale of production).

4. Conclusions

To date, PA in Italy still has a certain degree of resistance on the part of agricultural entrepreneurs due to the difficulty of understanding that the economic advantages of technology applied to agriculture are not immediate, but that their effects occur mainly in the long term. Through this case study, it was possible to evaluate the effect over time of precision agriculture technologies, which have brought economic and environmental benefits, due to the efficiency of the use of crop inputs and the organisation of business activities. Indeed, if on the one hand, the adoption of new technologies has represented for the farm an increase in fixed costs (depreciation of the capital), deriving from the investments made, on the other hand, the adoption of these technologies has ensured greater efficiency and greater speed of execution of agricultural operations, with significant savings in the labour force and the optimisation of inputs.

Some considerations must be made regarding the positivity that emerges from the adoption of precision agriculture concerning save in labour, quality, and traceability of production, and the positive environmental effect of precision agriculture. It is clear that labour capital is the only factor that, owing to the adoption of technology, undergoes a significant decrease, of about 20%. The decrease in labour costs is attributable to the efficiency of crop management resulting from precision agriculture since agricultural operations are performed with efficiency and speed. All these facts result in efficiency in the management of human resources, which, in this way, can also be reallocated to other company production activities. As regards the quality of durum wheat production, we underline that the qualitative parameters of the grain produced have significantly improved, both from a commercial point of view (the hectolitre weight and protein content values have increased) and phytosanitary (a lower incidence of attacks from part of phytopathogenic agents),

which are monitored by the farm thanks to the adoption of a traceability system through the use of a QR code. Finally, considering the environmental aspect, this work provides evidence of the savings in terms of inputs distributed in the field. In this sense, the adoption of precision agriculture guarantees sustainable agriculture from an environmental point of view. These potentials of technologies are increasingly recognised at a political level. Following the declaration for 'a smart and sustainable digital future for European agriculture and rural areas' signed by most Member States in April, the European Commission presented and discussed new technologies and digitalisation in agriculture highlighting the advantages and opportunities it offers for the sector. Then, the European Commission announced the Green Deal policy for Europe and its From Farm to Fork strategy, oriented to investing in cutting-edge research and innovation and preserving Europe's natural environment". In this deal, digital technologies are presented as 'enablers to achieve the sustainability goals'. In addition, for the period 2021–2027, the European Commission has proposed a Common Agricultural Policy (CAP) focused on the goals of social, environmental, and economic issues, giving a clear signal that it is necessary to build sustainability that is driven by digital agriculture. Indeed, the post-2020 CAP proposals take into account the importance of the use of technologies in the sector. By increasing the economic efficiency of a farm, precision agriculture provides an opportunity to simultaneously reduce the environmental impacts and improve productivity and profits on the farm. In addition to increasing efficiency, however, precision agriculture also could affect the policy of the agricultural sector. Future studies can analyse how the adoption of precision agriculture technologies interacts with different types of agro-environmental policies, and how they could change the relative effectiveness of those policies. Future studies can analyse how the adoption of precision agriculture technologies interacts with different types of agro-environmental policies and how they could change the relative effectiveness of those policies. In addition, as underlined in the case study, the post-adoption phase is asymmetrical, compared to the pre-adoption one. In fact, the economic results of a five-year pre-adoption period (2013–2017) are only compared to two years of the post-adoption period (2018–2019). As a consequence, these results should be evaluated only as a springboard for future research. More in-depth analyses are still required.

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