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Efficiency and inventory turnover in the primary sector: A regional analysis

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Abstract

This paper explores the performance of the agricultural sector on balance sheet data (2008–2017). A post-window data envelopment analysis (DEA) investigates the factors that influence firm performance, especially inventory turnover. According to the findings, inventory and accounts receivable turnover negatively influence firm efficiency, while the debt index exerts a positive effect both in the short term and the long term. The empirical results show that the northern Italian regions are more efficient than the central and southern regions, and it was confirmed that Sardinian farms achieve better scores than Sicilian farms.

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1. Introduction

Economic efficiency is a key diagnostic used for evaluating firm performance, designing and targeting short-, medium-, and long-term policies, and ultimately, guaranteeing firms' survival. As Borodin et al. (2016) emphasised, agricultural firms face volatile markets and are vulnerable to climate change, economic and financial fluctuations, and stringent regulations within an ever-competitive global environment. Several studies have investigated the economic efficiency of the farming sector by employing parametric stochastic frontier analysis (e.g., Benedetti et al., 2019), non-parametric data envelopment analysis (DEA; e.g., Galluzzo et al., 2017; Guth and Smędzik-Ambroży, 2019), comparing both methodologies (e.g., Moutinho et al., 2018), and post-DEA methods (e.g., Nowak et al., 2015). Yet, few studies on agricultural efficiency have used WDEA, and even fewer have applied the Simar-Wilson procedure (Shahraki et al., 2018; Yobe et al., 2020; Al-Mezeini et al., 2020). While the non-parametric stage DEA identifies relatively efficient firms, the parametric stage identifies statistically significant determinants that influence economic efficiency.

Despite this extensive literature on farming efficiency, there is still a shortage of investigations on the impact of inventory on agricultural economic efficiency (e.g., Husain and Alnefaee, 2016; Nuseva et al., 2017; Atnafu and Balda, 2018; Zhan and Liu, 2019), and much of the research on this relationship has been devoted to the secondary sector. Inventory turnover measures how many times a firm's inventory is sold and replaced over time (Engel, 2015; Osazefua, 2019). From the literature, there is no clear-cut answer regarding the actual impact of inventories. As far as the manufacturing sector is concerned, on the one hand, some studies highlight that high inventory levels and inventory days are associated with poor firm performance (Mohamad et al., 2016; Gu et al., 2017). When inventory turnover is low, products are more likely to be damaged, deteriorate, or even fail to fulfill customers' preferences. On the other hand, other studies show that raw material inventory tends to reduce costs due to production disruptions and product scarcity (e.g., due to adverse climate conditions). Hence, inventories can protect against price volatility, and adequate management can increase business profitability.

The present study contributes to the literature on the impact of the inventory turnover ratio on the economic efficiency of the agricultural sector. This issue is increasingly important since agricultural firms are expanding their traditional missions and enhancing support activities within agri-food, such as short food supply chains. Indeed, agricultural inventory can play an essential role in the European Union (EU) New Green Deal 2030, the so-called "farm to fork". In times of turmoil and pandemic, such as COVID-19, the objective is to empower consumers to choose sustainable and healthy food and, in turn, create business opportunities to supply agents who want to innovate and protect the environment.

This objective is explored via a post-WDEA approach. The first step involves a standard WDEA to elicit an indicator of efficiency over 2008 to 2017 (Charnes et al., 1985). On this basis, a Simar-Wilson procedure is adopted for each of the five identified windows (Cooper et al., 2007). The objective is to evaluate the main factors that influence firm efficiency, especially in which direction and to what degree it is impacted by inventory turnover. Moreover, via a window parametric approach, the model robustness and the stability of the coefficients are assessed within a temporal dynamic framework.

The empirical data on the Italian regions were taken from the AIDA database (*Analisi informatizzata delle aziende italiane*, Bureau van Dijk). The AIDA database collects data on the balance sheets of limited-liability and cooperative companies, obliged by law to provide annual accounts. AIDA also includes information about firms' location, economic sectors, and years of activity (Lotti and Marin, 2013). Three main domains are: time (annual), geographical setting (regional), sector of economic activity (e.g., farming, for crops and livestock). Hence, AIDA is useful for evaluating the profitability of agricultural firms and gathering financial data.

2. Literature review

A broad literature review is presented to shed light on the possible effects of inventory turnover on firm profitability and its implications, primarily focusing on the secondary sector. Empirical research shows that high inventory levels and inventory days are associated with poor long-term stock returns (Gu et al., 2017; Roni and Djumahir, 2018). Some empirical evidence suggests that managers can create value by reducing inventories and the number of days their accounts were outstanding. Likewise, Yuniningsih et al. (2018) reveal that inventory reduction significantly positively affects performance.

When inventory turnover is low, products spend more time on shelves. This circumstance increases the exposure window for damage, pilferage, and spoilage/expiration (Gaur et al., 2005, Wan et al., 2020). Excessive inventories increase the likelihood of lost or misplaced items (Kroes et al., 2018). Long inventory supply chains also tend to have longer order cycles, thus making them less responsive to changing tastes and preferences (Martinez et al., 2015) and more exposed to financial risk (Wang et al., 2020). Other studies show that inventory conversion exerts a negative effect on firm profitability. Hence, as the time required for inventory conversion increases, profitability decreases and vice versa (Panigrahi, 2014; Edwin and Florence, 2015; Jakpar et al., 2017).

While a positive effect of inventory reduction on operational performance has been reported in various studies (Anojan et al. 2013; Ponsian et al., 2014; Shahbaz et al., 2018), other studies reveal the opposite outcome. In this respect, other authors find that although inventory reduction positively affects organization performance, this effect varies with inventory and industry type (Eroglu and Hofer, 2011). Specifically, these studies highlight that raw material inventory has a higher impact on performance than work in progress inventory or finished goods inventory. Moreover, Mathuva (2010) finds a highly significant positive relationship between the period taken to convert inventories into sales and profitability. This outcome implies that firms that maintain sufficiently high inventory levels reduce the costs of a possible interruption in the production process and a loss of business due to product scarcity. In addition, high inventory levels reduce firm supply costs and protect them against price fluctuations. In this regard, Evci (2018) addresses some advantages to working with high inventory levels, such as preventing customer losses caused by not having enough stock level and protecting both parties against price volatilities. A high level of inventory, if adequately monitored and controlled, can also act as a buffer against volatility and order fluctuations, mainly due to more common adverse climate conditions that can alter production and relative prices (Jangga et al., 2015). Elsayed and Wahba (2016) suggest that while an inventory to sales ratio negatively affects organization performance in the initial growth and maturity stages, it presents a significant positive impact on performance in either the rapid growth stage or the revival stage.

Moreover, Chuang and Zhao (2019) find that while high demand leads to high inventory levels (sales effect), high inventory levels stimulate sales demand (demand stimulation effect) in a dynamic and uncertain environment. Likewise, Wan et al. (2020) suggest that an increased product variety leads to higher sales and higher inventory levels. Obermaier and Donhauser (2012) argue that organizations with the lowest inventory levels also had the worst performance. Other studies have also highlighted the lack of a clear-cut answer regarding this relationship (Mathuva, 2010; Folinas and Shen, 2014). Folinas and Shen (2014), for example, show that there is no significant relationship between inventory turnover and financial performance.

As previously stated, most of the cited studies mainly focus on the secondary sector, while the agricultural sector is largely neglected. Husain and Alnefaee (2016), via an ordinary least squares (OLS) regression analysis (2009–2014), examine the impact of inventory on the profitability of a selected set of agriculture and food companies in Saudi Arabia, revealing that a moderate negative correlation exists between inventory turnover in days and gross operating profit. One interpretation of this negative relationship is that the more time firms need to sell their inventories, the higher the adverse impact on their profitability. This outcome suggests that raw materials should be converted into finished goods and sold to customers without delay. Nuseva et al. (2017), via a regression analysis (2012–2015), found a positive relationship between inventory turnover and profitability at 40 coffee firms in Serbia. Via a DEA and a random forest regression analysis (2013–2017), Zhan and Liu (2019), focusing on 39 agricultural enterprises in China, found that a high turnover rate in inventory promotes financing efficiency.

3. Methodology

In the agricultural literature, several studies employ a standard two-stage DEA. Liu et al. (2013) provide a literature review on early two-stage DEA studies on the agricultural sector. Such a more complex framework has several advantages. In the first non-parametric stage, the DEA extracts efficiency scores but fails to indicate the potential causes of DMUs' inefficiency. This limitation is fulfilled in the second stage. The DEA scores are then correlated with other determinants and controls within a regression analysis. As a further novel contribution to the literature, the present paper investigates this relationship within a post-WDEA framework and controls coefficient stability across time (Detotto et al., 2012).

Based on a typical Cobb-Douglas framework, a WDEA elicits relative efficiency of a set of decision-making units (DMUs) to their peers and their performance over time (e.g., Pulina et al., 2010; Sardar et al., 2018; Yobe et al., 2020). The objective of a firm is to maximize its profits and minimize its costs or maximize its revenues, given the technological constraint faced. A generic production function for agricultural firms is as follows:

$$Y_{i,t} = \bar{A}\, F(L_{i,t,} K_{i,t}) \tag{1}$$

where Y is the output (value), $\bar{A}$ is the fixed technology, L is the labour, K is the capital stock, t is time, and i is the region; all the variables are expressed in logarithms (Biddle, 2010).

The WDEA theoretical framework is based on a set of observations for n different DMUs over a time span T. Overall, the panel consists of $(n * T)$ observations, which are then divided into a set of windows, and each window counts $(n * w)$ DMUs. Cooper et al. (2007) provide a formula to choose the optimum window width w, as follows:

If T is odd, then

$$w = (T + 1) / 2 \tag{2}$$

and if T is even, then

$$w = [(T + 1) / 2] + 0.5 \tag{3}$$

WDEA models can be constructed under either constant returns to scale (CRS) or variable returns to scale (VRS) (Coelli et al., 2005). The overall technical efficiency (TE) is obtained under CRS, while under VRS, TE can be further decomposed into scale efficiency and pure technical efficiency (PTE). In the production process, PTE reflects management's ability to save input for producing a given amount of output. Theoretically, two methods can be considered: demand-oriented efficiency, where output generation can be increased proportionally, leaving input consumption unchanged; and supply-oriented efficiency, where input consumption of DMU i can be reduced proportionally, leaving output unchanged. A statistical test is also run to assess whether the DMUs are empirically characterised by either CRS (as the null hypothesis) or VRS (Bogetoft and Otto, 2011). A score equal to 1 implies that the DMU is relatively efficient, while a score less than 1 indicates relative inefficiency to the sample of DMUs under investigation.

As a post-WDEA, a Simar–Wilson (2007) bootstrapping procedure is applied to investigate firm performance factors. To this end, the Robust DEA (rDEA) for the statistical package R, developed by Simm and Besstremyannaya (2016), is used. This approach implements Simar and Wilson's (2007) second algorithm for bias-correction of efficiency scores in either input- or output-oriented DEA models. The generic parametric equation is based on the WDEA efficiency scores and is expressed as

$$\theta_{it} = X_{it}\beta + \varepsilon_{it} \geq 1 \tag{4}$$

where

$$i = 1, \ldots, n$$

and

$$t = 1 \ldots T$$

and where θ_{it} (< 1) is the DMU's (i) (in)efficiency score at time t, X_{it} is a set of determinants and controls that can influence the DMUs' (in)efficiency, and β is the vector of robust coefficients in the truncated regression of reciprocal DEA score on the variables after the second loop. A negative (positive) sign of the coefficient implies that the variable has a positive (negative) impact on efficiency. The statistical significance of the coefficients is based on the matrix of the lower and upper bounds for beta, using either 1% or 5% confidence intervals; ε_{it} is the residual assumed to be white noise.

4. Context and empirical investigation

Agriculture is one of the key economic sectors in Italy and accounts for 2.2% of its gross domestic product (GDP); this figure reaches 4.1% when including packing and agri-food transformation directed to the service sector or retail (ISTAT, 2020). In 2019, the production value obtained by secondary and complementary activities approximated 22% of the total agricultural production value, representing a share of approximately 30% within the EU-28. Italy is also an interesting case study for its various landscapes, diverse climates, and endemic historical and socioeconomic features that make each region and province unique. The northern regions primarily produce grains, soybeans, meat, and dairy products, while the southern regions specialize in fruits, vegetables, olive oil, wine, and durum wheat. Even though many of its mountainous areas are unsuitable for farming, approximately 4% of the population is employed in farming. Most Italian agricultural firms are small, with an average size of eleven hectares (Galluzzo, 2017).

Data retrieved from AIDA on a panel of agricultural firms in 20 Italian regions operating between 2008 and 2017 is used for the empirical analysis. For the WDEA, as the first stage of the investigation, a set of outputs and inputs are considered. As a proxy of annual firm production, *sales revenue* is used as an output. This variable is the product between the price of goods and services and the number of units sold. Theoretically, Cook and Seiford (2009) remark that a one-output and two-inputs framework, or vice versa, can be employed.

Furthermore, the production process in the agricultural sector largely relies on human capital and, hence, *labour costs,* used as an input, are defined as the total expenditure borne by employers to employ workers. The second input, *physical capital*, is defined as the monetary value of all material and immaterial goods employed by the firm as production factors (e.g., buildings, machinery, and plants). As a further input, the model includes the *amount of current assets*, which consists of cash, accounts receivable, stock inventory, pre-paid liabilities, and other liquid assets.

Based on the WDEA, the parametric specification is provided in the following equation:

$$\theta_{it} = \beta_1 + \delta D_{it} + \beta_2 S_{it} + \beta_3 IT_{it} + \beta_4 AR_{it} + \beta_5 A_{it} + \beta_6 AS_{it} + \varepsilon_{it} \tag{5}$$

where

$$i = 1,.., N$$

and

$$t = 1 \dots T$$

θ_{it} is the DMU's (i) (in)efficiency score at time t, $\beta_1 \dots \beta_6$ are the parameters to be estimated, δ is the parameter of the shift intercept and D_{it} is the geographical dummy, S_{it} includes the long-term debt and the short-term debt, IT_{it} is the inventory turnover in days, AR_{it} is the accounts receivable turnover ratio, A_{it} represents firm age and AS_{it} is the age squared; ε_{it} is the residual that is assumed to be white noise.

Alternatively, in two separate models, S_{it} includes the long-term debt (Model 1) and the short-term debt (Model 2), respectively. This choice is supported by a high and significant correlation coefficient between these two indicators, which would lead to possible multicollinearity issues. The short-run debt index contains components such as debt with suppliers and mortgage payments of the year on total debt. The long-term debt index includes debt with banks for investments in fixed assets and more productive technologies. As one of the main aims of the investigation, IT is the inventory turnover in days, which measures the number of days a company holds its stock before being sold. Specifically, this indicator is calculated as follows:

$$IT = Inventory\ Turnover\ in\ days = (inventory\ /\ sales) * 365 \tag{6}$$

The accounts receivable turnover ratio (AR) is also included as a further determinant of efficiency. It indicates the average times for receivables to be converted into cash in a certain period. It is the ratio of sales revenue to accounts receivable average balance. As controls, firm age (A) and age squared (AS) are included in the equation, considering possible non-linearities. Furthermore, the geographical dummy D takes the value 1 if the region (i.e., Abruzzo, Basilicata, Calabria, Campania, Molise, Puglia, Sardinia, and Sicily) is in the southern part of the country, and 0 otherwise. Hence, δ is the parameter of the shift intercept. This control accounts for the degree to which socioeconomic and geographical factors influence firm efficiency (ISTAT, 2019).

5. Empirical results

5.1 WDEA

A comparison of the relative efficiency is provided amongst all the Italian regions across 10 years (2008–2017). Using the formula (3), as proposed by Cooper et al. (2007), the window width is set to six years, and a total of five windows are set for a total of 100 observations in each window. A supply-oriented framework is chosen, as it is expected that the primary objective of the firms is to minimize costs. The preliminary tests in each of the WDEA models suggest VRS. In fact, the null hypothesis of CRS cannot be accepted at the 1% level of significance (full results for all the WDA models can be provided upon request).

Table 1 summarizes the results obtained for each of the regions and each of the five windows. A window efficiency mean is computed for each Italian geographical area (i.e., northern, central, and southern). Efficiency scores for Sardinia and Sicily are provided separately to make straightforward comparisons with other studies (Galluzzo et al., 2017).

Table 1. VRS – efficiency means for the North, Centre, and South Italy.

Geographic setting	VRS MEAN				
	2008-2013	2009-2014	2010-2015	2011-2016	2012-2017
North	0.8223	0.8022	0.7876	0.7838	0.7835
Centre	0.8190	0.7965	0.7859	0.7875	0.7602
South	0.8101	0.7982	0.7734	0.7720	0.7766
Sardinia	0.8148	0.8107	0.7852	0.8032	0.7847
Sicily	0.8012	0.7827	0.7746	0.7710	0.7805

Notes: North=Aosta Valley, Emilia-Romagna, Friuli-Venezia Giulia, Liguria, Lombardy, Piedmont, Trento, Bolzano and Veneto. Centre=Lazio, Marche, Tuscany and Umbria. South= Abruzzo, Basilicata, Calabria, Campania, Molise, Apulia, Sardinia and Sicily.

The non-parametric findings reveal that the regions located in northern Italy have relatively higher efficiency scores than those in central and southern Italy. This outcome is consistent in all the windows, with the only exception being 2011–2016, where central Italy outperforms northern Italy. Notably, the WDEA results align with Galluzzo (2017) and, once more, show that Sardinian firms have higher performance scores than Sicilian firms. Furthermore, in the last two windows, 2011–2016 and 2012–2017, Sardinia has a higher performance score than northern and central Italy. Hence, the results provided here are useful in monitoring the efficiency trend of the agricultural sector on the two main Italian islands. Overall, the Italian agricultural sector presents a negative trend of efficiency in all geographical areas.

5.2 Simar-Wilson bootstrapping

Based on the WDEA a further parametric analysis is run (Table 2). The *sigma* is the robust standard deviation of the errors in the truncated regression of the reciprocal DEA score on the variables of interest. The number of bootstrap replications in the second loop of Simar and Wilson's (2007) algorithm is set to 2,000 (as a default). Since the sigma value is within the lower and upper bounds of the confidence interval, the model can be regarded as well specified in all the windows.

Table 2. Post-WDEA: Simar Wilson double bootstrapping- model with Long-term debt.

Window	2008-2013	2009-2014	2010-2015	2011-2016	2012-2017
Intercept	9.984120e-01	1.005866e+00***	9.692316e-01	9.838512e-01	1.002834e+00***
C.I minimum	0.9260778383	9.086834e-01	8.829261e-01	9.008855e-01	9.258262e-01
C.I. maximum	1.066050e+00	1.099942e+00	1.049732e+00	1.061957e+00	1.075383e+00
Long-term debt- S_{it}	-9.510342e-03	-1.967281e-02***	-9.621033e-03	-8.867799e-03	-8.976166e-03
C.I minimum	-0.0141065962	-2.622638e-02	-1.560426e-02	-1.431706e-02	-1.452704e-02
C.I. maximum	-4.778873e-03	-1.265043e-02	-3.714743e-03	-3.407666e-03	-3.480061e-03
I.T. in days - IT_{it}	3.938758e-02 ***	4.788100e-02***	4.398188e-02***	3.989148e-02***	3.833335e-02***
C.I minimum	0.0324532418	3.846303e-02	3.628001e-02	3.165045e-02	3.139349e-02
					4.520523e-02

C.I. maximum	4.596024e-02	5.748760e-02	5.195245e-02	4.735249e-02	
Acc.r..turnover - AR_{it} C.I minimum C.I. maximum	5.313813e-02*** 0.0418930897 6.462555e-02	7.290642e-02*** 5.629080e-02 8.914406e-02	7.288230e-02*** 6.056665e-02 8.551032e-02	7.199780e-02*** 5.959990e-02 8.554097e-02	6.781476e-02*** 5.689977e-02 7.919601e-02
South - D_{it} C.I minimum C.I. maximum	7.556099e-03 -8.921758e-03 2.419438e-02	7.520607e-03 -2.270157e-02 3.818350e-02	2.323511e-03 -2.310234e-02 2.699396e-02	-4.375558e-04 -2.477956e-02 2.258421e-02	2.621311e-03 -2.106036e-02 2.508431e-02
Age squared - AS_{it} C.I minimum C.I. maximum	3.006312e-05 *** 0.0000151715 4.490217e-05	3.878144e-05*** 1.732949e-05 6.124434e-05	2.443884e-05 4.833183e-06 4.384316e-05	1.940682e-05 8.664822e-07 3.741402e-05	1.647913e-05 -2.547629e-06 3.462235e-05
Age - A_{it} C.I minimum C.I. maximum	-2.404036e-03** -3.472988e-03 -1.260255e-03	-3.807694e-03*** -5.930193e-03 -1.804777e-03	-2.466387e-03 -4.323091e-03 -6.671960e-04	-2.021177e-03 -3.814159e-03 -2.557713e-04	-1.638615e-03 -3.362705e-03 1.579182e-04
Sigma C.I minimum C.I. maximum	0.1217112*** 0.1153296 0.1295145	0.1748012*** 0.1647764 0.1856455	0.1691171*** 0.1605337 0.1785434	0.1671589*** 0.1599229 0.1761282	0.1651487*** 0.1577271 0.1730871

Notes: *Sigma* is the robust standard deviation of the errors in the truncated regression of reciprocal of DEA score on the variables, after the second loop. C.I. = confidence interval. **, ***, a coefficient statistically significant at 5%, 1% respectively.

Model 1 includes the long-run debt index, which consistently positively affects efficiency but is only highly statistically significant in the 2009–2014 window. Notably, the coefficient of the inventory turnover in days is always highly significant in all the windows and exerts a negative effect on firm efficiency. This outcome is in line with previous research where the findings suggest that a low turnover implies poor sales and, therefore, excess inventory (Engel, 2015; Husain and Alnefaee, 2016). The accounts receivable turnover rate negatively impacts efficiency; this outcome implies that this financial variable reduces liquidity useful for modernizing fixed assets and other investments. The geographical control *South* does not consistently influence the firms' efficiency, although the effect is negative, but the 2011–2016 window. The age of a firm exerts an impact on its efficiency in a non-linear manner. Whereas being a young firm positively affects firm profitability, being an older firm has the opposite effect.

As a further step of the investigation, Model 2 includes the short run-debt index (Table 3). In the long run, the coefficient shows a positive impact on firm performance, but in this case, the coefficient is highly significant in all the windows analysed. Notably, once again, the coefficient of the inventory turnover in days is consistently and highly statistically significant in all the windows and exerts a negative effect on firm efficiency. This result is congruent with the research by Engel (2015) and Husain and Alnefaee (2016). In addition, the accounts receivable turnover rate has a negative and substantial impact on efficiency, which confirms that this financial variable decreases the amount of liquidity useful for modernizing assets and enhancing investments. The geographical control *South* does not have any remarkable influence on efficiency; however, the effect is always negative. The firm's age exerts an impact on its efficiency in a non-linear manner, and the coefficient of *AS* is statistically significant only within the 2009–2014 window.

Table 3. Post-WDEA: Simar Wilson double bootstrapping- model with Short-run debt.

Window	2008-2013	2009-2014	2010-2015	2011-2016	2012-2017
Intercept	1.169637e+00***	1.321778e+00***	1.199544e+00***	1.220276e+00***	1.248937e+00***
C.I minimum	1.098339e+00	1.222170e+00	1.109390e+00	1.135907e+00	1.173640e+00
C.I. maximum	1.242966e+00	1.414509e+00	1.287062e+00	1.303981e+00	1.323843e+00
short run-debt -S_{it}	-3.378232e-02***	-6.780838e-02***	-5.013389e-02***	-5.176873e-02***	-5.374464e-02***
C.I minimum	-3.995344e-02	-7.561033e-02	-5.726062e-02	-5.797215e-02	-5.972059e-02
C.I. maximum	-2.806860e-02	-5.957107e-02	-4.330047e-02	-4.573424e-02	-4.751482e-02
I.T. in days- IT_{it}	4.630002e-02***	6.155464e-02***	5.636969e-02***	5.422844e-02***	5.210137e-02***
C.I minimum	4.038435e-02	5.330901e-02	4.923356e-02	4.707353e-02	4.523897e-02
C.I. maximum	5.240947e-02	7.057155e-02	6.388904e-02	6.188538e-02	5.891644e-02
Acc.r.turnover - AR_{it}	4.798986e-02***	6.907774e-02***	7.182825e-02***	7.142474e-02***	6.880508e-02***
C.I minimum	3.794092e-02	5.658548e-02	5.957993e-02	5.915859e-02	5.784962e-02
C.I. maximum	5.895252e-02	8.256414e-02	8.491940e-02	8.285177e-02	7.926468e-02
South - D_{it}	3.525046e-03	4.350855e-03	5.598677e-03	4.637840e-03	9.542139e-03
C.I minimum	-1.737543e-02	-2.228680e-02	-1.923490e-02	-1.761512e-02	-1.213417e-02
C.I. maximum	2.313664e-02	3.030648e-02	2.944273e-02	2.636708e-02	3.103554e-02
Age squared - AS_{it}	2.107517e-05	2.669085e-05**	1.610834e-05	1.271994e-05	1.228179e-05
C.I minimum	7.467269e-06	1.233125e-05	-2.361605e-06	-4.962593e-06	-5.412407e-06
C.I. maximum	3.394779e-05	4.147037e-05	3.494719e-05	2.912701e-05	2.825873e-05
Age - A_{it}	-1.453010e-03	-2.260652e-03	-1.259145e-03	-8.745636e-04	-6.347109e-04
C.I minimum	-2.730173e-03	-4.030576e-03	-2.996901e-03	-2.553337e-03	-2.170406e-03
C.I. maximum	-2.310994e-04	-4.738308e-04	5.950487e-04	7.386778e-04	9.134897e-04
Sigma	0.1127936***	0.1584156***	0.1584198***	0.1565666***	0.155007***
C.I minimum	0.1064451	0.1507172	0.1508644	0.1494332	0.1480526
C.I. maximum	0.1193097	0.1689433	0.1672985	0.1644061	0.1627055

Notes: *Sigma* is the robust standard deviation of the errors in the truncated regression of reciprocal of DEA score on the variables, after the second loop. C.I. = confidence interval. **, ***, a coefficient statistically significant at 5%, 1% respectively.

6. Discussion and conclusions

This research explored the relationship between inventory and efficiency in the agricultural sector, largely neglected in the literature. A panel WDEA employed a large sample of firms over ten years (2008–2017), and a total of five windows were identified. The post-WDEA addressed the determinants that mainly affect firm efficiency.

The paper revealed that inventory turnover in days exerts a substantial negative impact on firm efficiency. High levels of stocks in the warehouse cause financial and non-financial burdens that reduce business profitability because of storage costs, additional warehouse expansion investments, loss of products, and missed opportunities to maximize production capacity. High inventory levels also adversely affect business cash flow, reducing efficiency and effectiveness and biased functionality (Agu et al., 2016). This negative outcome is in line with similar research in the secondary sector (Hançerlioğulları et al., 2016; Khan et al., 2016; Roni and Djumahir, 2016; Kroes et al., 2018). Agricultural firms must concentrate on preparing inventory budgets at timely intervals. As inventory contributes to a relevant quota of current assets, well-structured and planned management would positively impact business profitability (Selvanayakia et al., 2016). Hence, the negative effect of inventory on efficiency needs to be further monitored in the future. More and more agricultural firms are innovating towards packaging and finished products to be delivered to the service sector, where Italy is a leading country (ISTAT, 2019). This complementary and support activity should experience a further expansion driven by the EU-2030 "farm to fork" strategy and changes in preferences due to the adverse effects of the COVID-19 pandemic on long supply chains and consumers' preferences for organic and genuine products purchased directly from producers. The expansion of agri-food complement activities can shorten storage time, making agricultural raw material less perishable (Husain and Alnefaee, 2016).

As a further outcome, the accounts receivable turnover rate showed a negative impact on efficiency. As Gorondutse (2016) suggested, managers in small- and medium-sized enterprises (SMEs) can improve business profitability by reducing their cash conversion cycle. For Gu et al. (2017), a higher accounts receivable turnover rate results in faster enterprise receivables, fewer debt losses, and higher liquidity of the SME. However, according to the empirical findings, both the short-run debt index and the long-term debt index (including debt with banks) positively impact efficiency (Pulina and Santoni, 2018). This result is compatible with the fact that, although the short-run effect has proven to be stronger in the Italian agricultural sector than the accounts receivable turnover rate, this indicator can be associated with improving overall infrastructure. When financial debt tends to increase, the amount invested also tends to be higher.

The longevity of agricultural firms presented non-linear effects (see also Margaretha and Supartika, 2016; Pulina and Santoni, 2018). While being a young firm positively affected firm profitability, being an older firm had the opposite effect. Firms that operate for a relatively long time do not innovate or renew fixed assets, such as plants and equipment, making the overall production process obsolete. As Galluzzo (2016) remarks, the average Italian farm is close to 56 years old. Such longevity makes the sector relatively rigid, and young people find it challenging to invest in land capital. The non-linear outcome is also coherent with ISTAT (2019) report that addresses Italy's agricultural sector's important achievements in complementary and secondary activities. Young people are arguably more likely to enhance business innovation and diversification, such as complementary agri-food entrepreneurship (from packing to supplying finished products), renewable energy production (e.g., biomass, solar, wind, and photovoltaic energy), agritourism activities, and recreational and learning activities (Canovi and Lyon, 2019). The findings suggest that the EU-2030 strategy should be directed at young and skilled people who are likely to improve firms' economic efficiency and achieve the objective of the EU Green Deal, such as the farm to fork strategy, driven by direct channels of e-commerce.

The empirical findings also showed that the northern Italian regions are more efficient than the central and southern regions. This study also confirmed that the Sardinian agricultural sector still outperforms the Sicilian sector (Galluzzo, 2017). Additionally, in recent years, during real economic turmoil, Sardinian firms were more efficient than the other geographical macro-areas in the county. As Galluzzo (2017) emphasised, Sardinian firms are characterized by higher firm dimensions and CAP support.

Overall, the present analysis suggested that the key potential improvements that the agricultural sector in Italy can achieve are based on increasing investments in assets such as machinery and plants and efficient and effective inventory management. Although this paper focuses on Italian regions, it offers a novel dynamic framework in the field with the advantage of assessing the evolution and robustness of the findings across time. Future research should replicate this methodology for other geographical settings to further generalize the results, especially on the relationship between inventory turnover and economic efficiency.

References

Ahmad, K. and S.M. Zabri (2018) "The mediating effect of knowledge of inventory management in the relationship between inventory management practices and performance: The case of micro retailing enterprises" Journal of Business and Retail Management Research 12(2), 83-93.

Al-Mezeini, N.K., A. Oukil and A.M. Al-Ismaili (2020) "Investigating the efficiency of greenhouse production in Oman: A two-stage approach based on Data Envelopment Analysis and double bootstrapping" Journal of Cleaner Production, 247, doi:10.1016/j.jclepro.2019.119160.

Agu, A.O., H.O. Obi-Anike and C.N. Eke (2016) "Effect of inventory management on the organizational performance of the selected manufacturing firms" Singaporean Journal of Business Economics, and Management Studies 5(4), 56-69.

Anojan, V., N. Arulalan and B. Nimalathasan (2013) "Working capital management and its impact on profitability: a study of selected listed beverage, food and tobacco companies in Colombo stock exchange, Sri Lanka" *The International Journal of Business & Management* 1(6),15-20.

Atnafu, D. and A. Balda (2018) "The impact of inventory management practice on firms' competitiveness and organizational performance: Empirical evidence from micro and small enterprises in Ethiopia" *Cogent Business & Management* 5 (1), 1-16.

Benedetti, I., G. Branca and R. Zucaro (2019) "Evaluating input use efficiency in agriculture through a stochastic frontier production: An application on a case study in Apulia (Italy)" *Journal of Cleaner Production* 236, 1-10.

Biddle, E. (2011) "The introduction of the Cobb Douglas regression and its adoption by agricultural economists", *History of Political Economy* 43, 235-257.

Bogetoft, P. and L. Otto (2011) *Benchmarking with DEA, SFA, and R*, Springer-Verlag.

Borodin, V., J. Bourtembourg, F. Hnaien and N. Labadie (2016) "Handling uncertainty in agricultural supply chain management: A state of the art" *European Journal of Operational Research* 254, 348–359.

Canovi, M. and A. Lyon (2019) "Family-centred motivations for agritourism diversification: The case of the Langhe region, Italy" *Tourism Planning & Development*, doi.org/10.1080/21568316.2019.1650104.

Charnes, A., C.T. Clark, W.W. Cooper and B. Golany (1985) "A developmental study of data envelopment analysis in measuring the efficiency of maintenance units in the US air forces", *Annals of Operations Research* 2, 95–112.

Chuang, C.H. and Y. Zhao (2019) "Demand stimulation in finished-goods inventory management: Empirical evidence from General Motors dealerships" *International Journal of Production Economics* 208, 208-220.

Coelli T., P. Rao, C.J. O'Donnell and G.E. Battese (2005) "*An introduction to efficiency and productivity analysis*" Massachusetts: Kluwer Academic.

Cook, W.D. and L. Seiford (2009) "Data envelopment analysis (DEA) – thirty years on" *European Journal of Operational Research* 192, 1–17.

Cooper, W.W., L.M. Seiford and K. Tone (2007) "*Data envelopment analysis: a comprehensive text with models, applications, references and DEA-solver software"* 2nd edn. Springer, New York.

Detotto, C., M. Pulina and J.G. Brida (2014) "Assessing the productivity of the Italian hospitality sector: a post-WDEA pooled-truncated and spatial analysis" Journal of Productivity Analysis 42(2), 103-121.

Edwin, S. and M. Florence (2015) "The effect of inventory management on profitability of cement manufacturing companies in Kenya: A case study of listed cement manufacturing companies in Kenya" *International Journal of Management and Commerce Innovations* 3 (2), 111-119.

Elsayed, K. and H. Wahba (2016) "Reexamining the relationship between inventory management and firm performance: An organizational life cycle perspective" *Future business Journal* 2, 65-80.

Engel, C. (2015) "Economics of the firm: Identifying factors affecting the performance of agribusiness Corporations", A Research Paper Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in the field of Agribusiness Economics 1-45.

Eroglu, C. and C. Hofer (2011) "Lean, leaner, too lean? The inventory-performance link revisited" *Journal of Operations Management* 29(4), 356–369.

EU (2020). *Farm to fork strategy*, https://ec.europa.eu/food/sites/food/files/safety/docs/f2f_action-plan_2020_strategy-info_en.pdf

Evci, S. and N. Şak (2018) "The effect of working capital management on profitability in emerging countries: Evidence from Turkey" *Financial Management from an Emerging Market Perspective*, 205-218.

Folinas, D. and C.Y. Shen (2014) “Exploring Links among Inventory and Financial Performance in the Agricultural Machinery Industry” *International Journal of Food and Agricultural Economics* 2 (4), 1-12.

Gaur, V., M.L. Fisher and A. Raman (2005) “An Econometric Analysis of Inventory Turnover Performance in Retail Services” *Management Science* 51(2), 1-34.

Gu, W., M. Basu, Z. Chao and L. Wei (2017) “A united framework for credit evaluation for internet finance companies: Multi-criteria analysis through AHP and DEA” *International Journal of Information Technology & Decision Making* 16(3), 597–624.

Guesmi, B., T. Serra, A. Radwan and J.M. Gil (2018) “Egyptian organic agriculture: A local maximum likelihood approach” *Agribusiness* 34(2), 441-455.

Guth, M. and K. Smędzik-Ambroży (2019) “Economic resources versus the efficiency of different types of agricultural production in regions of the European union” *Economic Research-Ekonomska Istraživanja*, DOI: 10.1080/1331677X.2019.1585270

Hayami, Y. (1970) “On the use of the Cobb-Douglas production function on the cross-country analysis of agricultural production” *American Journal of Agricultural Economics* 52, 327-329.

Hançerlioğulları, G., E. Köksalmış and F. Çalışır (2017) “How does inventory performance affect operational performance? An example from U.S. space vehicles and aircraft parts industries” *Conference Paper*, 291-294.

Husain, S. and S. Alnefaee (2016) “The effects of working capital management on profitability of

firms: evidence from agriculture and food industry of Kingdom of Saudi Arabia” *Journal of Emerging Issues in Economics, Finance and Banking* 1(1), 1684-1698.

Galluzzo, N. (2017) “Technical and economic efficiency in some Italian farms: an analysis in two Italian islands” *Agricultural Economics Review* 18 (2), 30-39.

Gorondutse, A.H., R.A. Ali and A. Ali (2016) “Effect of trade receivables and inventory management on SMEs performance” *British Journal of Economics, Management & Trade* 12(4), 1-8.

Gu, W., M. Basu, Z. Chao and L. Wei (2017) “A United framework for credit evaluation for internet finance companies: multi-criteria analysis through AHP and DEA” *International Journal of Information Technology & Decision Making* 16(3), 597–624.

ISTAT (2019) *Annuario statistico italiano*. https://www.istat.it/it/files/2019/12/Asi-2019.pdf

ISTAT (2019) *Andamento dell’economia agricola*. https://www.istat.it/it/files/2020/05/Andamento-economia-agricola-2019.pdf

Jakpar, S., M. Tinggi, T.K Siang, A. Johari, K.T. Myint and M.S. Sadique (2017) “Working capital management and profitability: Evidence from manufacturing sector in Malaysia” *Journal of Business & Financial Affairs* 6(2), 1-9.

Janggaa, R., N. M Alia, M. Ismaila and N. Saharia (2015) “Effect of environmental uncertainty and supply chain flexibility towards supply chain innovation: An exploratory study” *Procedia Economics and Finance* 31, 262-268.

Kroes, J.R., S.A. Manikas and T.F. Gattiker (2018) "Operational leanness and retail firm performance since 1980" *International Journal of Production Economics* 197, 262–274.

Liu, J.S., L.Y. Lu, W.M. Lu and B.J. Lin (2013) "A survey of DEA applications" Omega 41(5), 893-902.

Lotti F. and G. Marin (2013) "Matching of PATSTAT applications to AIDA firms: discussion of the methodology and results" Questioni di Economia e Finanza (Occasional papers), 1-26.

Margaretha, F. and N. Supartika (2016) "Factors Affecting Profitability of Small Medium Enterprises (SMEs) Firm Listed in Indonesia Stock Exchange" Journal of Economics, Business and Management 4(2), 132-137.

Martínez, S., A. Errasti and M. Rudberg (2015) "Adapting Zara's 'Pronto Moda' to a value brand retailer"Production Planning Control 26 (9), 723–737.

Mathuva, D.M. (2010) "The influence of working capital management components on corporate profitability: A survey on Kenyan listed firms" Research Journal of Business Management 4(1), 1-11.

Mohamad, S.J.A., N.N. Suraidi, N.A Rahman and D.S.R. Suhaimi (2016) "A Study on Relationship between Inventory Management and Company Performance: A Case Study of Textile Chain Store" Journal of Advanced Management Science 4(4), 299-304.

Moutinho, V., M. Madaleno, P. Macedo, M. Robaina and C. Marques (2018) "Efficiency in the European agricultural sector: environment and resources" Environmental Science and Pollution Research 25, 17927-17941.

Nowak, A., T. Kijek and K. Domanska (2015) "Technical efficiency and its determinants in the European Union agriculture" Agricultural Economics 61(6), 275-283.

Nuseva, D., K. Mijic and D. Jaksic (2017) "The performances of coffee processors and coffee market in the Republic of Serbia" Ekonomika poljoprivrede 64(1), 307-322.

Obermaier, R. and A. Donhauser, (2012) "Zero inventory and firm performance: A management paradigm revisited" International Journal of Production Research 50 (16), 4543–4555.

Osazefua, I.J. (2019) "Operational efficiency and financial sustainability of listed manufacturing companies in Nigeria" Journal of Accounting and Taxation 11(1), 17-31.

Panigrahi, A.K. (2014) "Relationship between inventory management and profitability: An empirical analysis of Indian cement companies" Asia Pacific Journal of Marketing & Management Review 2(7), 107 – 120.

Ponsian, N., K. Chrispina, G. Tago and H. Mkiibi (2014) "The Effect of Working Capital Management on Profitability" International Journal of Economics, Finance and Management Sciences 2(6), 347-355.

Pulina, M. and V. Santoni (2018) "A two-stage DEA approach to analyse the efficiency of the hospitality sector" Tourism Economics 24(3), 352–365.

Pulina, M., C. Detotto and A. Paba (2010) “An investigation into the relationship between size and efficiency of the Italian hospitality sector: a window DEA approach. European” Journal of Operational Research 204(3), 613-620.

Sardar Shahraki A., N. Ali Ahmadi and M. Safdari (2018) “A new approach to evaluate the economic efficiency and productivity of agriculture sector: the application of window data envelopment analysis (WDEA)” Environmental Energy and Economic Research 2(3), 145-160.

Selvanayakia, S., S.D. Sivakumara, A. Rohinia and K. Manib (2016) “Financial management practices and profitability of modern rice milling firms in Kangayam cluster, Tamil Nadu” Agricultural Economics Research Review 29(2), 297-306.

Shahbaz, M.S., R.Z. Rasi, M.F. Ahmad and S. Sohu (2018) “The impact of supply chain collaboration on operational performance: Empirical evidence from manufacturing of Malaysia” International Journal of Advanced and Applied Sciences 5(8), 64-71.

Shahraki, A.S., N.A. Ahmadi and M. Safdari (2018) “A New Approach to Evaluate the Economic Efficiency and Productivity of Agriculture Sector: The Application of Window Data Envelopment Analysis (WDEA)” Environmental Energy and Economic Research 2(3), 145-160.

Simar, L. and P.W. Wilson (2007) “Estimation and inference in two-stage, semi-parametric models of production processes” Journal of Economics 13(6), 31–64.

Simm, J. and G. Besstremyannaya (2016) “Robust Data Envelopment Analysis (DEA) for R.” https://github.com/jaak-s/rDEA

Roni, H. and A.D. Djumahir (2018) “The effect of working capital management on profitability of state-owned enterprise in processing industry sector” *Journal of Applied Management* 16(2), 293-299.

Yobe C.L., S.R.D. Ferrer and M. Mudhara (2020) “Measuring the financial efficiency of agricultural cooperatives in South Africa: an application of the Simar–Wilson methodology” *Agrekon,* https://doi.org/10.1080/03031853.2020.1761845.

Yuniningsih, Y., V.N.S. Lestari, N. Nurmawati and B.N. Wajdi (2018) “Measuring automotive company’s capabilities in Indonesia in producing profits regarding working capital”*Jurnal Terapan Manajemen dan Bisnis* 4(1), 67-78.

Wan, X., R. Britto and Z. Zhou (2020) “In search of the negative relationship between product variety and inventory turnover” *International Journal of Production Economics*, 222.

Wang, Z., Q. Wang, Y. Lai and C. Liang (2020) “Drivers and outcomes of supply chain finance adoption: An empirical investigation in China” *International Journal of Production Economics*, 220 (c).

Zhan X. and L. Liu (2019) “Analysis of financing efficiency of Chinese agricultural listed companies based on machine learning” *Complexity*, 1-11.