

The impact of financial leverage on farm technical efficiency during periods of price instability

Article

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The impact of financial leverage on farm technical efficiency during periods of price instability

Purpose:

The main purpose of this work is to provide empirical evidence on the relationship between capital structure and technical efficiency for Italian cereal farms during the 2008 – 2014 period. Emphasis is given in the understanding of the relationship between the level of financial leverage for cereal farms and their production performance.

Methodology:

The methods employed in this research article are based on non-parametric techniques in order to derive technical efficiency estimates for a sample of Italian cereal farms based on available Farm Accountancy Data Network data to explore in depth the relationship amongst the financial exposure of the sector and the capacity to utilise an efficient and effective production technology. Furthermore, subsidies are considered in the model as a non-discretionary variable and therefore, as an input that farmers cannot directly influence within the production function. Hence, the non-discretionary Data Envelopment Analysis model is a more appropriate framework since it is not penalising farms at a lower level of Pillar I payments when benchmarked with farms that receive higher level of payments.

Findings:

The results show that significant improvements could be achieved for most of the farms in the sample by improving production and management practices. Furthermore, results provide an empirical support of the adjustment theory by showing a negative impact of debt to asset ratio to technical efficiency.

Originality:

This research article provides a first insight on the evolution of the Italian cereal farms debt-technical efficiency relationship in periods where high price instability has been observed.

Keywords: financial leverage; price instability; technical efficiency; capital structure; expenditure capacity;

Subject classification codes: Q12; Q14; D24

1 Introduction

Farm capital structure may have contrasting effects on farm efficiency and investment behaviour as a strand of the farm efficiency literature has pointed out (Davidova and Latruffe, 2007, Barry and Robinson, 2001, Bojnec and Latruffe, 2013, Fertó et al., 2017). In particular, farmers' ability to choose the best available technology is restricted when capital structure negatively influences farm's financial performance (Mugera and Nyambane, 2015). However, the opposite is supported by Berger and Bonaccorsi di Patti (2006) where they suggest that the performance of a decision-making unit (farm) may also have an impact on the choice of capital structure. Hence, farms operating on the production efficiency frontier are more likely to realise higher return for a given capital structure, and these higher earnings could be used as bulwark against portfolio risk (Margaritis and Psillaki, 2010). Therefore, this will allow farms to substitute equity for debt when considering their capital structure (Margaritis and Psillaki, 2010). As Pedersen and Olsen (2013) suggest, the evaluation of the performance of farming systems would be more effective if the holistic approach to leverage proposed by Barry and Baker (1971) is considered. Hence, when both the external and internal credit constraints are considered. External funding at a farm level is used to cover both production costs and to finance investment plans (machinery, specialised equipment, and buildings) in order to enhance farm production performance (Lambert et al., 2005). The debt is necessary to maintain or improve farm productivity and competitiveness by adopting technological innovation needed to increase farm efficiency (Featherstone et al., 2005). At the same time, financial leverage may affect farm technical efficiency by influencing farm production decision (Margaritis and Psillaki, 2007, Lambert and Bayda, 2015). Allocative efficiency may be constrained by lower farm expenditure capacity (Färe et al., 1990, Rungsuriyawiboon and Hockmann, 2015). In this case,

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3 farms response may rely on reducing the necessary expenditures to maintain the
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5 production assets with negative consequences on farm productivity, growth and
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7 efficiency (Mugera and Nyambane, 2015). In addition, it is possible that the farmer is
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9 not adopting the needed strategic adjustments to maintain productivity, efficiency and
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11 competitiveness (Hughes et al., 1985). The latter became relevant after the outbreak of
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13 the financial crisis in 2008 where the size of loans for farming industries increased. In
14
15 particular, financial leverage (gearing) in the European Union (EU) jumped from 14.1%
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17 to 17.9% in 2008 indicating an increase in the size of debts (Pietola et al., 2011). Across
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19 the EU, the average farm debt increased from €39,118 in 2007 to €50,022 in 2008.
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21
22 Overall, total liabilities for both the EU-15 and the EU-N10 increased by approximately
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24 50% between 2004 and 2012 (European Commission, 2015). According to Petrick and
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26 Kloss (2013), the recent period of financial uncertainty (economic and financial crisis)
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28 came along with the following short comes due to the exposure of EU farmers to
29
30 financial leverage: a) problems in the functionality of rural financial markets, b)
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32 reduction of farm incomes due to economic recession and c) lower demand for income
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34 elastic-food products. As stated by Hughes (1985) there are mainly three sources of
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36 financial stress for the farming sector: macroeconomic policies that in turn have an
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38 impact on prices and interest rates, sectoral policies that are often conceived to offset
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40 the former and individual management decisions. The period of 2008 – 2014, was
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42 characterised from a surge in price volatility that affected European and world cereal
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44 markets as well as profitability and cash flow of cereal farms (Tadesse et al., 2014). In
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46 addition, reduced public budget and spending cuts in agricultural and rural policies
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48 further limited the potential of agricultural policies to offset market volatility. The
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50 riskier economic environment, would have a negative impact on farmers gross
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52 investment and therefore in the long-term competitiveness of the sector and the ability
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3 of the farmers to sustain operations and growth (technical efficiency) within a
4 competitive agricultural market (Fertő et al., 2017, Bojnec and Latruffe, 2013, O'Toole
5 and Hennessy, 2015). According to Petrick and Kloss (2013) the crisis of the banking
6 sector in EU could potentially lead to a credit crunch for agricultural borrowers, by
7 marrying the way that rural financial markets are functioning. Financial uncertainty
8 could therefore lead to an increase of the level of debt over assets for the farming
9 industry and hence threaten farm survival and potentially lead to the exit from the
10 industry (Byrne et al., 2016, Musso and Schiavo, 2008). Furthermore, the period of
11 2008 – 2014, was characterised from surge in price volatility that affected European
12 and world cereal markets (Tadesse et al., 2014). Thus, contributing further to an
13 environment of financial uncertainty, price instability and high economic risk for the
14 farmers.

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17 In the recent years since 2008, the economic recession and dwindling demand for
18 income-elastic food products in Italy has caused a reduction on farm incomes and also a
19 distortion in agricultural production due to limited access to credit for Italian farmers
20 (Petrick Martin and Kloss, 2012). It is discussed in the literature that the relationship
21 between capital structure and farm business performance is different from corporate
22 firms due to characteristics¹ that may result in different decision-making patterns at
23 farm level and hence to capital structure (Zhengfei and Lansink, 2006). The uncertainty
24 in the financial environment (due to food price instability, economic recession, and
25 other exogenous parameters) has affected the Italian cereal market from 2008 onwards.
26 Therefore, cereal farmers had to adopt their strategies and production methods to cope

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¹ Family members participating in the production process and decision-making, business life cycle, legal form and liability status, government support in the form of agri-environmental payments etc.

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3 with exogenous parameters such as the 2010 drop in commodity prices, and hence
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5 maintain a healthy financial structure. According to Eurostat, the Italian cereal industry
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7 has been dramatically affected by the price crisis of 2008-2010 as the value of
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9 production fell by more than 30% in 2009 and fully recovered only in 2011. In terms of
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11 comparison, the overall agricultural production decreased only by 8% in the same
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13 period. Noticeably, credit to agriculture became more and more important as the price
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15 instability unfolded. In 2014 the amount of bank loans to farms was about 20% higher
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17 than in 2008 as illustrated by the data from Bank of Italy. In the same years, the share of
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19 short-term loans rose from 56% to 70% of the total amount, an indication that farmers
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21 resorted to loan financing mainly to deal with liquidity problems and economic stresses.
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23 Thus, the objective of this paper is to provide empirical evidence on the relationship
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25 between capital structure and technical efficiency for Italian cereal farms during the
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27 2008 – 2014 period based on available data derived from the Farm Accountancy Data
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29 Network (FADN). Emphasis is given in the understanding of the relationship between
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31 the level of financial leverage for a sample of cereal farms and their production
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33 performance. The manuscript contributes into the relevant literature since it provides a
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35 first insight on the evolution of the Italian cereal farms debt-technical efficiency
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37 relationship in periods where uncertainty affected both the financial and commodity
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39 markets. The analysis offers a better understanding on the relationship between short,
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41 intermediate and long-term debt of the Italian cereal farms. The basic hypothesis tested
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43 here is that of the impact that external debt has on the ability of the cereal farmer to
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45 adjust production decision and, consequently on the technical efficiency of the decision-
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47 making unit (farm). In addition, it provides empirical evidence which helps to
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49 characterise the relationship between farm production and economic performance and
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51 the capital structure for the Italian cereal sector. The manuscript explores the Italian
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3 cereal sector as one of the most representative production sector of the Italian
4 agricultural industry after specialist olives². Furthermore, cereal farmers represent a
5 significant percentage of the rural population in Italy with an average of 43ha UAA
6 with smaller farmers (less than 10ha) facing difficulties in dealing with the complexity
7 of the Italian agricultural sector (Salvioni et al., 2009) hence, more likely to be
8 negatively affected in periods of price instability and financial uncertainty.
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18 **2 Farm performance and capital structure**

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21 Several theoretical explanations, often predicting contrasting evidence, have been put
22 forward to explain the existence, if any, of a direct relationship between measures of
23 indebtedness such as the leverage or Debt to Asset Ratio (DAR) and Technical
24 Efficiency (TE) (Shaik, 2015). The relative theories, the direction of the relationship
25 and the expected sign are summarised in Table 1. The DAR is in fact a leverage ratio
26 which indicates how the agribusinesses have acquired their assets over a period of time.
27 Together with other financial indicators it demonstrates the future economic
28 sustainability of the agribusiness and the potential of the business to meet its current
29 debt obligations as well as whether the agribusiness has the ability to pay a return on
30 their investment. According to Zhengfei and Lansink (2006) financial indicators may
31 not fully reveal the relationship between farm performance and managerial activities to
32 improve performance when the effect of financial leverage is taken into consideration.
33 Instead, Zhengfei and Lansink (2006) suggest that a measure of TE which is
34 independent of market prices is more appropriate.
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59 ² Notably in terms of number of holdings
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3 The Fisher separation theorem states that, under perfectly functioning financial markets,
4 financial and investment decisions are independent. Therefore, TE, which depends on
5 investment decisions, should not be related to the way investments are financed
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10 (Lambert et al., 2005). However, in the context of agricultural investment, according to
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12 O'Toole et al. (2014), the financing constraints affect farmers' investment decisions
13 through an excess reliance on internal farm funds for investment and farmer's
14 investment strategies are based on the business fundamentals such as profitability.
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20 However, since the hypothesis of perfectly functioning financial markets is a rather
21 restrictive one, especially in times of credit rationing, several alternative theoretical
22 explanations have been advanced: free cash flow, agency cost and credit evaluation
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24 (Russell et al., 2017, Nadolnyak et al., 2017). The free cash flow model (Jensen and
25 Meckling, 1976) posits that higher leverage reduces inefficiency by inducing stricter
26 discipline on relaxed management which waste the abundant financial resources in self-
27 serving objectives against the interest of the principal (the ownership). High debt ratios
28 reduce the waste of cash by managers either through the need to generate cash to repay
29 the debt or through the menace of liquidation. In the farm context where management
30 and ownership is usually reunited in the same subject, the farmers are agents urged by
31 lenders (principals) to exert greater effort to be able to repay the debt (Barry and
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61 The agency cost model (Margaritis and Psillaki, 2010) states a negative relationship
62 between indebtedness and efficiency in a context of imperfect information as lenders
63 transfer to borrowers the cost of monitoring thus, raising the costs of indebted farms.
64 These additional costs are likely to reduce the TE of the affected farms in comparison
65 with less indebted ones (Brewer and Featherstone, 2017). Both the agency cost and the
66 free cash flow model hypothesise a causal relationship (even if with opposite sign) from

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3 indebtedness to technical efficiency. The credit evaluation hypothesis- also known as
4 the efficiency risk hypothesis- postulates instead a reverse causation relationship where
5 efficiency causes higher leverage as banks prefer borrowers with a low risk of financial
6 distress (Parsons Chris and Titman Sheridan, 2011). Technical efficient firms may
7 easily borrow as they are more likely to repay the debt (Demsetz, 1973, Berger and
8 Bonaccorsi di Patti, 2006, Pedersen and Olsen, 2013). The empirical relevance of this
9 mechanism should be more salient in contexts where loan applications are usually
10 evaluated according to solvency, repayment capability, profitability, management
11 ability and other financial and managerial variables³ (Margaritis and Psillaki, 2007).
12 Conversely where loans are granted mainly on the availability of adequate collaterals, as
13 it is the case in Italy, the hypothesis is less relevant (Davidova and Latruffe, 2007,
14 Latruffe et al., 2008). Other hypothesis on the indebtedness and TE relationship are
15 specific to the farm sector: the capital embodiment theory and the adjustment cost
16 theory (Rungsuriyawiboon and Hockmann, 2015).
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Table 1 *Approximately here*

Chavas and Aliber (1993) note that technical change in agriculture is often embodied in intermediate and long run assets such as machinery or new orchard varieties. If this is the case, then productivity improvements can be attained only by investing in the new

³ Similarly, supply of credit to farmers has been found to positively correlate with observed changes in farm income.

However, supply of operating (short term) credit appears to be less reactive to changes in farm income with respect to supply of capital credit BARRY, P. J., BAKER, C. B. & SANINT, L. R. 1981. Farmers' Credit Risks and Liquidity Management. *American Journal of Agricultural Economics*, 63, 216-227.

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3 technical assets which are often purchased and hence, resort farmers to being in debt
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5 (Sivertsson and Tell, 2015, Fertő et al., 2017)⁴. According to this theory more indebted
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7 farms should have a renovated technical capital and show higher technical efficiency.
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10 The adjustment theory was first proposed by Paul et al. (2000) in discussing the impact
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12 of the 1986 liberalization reform of the Agricultural Policy in New Zealand. According
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14 to this theory the financial constraints faced by indebted farms reduced their ability to
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16 adjust the new deregulated environment thus decreasing their efficiency. In this case a
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18 negative relationship between indebtedness and TE is assumed.
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21 Hence, a variety of theories providing opposite predictions have been put forward to
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23 explain the DAR and TE relationship in the farm sector and beyond. Empirical evidence
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25 is mixed as far as it concerns the sign of the relationship while, exogeneity of debt is
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27 mainly assumed and not tested but for the case of Davidova and Latruffe (2007), as it is
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29 shown in Table 2
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35 Table 2 *Approximately here*
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40 Noticeably, a group of researchers decompose the overall DAR into the corresponding
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42 short term intermediate and long-term measures. In Chavas and Aliber (1993), Lambert
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44 et al. (2005) and Mugera and Nyambane (2015) where intermediate DAR is analysed it
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46 is found to have a positive relationship with TE supporting the capital embodiment
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48 theory. Results about overall and short-term DAR are mixed even if more negative
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50 signs are observed. A number of factors are likely to affect the observed evidence. First,
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56 ⁴ Farm investment is not only constrained by long term credit availability. Also short term credit availability may
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58 prompt reaction to restore this source of liquidity by adjustments which affect technical efficiency such as sales
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60 of capital assets *ibid*.

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3 different methods are used to estimate the DAR and TE relationship either single stage
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5 stochastic frontier with simultaneous estimation of inefficiency model or two stage non-
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7 parametric DEA estimates followed by OLS or Tobit estimation of the inefficiency
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9 model. Moreover, different specification of both the SFA and DEA model select several
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11 alternative TE measures and covariates that can affect the estimate of the parameter of
12
13 DAR. Ultimately the historical and institutional context in which the investigated farms
14
15 operate is likely to impact on the DAR and TE relationship (Giannetti, 2003), noticeable
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17 examples being the Davidova and Latruffe (2007) and Catherine et al. (2000).

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21 This study will employ non-parametric techniques in order to derive TE estimates for a
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23 sample of Italian cereal farms to explore in depth the relationship amongst the financial
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25 exposure of the sector and the capacity to utilise an efficient and effective production
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27 technology. Considering that loans in the Italian agribusiness sector are granted based
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29 on collateral we assume that DAR impacts TE and hence, the credit evaluation
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31 hypothesis is not relevant in this context. However, we cannot dismiss *a priori* any of
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33 the other hypothesis put forward by the literature in regards to the sign of the
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35 relationship between DAR and TE, not least the adjustment theory. Indeed, since our
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37 sample is covering the period 2008 to 2014 we take into consideration two factors that
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39 have significantly contributed to the financial distress of Italian cereal farms (economic
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41 and commodity price instability). By promoting the understanding in regards to
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43 financial capital structure, and the provision of a new insight into the relationship
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45 between DAR and TE for the Italian cereal sector, this study is contributing to the
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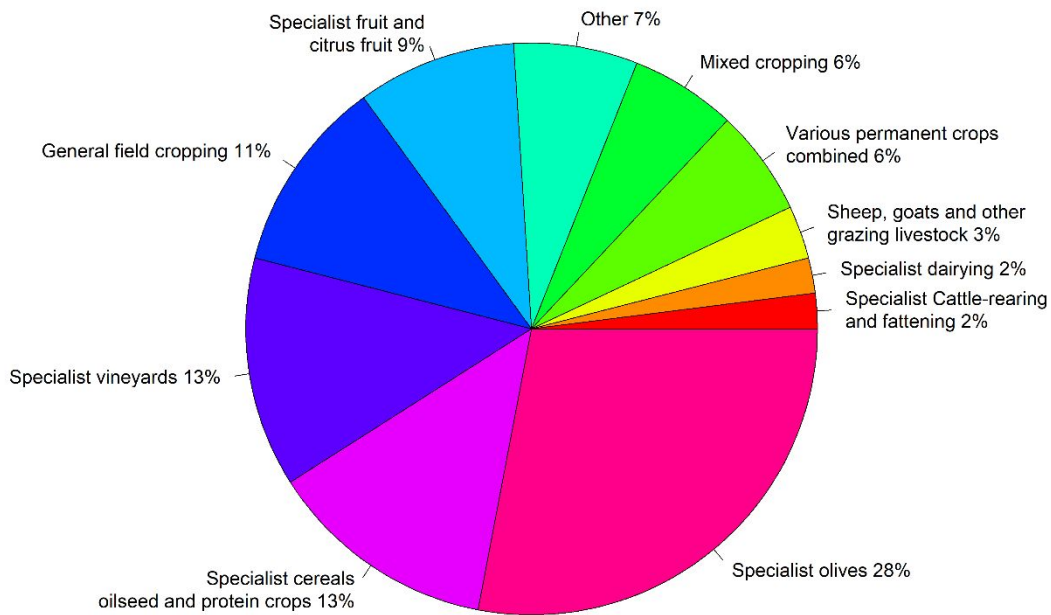
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3 development of relevant policy and fiscal interventions such as those envisaged by the
4 recently proposed Agriculture Italian Guarantee Multiregional Platform (AIGMP)⁵.
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9 **3 Methods and data**

10 Farm accountancy data for the empirical model was derived from Rete di Informazione
11 Contabile Agricola (RICA), the Italian equivalent of FADN. The average size of the
12 sample is about 11,000 farms per year between 2008 - 2014. The survey is performed
13 by the former National Institute of Agricultural Economics and is responsible for
14 collecting both financial and structural data for an individual farm. Although the RICA
15 dataset is a partially rotating panel, for the purposes of this study is considered as a
16 repeated cross-sectional sample. Cereal Farms amount to about 11% of the total
17 sampled farms, a figure in line with the weight of cereal farms over total Italian
18 agricultural holdings (Figure 1). With over 4 billion Euro of output in 2014, Italy was
19 the third cereal producer in the European Union after France and Germany and just
20 above UK and Poland.
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54 ⁵ Instruments to optimise the use of capital aimed at facilitating access to credit and investment for small and medium
55 sized farms and agribusinesses and hence improve the competitiveness of the Italian agri-food sector
56 (<https://en.cdp.it/Clients/Financial-Institutions/Instruments-To-Optimise-The-Use-Of-Capital/Agri-Platform/AGRI-Platform.kl>)
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Figure 1: Number of holdings by main type of farming in Italy (2010 data)



Source: EUROSTAT, Agricultural Census in Italy (2012)

Efficiency was estimated by carrying out an input-oriented sub-vector DEA model for each year⁶ of the sample and for each Italian macro-region⁷ under the constraint of constant returns to scale, thus obtaining total technical efficiency (TTE) estimates. The sub-vector (SBV) or non-discretionary DEA model has been used to account for the non-discretionary input of the CAP pillar one subsidies. It is assumed that farmers have no control over the amount of money that they receive and hence it is an input that they cannot directly influence within the production function. Therefore, a non-discretionary or SBV DEA model is used to evaluate input use efficiency estimates for cereal farms.

⁶ For this reason we considered nominal and not deflated values.

⁷ Italian macro-regions are defined as NUTS1 regions (North West, North East, Centre, South, Islands). To obtain 4 similarly sized sub samples we aggregated South Italy with the Islands resulting in 4 macro-regions.

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3 According to Gadanakis and Areal (2018) the SBV DEA model is more suitable to
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5 correctly assess the relative performance of each farm and therefore, account for the
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7 effect of the annual variation in amount of subsidies that the farmers receive in
8
9 production efficiency. A detailed discussion and the results of a meta-analysis in regard
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11 to the treatment of subsidies in the estimation of technical efficiency is available in
12
13 (Minviel and Latruffe, 2016). The importance of subsidies in technical efficiency
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15 (Latruffe et al., 2016) is not ignored by the model, instead, it is consider as a parameter
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17 that could have an impact on the efficiency outcome. Therefore, as a non-discretionary
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19 variable, subsidies are not used to penalise farms at a lower level of Pillar I payments
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21 when benchmarked in DEA with farms that receive higher level of payments. The DEA
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23 model includes two outputs (the value in Euros of the production of cereals and other
24
25 agriculture products) and five inputs: the value in Euros of fixed capital costs
26
27 (depreciation) and intermediate consumption, the total labour used per farm in Annual
28
29 Working Units (AWU), the utilized agricultural area (UAA) in hectares and the
30
31 Common Agricultural Policy 1st pillar subsidies received per farm (see Table 3 for
32
33 variable definitions). Since DEA results are highly sensitive to the presence of outliers,
34
35 we carried out a statistical method based on the algorithm proposed by Billor et al.
36
37 (2000) for the detection of multiple outliers in multivariate data.
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45 Table 3: *Approximately here*
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49 Table 4 reports summary statistics for the variables included in the DEA model. The
50
51 average value of Pillar I subsidies remains nearly constant over the period, as well as
52
53 the amount of utilized agricultural area (UAA) and labour (Annual Working Units).
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55 However, the value of fixed capital costs slightly increases over the period under
56
57 consideration, while the value of intermediate consumption remains constant over 2008-
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2010 and increases in 2011 and 2012 (22% increase) reaching its peak in 2013 (38,000 €). In regards to crop output we observe a significant variation in the period under consideration with the lowest values of crop output in 000s euros observed in 2009 (42,000 €) and the highest in 2012 (60,000 €). Other agricultural output is higher in the years prior to 2010 (12,000 €) while it drops to an average of 7,000 € for the remaining of the period.

Table 4: *Approximately here*

To formalise the above let us assume that we observe a set of n farms and each farm $i = \{1, \dots, n\}$ has a set of inputs and outputs representing multiple performance measures. Considering then that each farm i uses J ($j = 1, \dots, J$) inputs, x_j to produce S outputs y_r ($r = 1, \dots, S$). The general form of an input-oriented DEA dual model (conventional (CNV) DEA model) with all inputs variable is as follows:

$$\begin{aligned}
 & \min_{\theta, \lambda^i} \theta'_{iCNV} \\
 & \text{s.t.} \quad \theta x'_{ji} \geq \sum_{i=1}^n \lambda^i x_{ji} \quad (i) \\
 & \quad \quad y'_{ri} \leq \sum_{i=1}^n \lambda^i y_{ri} \quad (ii) \\
 & \quad \quad \lambda^i \geq 0 \quad (iii)
 \end{aligned} \tag{1}$$

Where, θ'_{iCNV} , is a scalar, representing the efficiency score for each of the n farms estimated by the CNV DEA model. The estimate will satisfy the restriction $\theta_i \leq 1$ with the value $\theta_i = 1$ indicating an efficient farm. This is because the ratio is formed relative to the Euclidean distance from the origin over the production possibility set.

Also, in the above formulation we consider that there is a set of discretionary or variable inputs DI , $DI \subset \{1, \dots, j\}$ and a set of non-discretionary inputs NDI , $NDI = \{1, \dots, F\}$

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3 \ DI = {h ∈ {1,⋯,J} | h ∉ DI} that cannot be adjusted or are held fixed at least in the
4
5 short run. The combination of the DI and NDI variables therefore defines the
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7 technology set P_{SBV}:

$$8 \quad P_{SBV} = \{(x_{DIj}, x_{NDIj}, y_{ri}) \mid x_{DIj} \text{ and } x_{NDIj} \text{ can produce } y_{ri}\} \quad (2)$$

11
12 As suggested by Bogetoft and Otto (2010) in cases where DI and NDI variables exist, a
13
14 traditional and popular variation of the Farrell (1957) procedure is used to solve the
15
16 linear DEA programme with respect to the largest proportional reduction in the DI
17
18 variables alone.

$$19 \quad \theta((x_{DIj}, x_{NDIj}, y_{ri}); P) = \min_{\theta} \{\theta \mid (\theta x_{DIj}, x_{NDIj}, y_{ri}) \in P\} \quad (3)$$

21
22 The linear DEA programme can therefore be modified as follows where only the DI
23
24 variables are reduced. Thus, the input use DEA efficiency score when accounting pillar
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26 one subsidy variations for observation x', θ' , is estimated by the following linear
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28 programming (LP) problem:
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$$31 \quad \begin{aligned} & \min_{\theta, \lambda^i} \theta'_{SBV} \\ & s.t. \quad \theta x'_{DIj} \geq \sum_{i=1}^n \lambda^i x_{DIj} \quad j \in DI \quad (i) \\ & \quad \quad x'_{NDIj} \geq \sum_{i=1}^n \lambda^i x_{NDIj} \quad j \in NDI \quad (ii) \\ & \quad \quad y'_{ri} \leq \sum_{i=1}^n \lambda^i y_{ri} \quad (iii) \\ & \quad \quad \lambda^i \geq 0 \quad (iv) \end{aligned} \quad (4)$$

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Where, x_{DIj} is the j^{th} discretionary input for farm i , x_{NDIj} is the j^{th} non-discretionary input for farm i and y_{ri} is the r^{th} output for farm i , $i=(1, \dots, n)$, $j=(1, \dots, m)$ and $r=(1, \dots, s)$.

The optimal value θ'_{iSBV} represents the SBV efficiency score for each farm and its values lie between 0 and 1. This efficiency score indicates the degree to which a farm can reduce the use of its discretionary inputs without decreasing the level of outputs regarding the best performers or benchmarking farms in the sample. The first two

constraints limit the proportional decrease in both discretionary (equation - 4(i)) and non-discretionary (equation - 4(ii)) inputs, when θ'_{ISBV} is minimised in relation to the input use achieved by the best observed technology. The third constraint ensures that the output generated by the i^{th} farm is less than that on the frontier. All three constraints ensure that the optimal solution belongs to the production possibility set. The final constraint expressed by the equation 4(iv), called also the convexity constraint, ensures the CRS assumption of the DEA SBV model (Cooper et al., 2006).

The DEA model under the Variable Returns to Scale assumption (the constrain iv , in equation (4) is now $\lambda^l = 1$) decomposes technical efficiency into pure technical efficiency (PTE) and scale efficiency (SE) (Fare et al., 1993) . Therefore, by estimating technical efficiency scores under assumptions of CRS (TE_{CRS}) - known as a measure of overall technical efficiency (OTE) - and VRS (TE_{VRS}) one can measure the SE which measures the impact of scale size on the productivity of the farm. SE efficiency is therefore defined as follows:

$$SE = \frac{TE_{CRS}}{TE_{VRS}}$$

SE can take values between 0 and 1. When $SE = 1$ a farm is operating at optimal scale size and otherwise if $S < 1$. The information revealed by SE is used to indicate potential benefits from adjusting farm size. Furthermore, $SE = \frac{TE_{CRS}}{TE_{VRS}}$ can be used to decompose TE_{CRS} into two mutually exclusive and non-additive components, the pure technical efficiency (PTE) (estimated by the VRS specification) and SE .

$$TE_{CRS} = TE_{VRS} * SE$$

This allows an insight into the source of inefficiencies. The TE_{VRS} specifies the possible efficiency improvement that can be achieved without altering the scale of operations. On the other hand, the TE_{CRS} and SE measures require the farm to adjust its scale of

operation to improve efficiency and therefore should be viewed as long run measure that aims to reduce inputs for the long run improvement in efficiency. Furthermore, to investigate the impact of indebtedness on farm performance we have used the two stage semi-parametric model as it suggested in Simar and Wilson (2007).

Studies measuring productivity and efficiency using DEA to investigate the impact of environmental factors (a vector of z variables that can either be continuous or discrete) at a second stage analysis have suffered from two problems. 1) Serial correlation among the DEA estimates and 2) Correlation of the inputs and outputs used in the first stage with second-stage environmental variables (Simar and Wilson, 2007). A solution to these problems consists of bootstrapping the results to obtain confidence intervals for the first stage productivity or efficiency scores (Simar and Wilson (1999, Simar and Wilson, 2007). The significance of the Simar and Wilson (2007) double bootstrap procedure derives from the bias corrected efficiency estimation of θ'_{iSBV} (estimated by expression (4)). These estimates are used as parameters in a truncated regression model. A detailed presentation of the double bootstrapped procedure and the Algorithm 1 used in this paper is available in Simar and Wilson (2007).

The truncated model to solve is of the form:

$$\hat{y} = z_i\beta + \varepsilon_i$$

Where, \hat{y} the bias corrected efficiency estimates, z_i a vector of environmental variables (a vector of farm control variables), β a vector of parameters to be estimated and ε_i is the error term.

Table 5 reports summary statistics of the lagged leverage and control variables included in the regression model. Since the lagged leverage is considered in the analysis, data related to year 2008 will be dropped and the period 2009 – 2014 will be considered in the truncated regression model. This will also have an impact into the number of observations

(reduced/year) as it is demonstrated in Table 5. The control variables selection allows for testing the main management and structural characteristic of Italian cereal farms in relation to technical efficiency and financial performance. In order to capture any potential variation across the different Italian regions, regional dummies are introduced which divide the country into the North East (NE), North West (NW), Central, South and to the Island regions. The North West region is considered as the base category for the analysis since it is the most industrialised and developed region in the country (referred as the “Industrial Triangle” Milan, Turin Genoa). The regional dummies are used to explore differences in technical efficiency amongst farm businesses and therefore, identify areas where interventions are required in the form of policy support or extension services. Apart from regional dummies the analysis builds on variables which consider farmer and farm characteristics to provide further insight to the structural characteristics of the farm system and the relationship to technical efficiency. Farmer characteristics such as age and years in education of the farmer are considered to explore the relationship between managerial capabilities and technical efficiency. Hence, it is assumed that a younger farmer with more years in education would be keener to adopt contemporary methods of production and therefore be technical efficient. In addition, the role of gender in decision making and technical efficiency is explored. The variable associated to the share of rented land is testing the assumption that farmers with a higher percentage of rented land are more technical efficient as it is also the case of farm business with a high share of family labour. Furthermore, the share of tangible assets over total assets is considered in order to measure the impact of over capitalisation of the Italian cereal sector and its impact to technical efficiency. In addition, a dummy for farms located in municipalities classified as less favoured areas (LFAs) was used to test the assumption of LFAs having limited access to resources and therefore being least technical efficient.

Table 5: *Approximately here*

The (lagged) level of indebtedness or leverage is the main variable of interest. It has been constructed as the ratio of total liabilities over total assets. Although, the value for the DAR is very low, with small changes over the period 2009-2014, it is important to focus on this ratio since it will allow us to explore the financial sustainability of the cereal farms in Italy. The ratio of tangible to total assets shows a decline over the period 2009-2014, revealing a relative decrease in long-term investments. In addition, the analysis is considering the disaggregation of the DAR into the lagged long term and the short-term DAR. Hence, the second stage regression is considering two variants of the model. The assumption behind these two models is that the model with the lagged long term and the contemporaneous short-term DAR is exploring further the impact of short-term DAR into technical efficiency as it is discussed in Barry et al. (1981). Hence, explore how the short-term DAR can demonstrate the use of short run credit as a reserve that provides liquidity to the business within an uncertain financial environment.

3 Results and discussion

A summary of the DEA SBV model results is presented in Table 6. The figures of mean efficiency represent the average potential equiproportional input reduction keeping constant the output, so smaller scores reveal greater inefficiency. An increase in the average efficiency score is observed in 2012 and is then maintained to similar levels for the remaining of the period under consideration. In addition, results indicate that efficiency is quite dispersed especially in the harvest periods of 2008, 2009 and 2010 (SD = 0.229, 0.235 and 0.227 respectively). These results suggest the need for

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3 improvements in production and management practices for the majority of the farms in
4 the sample. In particular, it could be suggested that a 44% equiproportional reduction in
5 the use of inputs is required for 2008, 42% for 2009, 40% for 2010, 34% for 2011, 30%
6 for 2012, 32% for 2013 and 30.2% 2014. In addition, it can be observed that the overall
7 mean efficiency over the period of interest has increased to 0.698 in 2014 when
8 compared to 0.561 in 2008. Similarly, the number of efficient farms on the frontier has
9 also increased from 8.70% of the farms in the sample in 2008 to 13.97% for 2014.
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11 However, to conclude on the progress of technical efficiency a dynamic efficiency
12 model is required (Namiotko and Balezentis, 2017). It is important though to mention
13 that we observe a positive shift of the number of farms towards the efficient frontier.
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15 Overall, a shift towards a more technical efficient status for the farms in the sample is
16 observed since the percentage of farms with an efficient score less than 0.5 has
17 decreased to 33.65% when compared to the 61.76 in 2008. This is in line with Cechura
18 et al. (2015) that have observed similar catching-up and falling behind processes for
19 most of the EU cereal producers. In particular, technological change contributed
20 positively towards technical efficiency of the Italian cereal sector and specifically for
21 the years 2012 and 2014 while lower levels of technical efficiency have been observed
22 for the years prior to 2010. This positive progress on technical efficiency for Italian
23 cereal farms is also observed by Latruffe et al. (2016) where a positive association
24 between subsidies and TE is observed and especially for the after decoupling period
25 (2003 CAP reform). Moreover, Gitto (2017) has observed the same patterns for the
26 different regions in Italy with North region being the most TE area in Italy when the
27 agricultural sector is considered.
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5 During the 2008 – 2014 period, on average 12% of the farms operated under constant
6 returns to scale, hence indicating that a percentage of the farms in the sample is not
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8 required to adjust their scale of operations in order to improve efficiency in the long
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10 run. However, the majority of the farms is operating under a status of decreasing or
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12 increasing returns to scale and therefore, adjustment in the scale of operations is
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14 required in the long term. Table 7 presents the distribution of the efficiency estimates
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16 for both the pure technical efficiency (VRS DEA) and the scale efficiency (SE). The
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18 average pure technical efficiency between 2018 - 2014 is 0.72 and is higher than the
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20 overall technical efficiency as it is estimated by the SBV CRS DEA model (mean
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22 $SBV_{eff} = 0.64$). Hence, it indicates that Italian farms have a greater ability to catch up
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24 with technological changes when compared to their ability to allocate resources and
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26 adjust their management practices.
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35 Table 7: *Approximately here*
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39 In addition, the Fare et al. (1985) procedure (to define the status of increasing or
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41 decreasing returns to scale) concluded that most of the farms in the sample in average
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43 operate under increasing returns to scale (61%), followed by farms operating under
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45 diminishing returns to scale (25%). The latter could be used as an indicator of
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47 overcapitalisation or over mechanisation of the Italian cereal sector while the high
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49 percentage of increasing returns to scale is an indicator demonstrating the need for
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51 further improvements in the scale of operations and scale efficiency of the Italian cereal
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53 farms. The remaining of the sample operates under constant returns to scale.
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Table 8: *Approximately here*

The results of the model where the lagged long-term DAR and the contemporaneous short-term DAR are considered are summarised in Table 9. In both models, hence, either in the model where the lagged DAR is considered (Table 8), or where the lagged long term DAR and the contemporaneous short term DAR (Table 9) are considered, the negative impact of DAR in 2010 may be viewed as an empirical support of the adjustment theory posited by Paul et al. (2000). Indeed, the years 2009-2010 were characterized by a dramatic drop in the cereal prices (-30% in 2009) which was followed in 2010 by a timid increase by 6%, still far below the 2007-2008 level. In 2011, prices were back to the peak of 2008 and stayed more stable for the following years. Thus, years 2009 and 2010 were particularly unfavourable for the cereal industry because of both the drop in output prices and the adverse terms of trade⁸. Therefore, financial exposure seems to be a source of inefficiency in time of price instability when farms need to face adjustment hardship to cope with rapidly changing price scenarios. The drop in cereal prices increases the financial constraints faced by indebted farms, thus reducing their ability to cope with higher financial stress and in turn decreasing their efficiency as is also indicated by the results of the SBV CRS DEA model (lower mean efficiency scores for 2008, 2009 and 2010 within the period). Furthermore, the negative sign observed for 2010 is also compatible with the agency cost theory of Jensen and Meckling (1976) as it is also discussed in Latruffe et al. (2016). Overall,

⁸ It is worth noticing that an adverse term of trade arises again in 2014 when the output price index is still falling from its 2011 peak whereas the input price index reaches a peak

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3 across the period under consideration an inconsistency is observed in terms of the
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5 direction of the relationship between the DTA and TE for the Italian cereal farms which
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7 is also concluded in other studies (Latruffe et al., 2016, Davidova and Latruffe, 2007).
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16 Furthermore, tangible to total assets is another variable which in all years negatively
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18 impacts on efficiency. One possible reason for the negative impact of the ratio is the
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20 overcapitalization of Italian small farms which often are over mechanized. This is also
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22 in line with the finding of the returns to scale analysis where 25% of the farms in the
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24 sample operate under diminishing returns to scale.
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28 Also farms with higher proportion of rented land are less efficient perhaps because of
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30 agency problems stemming from misalignment of farmer and landowner incentives, as
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32 posited by Giannakas et al. (2001), Hadley (2006) and Michler and Shively (2015). This
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34 in fact indicates that ownership of the land has a positive impact to technical efficiency
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36 since increases the incentives of the farmer to maximise effort and hence achieve higher
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38 production output (Michler and Shively, 2015, Heath, 2015). Another possible
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40 explanation may be found in reduced farmers' attitude towards long-term investment as
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42 effect of land tenure. As it has been expected farming systems based within LFAs will
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44 be less technical efficient when compared with the remaining farms in the sample with
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46 an exception of year 2009 where the coefficient is positive and statistically significant
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48 (0.05, p-value <0.05). For LFAs in years 2010 – 2014, the relationship is negative,
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50 though it is statistically significant only for the years 2011 and 2012. Finally, the
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52 coefficients of regional dummies reveal that cereal farms in North Italy (mainly North-
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54 Western regions and Central regions) are on average more efficient than in those located
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3 in the Island and Southern regions (Gitto, 2017). Especially for the Southern regions
4 the results indicate that for the 2009 and 2010 the coefficient is negative and statistically
5 significant (-0.06 and -0.12 respectively, p -value < 0.01). However, the relationship
6 sign is changing for the remaining of the period without though this being statistically
7 significant. The years of education of conductor, a proxy for human capital, has a
8 positive sign for all years in consideration but it is statistically significant only for the
9 years 2009 and 2010. Furthermore, considering the gender of farm conductor is
10 negative for the period under consideration but only statistically significant for the years
11 2009, 2010, 2012 and 2013. The results associated with the two age dummy variables of
12 conductor provide a mixed outcome and it is difficult to draw a clear conclusion.
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14 Considering the variable of interest i.e. DAR, the results confirm most of the findings in
15 the literature regarding technical efficiency and its relationship to debt to asset ratio
16 where a variation in the direction of the relationship is stated. The results contribute to
17 the discussion regarding the best way to pursue structural adjustment in Italy which so
18 far is left to market forces with dramatic surge in the percentage of rented UAA in Italy.
19 Further and more targeted research is needed on this point. The lower TE estimates of
20 Southern regions and especially in the years where price instability is observed (2009
21 and 2010) is of particular interest for policy makers since it confirms the overall need
22 for further supporting agricultural systems based in the South of Italy in the form of
23 investment subsidies and mechanisms that could contribute to the absorption of market
24 price shocks. Indeed, the empirical results presented in Table 8 and Table 9 support the
25 adjustment theory. Moreover, as it has been indicated by Gitto (2017) for Italian regions
26 and as it has also been demonstrated by Latruffe et al. (2016) the positive shift of the
27 farms to the frontier could be interpreted as an indication that decoupled payments have
28 a positive influence on allocative efficiency. Therefore, it gives an indication of the
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3 direction that the support designed to facilitate access to credit and investment needs to
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5 take. This is extremely important when considering the small size of the Italian
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7 specialised cereal farms and their contribution to the rural economy.
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10 11 **4 Conclusions**

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14 In this paper, an SBV CRS DEA model was utilised to measure farm output efficiency
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16 of Italian cereal farms and to assess the relationship between farm capital structure and
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18 farm efficiency in the eve of the upsurge of cereal price instability in years 2008 - 2014
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20 and financial uncertainty. The empirical findings show that the relationship between
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22 farm efficiency and leverage is not statistically significant for all years but 2010.
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24 Interestingly, 2009 is the very year when cereal prices dropped by almost 30% after the
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26 upsurge of 2007 - 2008 thus posing a significant stress on cereal farmers reflected to the
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28 technical efficiency of 2010. Similarly, to the policy induced price drop analysed by
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30 Paul et al. (2000) in New Zealand, results provide support for the adjustment theory as a
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32 possible explanation of the negative relationship between DAR and farm technical
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34 efficiency. According to this theory the financial constraints faced by indebted farms
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36 reduced their ability to adjust the dramatic deregulation of the agricultural sector in New
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38 Zealand, thus decreasing their efficiency. In the 2010 case a price shock caused a
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40 collapse of the output value as the one observed in New Zealand after the reform which
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42 in turn financially stressed especially indebted farms. As far as the authors know, no
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44 other study has highlighted the negative effect of such stress on the technical efficiency
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46 of Italian cereal farms. The paper contributes to the ongoing literature about the
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48 relationship of farm indebtedness and technical efficiency, a literature which posits a
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50 number of different testable propositions derived from alternative theoretical models.
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52 Every new empirical study which provides evidence against or in favour of a specific
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3 model contributes to the development of this strain of the agricultural finance
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5 theoretical debate.
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9 In addition, our findings contribute to the debate on policy interventions aimed at
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11 mitigating the effect of price instability on farm economic sustainability. Underlining
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13 the relationship between financial constraints and farm flexibility to adapt to price
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15 instability, our results suggest the provision of additional support to increase the ability
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17 of farmers to cope with sharp price variations. Notably exploring the impact of a
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19 number of variables on TE we provide also suggestions on possible dimensions of the
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21 relative vulnerability of farms in times of high price instability. This type of information
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23 may prove relevant to policy makers when debating the focus and the direction of
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25 specific policy interventions for the agricultural sector (i.e. which regions in the country
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27 to focus, deciding on which age group and what other sociodemographic characteristics
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29 to consider, tenure status etc.). The paper presents a number of limitations that hint to
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31 further developments. The current DEA model is static. A dynamic model (a time
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33 variant dynamic model) could further explore the relationship between DAR and
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35 efficiency within the adjustment theory even if this would come at the cost of reduced
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37 external validity due to the rotated panel nature of the Italian FADN. Also the role of
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39 prices changes is only indirectly implied in the model by comparing results from
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41 different years, a further development may take into account this limit for instance using
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43 unit values as a covariate. Finally, the results indicate that the adjustment theory might
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45 be even more relevant for more capital-intensive agricultural sectors (dairy industry)
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47 beyond the cereal farming sector which has been the focus of this paper. However, the
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49 cereal sector is the one that experienced the largest rise in price instability in the
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51 considered period, thus remaining a valid case to study the relationship between DAR
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53 and TE despite its relatively low capital intensity.
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Table 1: Theoretical findings on the relationship between Debt to Asset Ratio (DAR) and Technical Efficiency.

| <i>Theory</i> | <i>Direction of the Relationship</i> | <i>Expected sign of Relationship</i> | <i>Reference</i> |
|-------------------------------------|--------------------------------------|--------------------------------------|--|
| <i>Fisher separation theorem</i> | - | - | <i>Lambert et al., 2005</i> |
| <i>Free cash flow model</i> | DAR → TE | <i>Positive</i> | <i>Jensen and Meckling, 1976)</i> |
| <i>Agency cost model</i> | DAR → TE | <i>Negative</i> | <i>Margaritis and Psillaki, 2010</i> |
| <i>Credit evaluation hypothesis</i> | TE → DAR | <i>Positive</i> | <i>Berger and Bonaccorsi di Patti (2006)</i> |
| <i>Capital embodiment theory</i> | DAR → TE | <i>Positive</i> | <i>Chavas and Aliber (1993b)</i> |
| <i>Adjustment theory</i> | DAR → TE | <i>Negative</i> | <i>Paul et al. (2000)</i> |

Table 2: Empirical findings on the relationship between Debt to Asset Ratio (DAR) and Technical Efficiency.

| <i>Authors</i> | <i>Country</i> | <i>Endogeneity of debt</i> | <i>Sign of relationship</i> |
|--|---------------------------|---|--|
| <i>D. Lambert et al. (2005)</i> | USA | (assumed) | - (short term DAR) + (intermediate DAR) |
| <i>A.W. Mugeru and Nyambane (2015)</i> | Australia | (assumed) | + (short term DAR) ns (long term DAR) |
| <i>Chavas and Aliber (1993a)</i> | USA | (assumed) | ns (short term DAR) + (intermediate DAR) + (long term DAR) |
| <i>Hadley (2006)</i> | UK | (assumed) | - (DAR) |
| <i>Davidova and Latruffe (2007)</i> | Czech Rep. | (tested and rejected for private farms) | - (DAR) depending on farm type |
| <i>Latruffe, Bravo-Ureta, Carpentier, and Desjeux (2016)</i> | Denmark & Poland Spain | (account for endogeneity) | - (DAR) + (DAR) |
| <i>Giannakas, Schoney, and Tzouvelekas (2001)</i> | Canada | (assumed) | + (DAR) |
| | New Zealand | (assumed) | - (DAR) |

Table 3: Definition of variables used in the DEA sub-vector model

| <i>Variable</i> | <i>Definition</i> |
|--|---|
| <i>Crop Output (000€)</i> | Total <u>crop</u> output (sales+change in stocks+ farmhouse consumption) net of subsidies, of cereal crops |
| <i>Other <u>Agricultural</u> Output (000€)</i> | Total <u>agricultural</u> output net of subsidies - crop output |
| <i>Pillar I subsidies (000€)</i> | Subsidies (CAP first pillar) <u>excluding</u> investment subsidies |
| <i>Labour (AWU)</i> | Number of total Annual Work Units |
| <i>UAA <u>H(ha)</u></i> | Utilized Agricultural Area <u>in hectares</u> |
| <i>Intermediate consumption (000€)</i> | Total intermediate consumption (total specific costs_+ total farming overheads) |
| <i>Fixed capital costs (000€)</i> | Depreciation |

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Table 4: Descriptive statistics of outputs and inputs used in the DEA sub-vector model

| | 2008 | | 2009 | | 2010 | | 2011 | | 2012 | | 2013 | | 2014 | |
|--|-------------|------|-------------|------|-------------|------|-------------|------|-------------|------|-------------|------|-------------|------|
| | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. |
| Crop Output (000€) | 46 | 73 | 42 | 74 | 51 | 71 | 58 | 78 | 60 | 75 | 56 | 76 | 58 | 86 |
| Other <u>Agricultural</u> Output (000€) | 12 | 21 | 11 | 21 | 7 | 13 | 8 | 15 | 6 | 11 | 7 | 13 | 7 | 14 |
| Pillar I subsidies (000€) | 19 | 29 | 20 | 29 | 20 | 32 | 21 | 31 | 20 | 29 | 21 | 32 | 21 | 37 |
| Labour (AWU) | 1.1 | 0.8 | 1.1 | 0.8 | 1.1 | 0.7 | 1.2 | 0.8 | 1.2 | 0.8 | 1.2 | 0.8 | 1.2 | 0.8 |
| UAA (<u>haHe</u>) | 43.8 | 53.9 | 45 | 51.6 | 43.4 | 49.3 | 44.2 | 49.7 | 42.9 | 45.5 | 43.4 | 48.2 | 43.1 | 47.7 |
| Intermediate consumption (000€) | 32 | 39 | 31 | 38 | 31 | 43 | 37 | 47 | 38 | 46 | 38 | 48 | 38 | 50 |
| Fixed capital costs (000€) | 7 | 10 | 7 | 11 | 6 | 11 | 6 | 11 | 6 | 10 | 6 | 11 | 6 | 12 |
| Number of observations | 1517 | | 1332 | | 1292 | | 1292 | | 1265 | | 1229 | | 1052 | |

Table 5: Summary statistics of the control variables included in the regression model

| | 2009 | | 2010 | | 2011 | | 2012 | | 2013 | | 2014 | |
|--|-------------|-------|------------|-------|------------|-------|------------|-------|------------|-------|------------|-------|
| | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. |
| CRS eff. scores | 0.57 | 0.23 | 0.60 | 0.22 | 0.67 | 0.19 | 0.69 | 0.19 | 0.68 | 0.19 | 0.69 | 0.19 |
| <u>Lagged</u> Debt to asset ratio (DAR) | 0.02 | 0.1 | 0.02 | 0.09 | 0.02 | 0.12 | 0.01 | 0.09 | 0.01 | 0.08 | 0.02 | 0.11 |
| <u>Lagged</u> Long term DAR | 0.00 | 0.04 | 0.00 | 0.04 | 0.00 | 0.02 | 0.00 | 0.01 | 0.00 | 0.03 | 0.00 | 0.03 |
| <u>Contemporaneous</u> Short-term DAR | 0.02 | 0.10 | 0.02 | 0.12 | 0.01 | 0.09 | 0.01 | 0.08 | 0.01 | 0.09 | 0.01 | 0.09 |
| Share tangible assets | 0.79 | 0.24 | 0.73 | 0.27 | 0.73 | 0.26 | 0.69 | 0.27 | 0.67 | 0.28 | 0.64 | 0.29 |
| Share farm labour | 0.94 | 0.17 | 0.95 | 0.16 | 0.95 | 0.16 | 0.95 | 0.16 | 0.95 | 0.14 | 0.95 | 0.14 |
| Education in years | 8.13 | 3.78 | 8.72 | 3.53 | 8.69 | 3.65 | 8.75 | 3.53 | 8.75 | 3.39 | 9.07 | 3.34 |
| Age (Years) | 57.91 | 14.24 | 57.83 | 14.31 | 58.75 | 13.89 | 59.23 | 13.95 | 59.55 | 13.90 | 58.60 | 13.41 |
| Share rented land (%) | 0.37 | 0.42 | 0.39 | 0.42 | 0.35 | 0.41 | 0.37 | 0.41 | 0.38 | 0.42 | 0.42 | 0.41 |
| Young (%) | 11% | | 11% | | 8% | | 7% | | 7% | | 7% | |
| Elder (%) | 31% | | 32% | | 34% | | 34% | | 35% | | 33% | |
| Female (%) | 16% | | 16% | | 17% | | 17% | | 16% | | 16% | |
| Farms in total LFA (%) | 27% | | 26% | | 27% | | 26% | | 28% | | 23% | |
| Region NW (%) | 34% | | 41% | | 32% | | 34% | | 33% | | 41% | |
| Region NE (%) | 24% | | 20% | | 24% | | 22% | | 22% | | 23% | |
| Region Central (%) | 20% | | 18% | | 19% | | 21% | | 22% | | 16% | |
| Region South (%) | 18% | | 19% | | 23% | | 21% | | 21% | | 18% | |
| Region Islands (%) | 3% | | 2% | | 2% | | 2% | | 2% | | 2% | |
| Number of observations | 1002 | | 741 | | 953 | | 897 | | 899 | | 657 | |

Note: Standard output calculated according to Regulation (EC) No 1242/2008. Region NW includes Piedmont, Lombardy, Liguria and Aosta Valley; region NE includes Veneto, Emilia Romagna, Trentino Sud Tirol, Friuli Venezia Giulia and Emilia Romagna; Region Central Includes Tuscany, Umbria, Marche and Lazio, South includes Abruzzi, Molise Apulia, Campania, Basilicata, Calabria; Island includes Sicily and Sardinia.

Table 6: Summary table of efficiency scores derived from an input oriented non-discretionary CRS DEA model

Overall Technical Efficiency SBV CRS model

| Efficiency Distribution | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|-------------------|-------------|-------------|-------------|-------------|-------------|-------------|
| | % of Farms | | | | | | |
| $Eff < 0.5$ | 43.90% | 43.99% | 37.49% | 22.91% | 14.62% | 18.39% | 17.78% |
| $0.5 \leq Eff < 0.6$ | 17.86% | 15.54% | 18.40% | 18.50% | 17.63% | 18.88% | 15.87% |
| $0.6 \leq Eff < 0.7$ | 12.79% | 11.41% | 12.47% | 17.26% | 22.92% | 19.85% | 17.68% |
| $0.7 \leq Eff < 0.8$ | 8.44% | 8.11% | 9.16% | 16.02% | 15.18% | 14.81% | 16.16% |
| $0.8 \leq Eff < 0.9$ | 5.47% | 6.16% | 8.01% | 10.29% | 10.12% | 9.60% | 11.60% |
| $0.9 \leq Eff < 1$ | 2.83% | 3.60% | 4.31% | 4.33% | 5.93% | 5.70% | 6.94% |
| Efficiency = 1 | 8.70% | 11.19% | 10.16% | 10.68% | 13.60% | 12.77% | 13.97% |
| Mean Efficiency | 0.561 | 0.580 | 0.601 | 0.661 | 0.700 | 0.682 | 0.698 |
| SD Efficiency | 0.229 | 0.235 | 0.227 | 0.198 | 0.188 | 0.196 | 0.203 |
| Number of Farms | 1517 | 1332 | 1299 | 1292 | 1265 | 1229 | 1052 |

Note: outliers and observations with either negative outputs or negative inputs dropped

Table 7: Distribution of the overall technical efficiency decomposition into pure technical and scale efficiency expressed as percentages

| Efficiency Distribution | 2008 | | 2009 | | 2010 | | 2011 | | 2012 | | 2013 | | 2014 | |
|-------------------------|--------------------|---------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------------------|--------|
| | <u>% of Farms</u> | | | | | | | | | | | | | |
| | Pure* ¹ | Scale* ² | Pure | Scale | Pure | Scale | Pure | Scale | Pure | Scale | Pure | Scale | Pure | Scale |
| <i>eff</i> <0.5 | 31.64% | 3.89% | 28.60% | 3.75% | 17.32% | 7.54% | 10.22% | 2.71% | 5.78% | 1.26% | 8.14% | 2.69% | 8.37% | 2.09% |
| 0.5≤ <i>eff</i> <0.6 | 16.55% | 3.69% | 14.49% | 5.26% | 16.47% | 4.85% | 15.87% | 3.17% | 12.26% | 1.58% | 13.67% | 2.60% | 12.08% | 2.19% |
| 0.6≤ <i>eff</i> <0.7 | 12.79% | 4.81% | 12.01% | 6.08% | 13.39% | 7.78% | 17.03% | 4.72% | 17.48% | 5.77% | 16.27% | 3.34% | 13.80% | 5.04% |
| 0.7≤ <i>eff</i> <0.8 | 8.37% | 7.58% | 10.06% | 10.74% | 12.47% | 9.01% | 15.09% | 9.29% | 16.38% | 9.17% | 14.08% | 8.62% | 14.65% | 8.18% |
| 0.8≤ <i>eff</i> <0.9 | 5.87% | 15.49% | 7.21% | 13.74% | 10.16% | 15.01% | 10.53% | 15.94% | 11.47% | 16.05% | 9.52% | 16.60% | 11.04% | 17.13% |
| 0.9≤ <i>eff</i> <1 | 3.76% | 55.83% | 4.13% | 49.25% | 5.08% | 45.65% | 7.51% | 53.48% | 8.23% | 52.57% | 7.89% | 53.38% | 8.94% | 51.47% |
| Efficiency=1 | 21.03% | 8.70% | 23.50% | 11.19% | 25.10% | 10.16% | 23.76% | 10.68% | 28.40% | 13.60% | 30.43% | 12.77% | 31.11% | 13.99% |
| Mean Efficiency | 0.635 | 0.884 | 0.666 | 0.871 | 0.711 | 0.845 | 0.745 | 0.889 | 0.776 | 0.902 | 0.762 | 0.898 | 0.776 | 0.899 |
| SD Efficiency | 0.231 | 0.229 | 0.229 | 0.161 | 0.208 | 0.182 | 0.187 | 0.141 | 0.176 | 0.122 | 0.190 | 0.133 | 0.188 | 0.133 |
| Number of Farms | 1517 | | 1332 | | 1299 | | 1292 | | 1264 | | 1229 | | 1052 1 | |

*¹ = Pure technical efficiency, *² = Scale efficiency

Table 8: Exploring the relationship between technical efficiency of Italian arable farms with the lagged DAR and other farm and farm management characteristics

| | 2009 | | 2010 | | 2011 | | 2012 | | 2013 | | 2014 | |
|------------------------------|-------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|
| | Coef. | S.E. | Coef. | S.E. | Coef. | S.E. | Coef. | S.E. | Coef. | S.E. | Coef. | S.E. |
| <i>Lagged DAR</i> | -0.05 | 0.07 | -0.16** | 0.08 | 0.09 | 0.07 | 0.01 | 0.09 | 0.03 | 0.07 | -0.10 | 0.07 |
| <i>Share tangible assets</i> | -0.26*** | 0.03 | -0.16*** | 0.04 | -0.13*** | 0.03 | -0.16*** | 0.03 | -0.13*** | 0.03 | -0.21*** | 0.04 |
| <i>Share farm labour</i> | -0.13*** | 0.04 | -0.05 | 0.05 | -0.16*** | 0.04 | -0.13*** | 0.04 | -0.12*** | 0.05 | -0.13** | 0.05 |
| <i>Education in years</i> | 0.03*** | 0.01 | 0.03* | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.00 | 0.01 | 0.00 | 0.02 |
| <i>Share rented land</i> | -0.04** | 0.02 | -0.06*** | 0.02 | -0.01 | 0.02 | -0.05*** | 0.02 | -0.04* | 0.02 | -0.06** | 0.03 |
| <i>Young</i> | -0.02 | 0.02 | 0.01 | 0.03 | -0.01 | 0.02 | -0.01 | 0.02 | 0.00 | 0.02 | 0.05* | 0.03 |
| <i>Elder</i> | -0.02 | 0.01 | 0.00 | 0.02 | 0.02* | 0.01 | -0.01 | 0.01 | -0.05*** | 0.01 | -0.02 | 0.02 |
| <i>Female</i> | -0.06*** | 0.02 | -0.06*** | 0.02 | -0.02 | 0.02 | -0.03** | 0.02 | -0.03** | 0.02 | -0.02 | 0.02 |
| <i>Share rented land</i> | -0.04** | 0.02 | -0.06*** | 0.02 | -0.01 | 0.02 | -0.05*** | 0.02 | -0.04* | 0.02 | -0.06** | 0.03 |
| <i>Farm in total LFA</i> | 0.05** | 0.02 | -0.02 | 0.02 | -0.04** | 0.02 | -0.04* | 0.02 | -0.03 | 0.02 | -0.01 | 0.02 |
| <i>Region NE</i> | 0.23*** | 0.02 | 0.16*** | 0.02 | 0.14*** | 0.02 | 0.07*** | 0.02 | 0.08*** | 0.02 | 0.22*** | 0.02 |
| <i>Region Central</i> | 0.06*** | 0.02 | 0.04* | 0.02 | 0.03 | 0.02 | 0.06*** | 0.02 | 0.06*** | 0.02 | 0.10*** | 0.03 |
| <i>Region South</i> | -0.06** | 0.02 | -0.12*** | 0.03 | 0.05*** | 0.02 | 0.03* | 0.02 | 0.04* | 0.02 | 0.10*** | 0.03 |
| <i>Region Islands</i> | 0.06 | 0.04 | -0.16*** | 0.06 | -0.02 | 0.04 | -0.02 | 0.05 | 0.00 | 0.04 | -0.02 | 0.05 |
| <i>Constant</i> | 0.76*** | 0.05 | 0.70*** | 0.07 | 0.81*** | 0.05 | 0.87*** | 0.06 | 0.85*** | 0.06 | 0.86*** | 0.09 |
| <i>N</i> | 1002 | | 741 | | 953 | | 897 | | 899 | | 657 | |
| <i>Log Likelihood</i> | 348 | | 253 | | 388 | | 380 | | 362 | | 292 | |

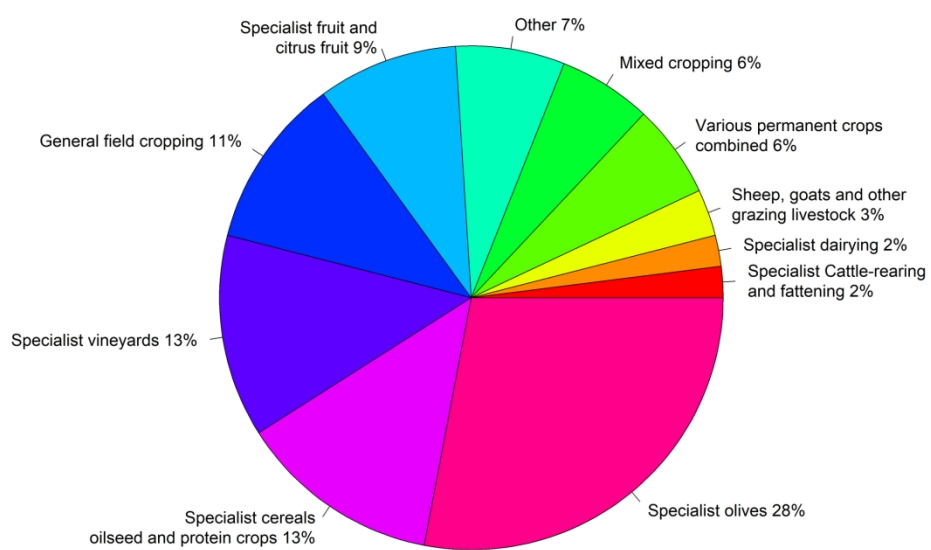
Significance codes: '***' 0.01 '**' 0.05 '*' 0.1

Table 9: Exploring the relationship between technical efficiency of Italian arable farms with the lagged long term DAR, the contemporaneous short term DAR and other farm and farm management characteristics

| | 2009 | | 2010 | | 2011 | | 2012 | | 2013 | | 2014 | |
|---------------------------------------|-------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|
| | Coef | S.E. | Coef | S.E. | Coef | S.E. | Coef | S.E. | Coef | S.E. | Coef | S.E. |
| <i>Lagged Long term DAR</i> | -0.08 | 0.14 | -0.07 | 0.20 | 0.26 | 0.35 | -0.27 | 0.37 | -0.23 | 0.23 | 0.08 | 0.28 |
| <i>Contemporaneous Short term DAR</i> | -0.08 | 0.07 | -0.19** | 0.08 | 0.14 | 0.09 | -0.06 | 0.10 | 0.04 | 0.07 | -0.13 | 0.09 |
| <i>Share tangible assets</i> | -0.25*** | 0.03 | -0.15*** | 0.04 | -0.13*** | 0.03 | -0.15*** | 0.03 | -0.13*** | 0.03 | -0.20*** | 0.03 |
| <i>Share farm labour</i> | -0.13*** | 0.04 | -0.05 | 0.05 | -0.16*** | 0.04 | -0.13*** | 0.04 | -0.12*** | 0.05 | -0.13** | 0.05 |
| <i>Education in years</i> | 0.03*** | 0.01 | 0.03* | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.00 | 0.01 | 0.00 | 0.02 |
| <i>Share rented land</i> | -0.04* | 0.02 | -0.06*** | 0.02 | -0.01 | 0.02 | -0.05** | 0.02 | -0.04* | 0.02 | -0.05** | 0.02 |
| <i>Young</i> | -0.02 | 0.02 | 0.01 | 0.02 | -0.01 | 0.02 | -0.01 | 0.02 | 0.00 | 0.03 | 0.05* | 0.03 |
| <i>Elder</i> | -0.02 | 0.01 | 0.00 | 0.02 | 0.02* | 0.01 | -0.01 | 0.01 | -0.06*** | 0.01 | -0.02 | 0.02 |
| <i>Female</i> | -0.06*** | 0.02 | -0.05*** | 0.02 | -0.02 | 0.02 | -0.03** | 0.02 | -0.04** | 0.02 | -0.02 | 0.02 |
| <i>Share rented land</i> | -0.04* | 0.02 | -0.06*** | 0.02 | -0.01 | 0.02 | -0.05** | 0.02 | -0.04* | 0.02 | -0.05** | 0.02 |
| <i>Farm in total LFA</i> | 0.05** | 0.02 | -0.03 | 0.02 | -0.04** | 0.02 | -0.04** | 0.02 | -0.03* | 0.02 | -0.01 | 0.02 |
| <i>Region NE</i> | 0.23*** | 0.02 | 0.15*** | 0.02 | 0.15*** | 0.02 | 0.06*** | 0.02 | 0.08*** | 0.02 | 0.22*** | 0.02 |
| <i>Region Central</i> | 0.06*** | 0.02 | 0.05* | 0.02 | 0.03 | 0.02 | 0.06*** | 0.02 | 0.06*** | 0.02 | 0.10*** | 0.03 |
| <i>Region South</i> | -0.06** | 0.02 | -0.12*** | 0.03 | 0.06*** | 0.02 | 0.03 | 0.02 | 0.04* | 0.02 | 0.10*** | 0.03 |
| <i>Region Islands</i> | 0.06* | 0.04 | -0.16*** | 0.05 | -0.03 | 0.04 | -0.02 | 0.05 | 0.00 | 0.05 | -0.02 | 0.05 |
| <i>Constant</i> | 0.75*** | 0.05 | 0.69*** | 0.07 | 0.81*** | 0.06 | 0.87*** | 0.06 | 0.85*** | 0.06 | 0.86*** | 0.08 |
| <i>N</i> | 1002 | | 741 | | 953 | | 897 | | 899 | | 657 | |
| <i>Log Likelihood</i> | 348 | | 255 | | 389 | | 381 | | 362 | | 292 | |

Significance codes: '***' 0.01 '**' 0.05 '*' 0.1

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Number of holdings by main type of farming in Italy (2010 data)

381x254mm (150 x 150 DPI)