Profit-sharing, technical efficiency change and finance constraints

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Abstract

This paper analyses the mechanisms through which profit-sharing schemes may induce debt constrained firms to improve technical efficiency over time to guarantee positive profits. This hypothesis is first formalised in a partial equilibrium framework and then is tested on a sample of Italian traditional and cooperative firms. Technical efficiency change indexes are computed by DEA. These are regressed on a measure of finance constraints to analyse their impact on firms' efficiency growth. The results support the hypothesis that a restriction in the availability of financial resources can affect positively the growth in efficiency in firms with profit-sharing schemes.

Keywords: technical efficiency, finance constraints, profit-sharing.
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1 Introduction

Profit-sharing is increasingly becoming an important contractual arrangement to improve workers' commitment to their employer and at the same time to enhance a firm's productivity (Uvalic, 1991; Weitzman, 1995; Cahuc and Dormont, 1997; Perotin and Robinson, 1998). Profit-sharing is particularly important in firms where productivity depends largely on workers' capabilities and skills (often specific to the firm where they are employed) and on their willingness to undertake an investment in this firm-specific human capital[1]. Indeed, it is well-known in the economic literature that in these cases, workers may have the incentive to under-invest because they are afraid of being expropriated ex post by their employers (so-called hold-up problem) (Hart, 1995). In this case, profit-sharing may solve the hold-up problem: indeed, by allowing employees to benefit from the economic success of the firm, profit-sharing may reduce the threat of ex post expropriation and induce the employees to undertake the optimal amount of firm-specific investment necessary to enhance a firm's productivity.

In this paper we suggest that profit-sharing may also have an additional advantage, that of providing the firm with a buffer against adverse financial shocks, following for instance a credit crunch. A substantial body of literature has suggested that informational asymmetries between firms and lenders may limit the amount of external funds to which a firm can have access (Stiglitz and Weiss, 1981). Finance constraints may make a firm sensitive to adverse macroeconomic shocks with a negative impact on investment and production[2]. In this case, to keep the same level of efficiency and productivity, a firm has to re-adjust the mix of inputs, typically by cutting employment. However, if a profit-sharing scheme is on place, the re-adjustment of the inputs' mix does not imply shedding workforce. Indeed, as workers receive a share of the firm's surplus, they can decide to increase their contribution to the firm's production and so counterbalance the impact of the negative financial shock.

These considerations set the agenda for this paper. Its purpose is to test empirically the hypothesis that finance constraints create an incentive for debt-constrained firms with a profit-sharing scheme to improve efficiency along time, using a sample of Italian traditional and cooperative firms. The work is divided into two parts. We first consider the relationship between borrowing constraints, profit sharing and efficiency change and suggest a channel through which finance pressure can affect incentives within a firm to improve efficiency. In the second part of the paper, we test empirically this prediction for a panel of traditional and cooperative Italian firms, specialised in the production of wine, over the time 1996-2001. The data have been extracted from the database AIDA. We adopt

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[1] See Blair (1995, 1999) on this point. Robinson et al. (2002) provide empirical evidence for a sample of UK firms showing that the likelihood of employee ownership is higher in firms where it is higher the incidence of firm-specific human capital.

[2] An extensive survey on these issues is provided in Gertler and Gilchrist (1993). Among others, see Fazzari, Hubbard and Petersen (1988) for an analysis of the relationship between the within-firm variations in physical investment and internal finance in a panel of U.S. manufacturing firms. Hoshy, Kashyap and Petersen (1991) and Devereux and Schiantarelli (1989) offer the same kind of evidence for Japanese firms and British firms, respectively.

a two-stage approach (Fried et al., 1993). First, technical efficiency growth is measured by computing a production frontier for the whole sector and measuring the distance of each firm from the frontier (Farrell, 1957). The production frontier is computed by using linear programming or Data Envelopment Analysis (DEA). Then efficiency change is regressed on some measures of finance constraints, after controlling for factors contributing to the firms' heterogeneity.

The structure of the paper is the following. Section 2 models the relationship between credit constraints, technical efficiency change and profit-sharing. The empirical model and the results are presented in Section 3. Finally some concluding remarks are offered in Section 4.

2 The General Framework

In this model, we aim at showing that firms with a profit-sharing scheme may experience an improvement in technical efficiency over time once they are hit by a negative shock to their financial resources. In itself, this may not seem a very intuitive result. Indeed, basic economic theory tells us that an inefficient firm that is exposed to a negative shock would, in general, not be able to improve its efficiency relative to other firms in the same industry which are not being exposed to the same distortion. However, this argument is based on first-best reasoning where the firm is only exposed to one distortion. In many cases, firms face multiple distortions and these may interact in such a way that it, in fact, becomes possible and profitable for a firm who is being exposed to an additional distortion, say a tightening of its access to credit, to reduce the slack in relation to some other distortion and thereby, as a net result, improve technical efficiency. The model developed below provides an example of how this might work. We imagine that firms located in a particular industry are exposed to two distortions: a) they have limited access to the credit market implying that they do not have sufficient financial resources to rent the optimal amount of physical capital and b) there exists an hold-up problem as the worker of the firm has to make costly investments in effort for which she can only hope to recoup a fraction of the return and therefore she will prefer to under-invest. The firms in the industry are exposed to different credit constraints and some are more efficiently organized than others. The model shows that a tightening of the credit constraint in a particular firm which is not currently on the frontier can help the firm to catch up with the more efficient ones because the worker is induced to invest more effort; that is, we should expect to see technical efficiency increasing over time following a tightening of credit constraints.

The framework we consider is quite simple. Consider an industry with $i = 1, .., N$ firms. There are $i = 1, .., N$ identical workers each working in the firm i. The allocation of each worker to each firm is made before the size of the net profits for the worker is decided. Once this is decided, we assume that the worker cannot leave the firm. Each period the firm uses the following (convex) production technology:

$$y_{i,t} = F(e_{i,t-1}, k_{i,t})$$

Output is being produced by two inputs and is being sold at an exogenously fixed price, normalized to 1. First, $k_{i,t}$ is the amount of physical capital equipment rented from a competitive market at the price of 1. In our setting, capital does not depreciate, so the stock of capital a firm can use does not change from one period to the other. We assume the firm does not make investment in physical capital and rents new capital every period. The expenditure has to be paid up front and thus has to be financed through credit. We assume that the firm is credit rationed. Finance constraints arise from the fact that the bank cannot observe what happens in the firm and in particular cannot observe the worker's effort; therefore it may never know whether low output is due to external negative shocks or low effort. In this case, the bank will find optimal to restrict the financial resources available to the firm. Therefore the maximum amount of capital available for firm i in period t is $\overline{k}_{i,t}$ and this constraint is always binding. The debt is paid back in full at the end of each period and, without loss of generality, we assume that the rental rate is r. Second, the worker in the firm provides a firm-specific input (e) which we can think of as related to the effort of learning new techniques which are specific to the firm and that therefore outside the firm they are of no use. We assume that in every time period new techniques are to be learnt by the worker. However, the decision on how much effort to invest in period t is made in period $t-1$ where the planning is done.

To simplify the analysis we study a simple linear approximation to the production function F:

$$y_{i,t} = ae_{i,t-1} - \frac{1}{2}e^2_{i,t-1} + bk_{i,t} + \gamma k_{i,t}e_{i,t-1} \tag{1}$$

where $a > 0$, $b > 0$; γ can be either positive or negative and indicates whether marginal product of effort vested in organization is more or less productive in a firm with access to more capital equipment. We assume that the b in the production function is sufficiently large to ensure that the firm will actually borrow money up to the limit $(b + \gamma e_{i,t-1} > 1 + r)$. We exclude the possibility of technical change from one period to the next. This assumption allows us to concentrate on technical efficiency growth only and to exclude issues related to shifts of the production function due to technical progress.

The worker decides each period on how much effort to devote for the next period. Once the decision has been made, it cannot be undone immediately. The worker makes the decision in anticipation of how much capital can be rented in the future which in turn is determined by the credit constraint. We assume that the worker in firm i is rewarded by a share s_i of the net profit $y_{i,t} - (1+r)k_{i,t}$. The per period utility function[3] of the worker is defined as:

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[3] We implicitly assume that the worker's reservation utility is zero.

$$u_{i,t} = c_{i,t} - \frac{1}{2}e_t^2$$

with $c_{i,t}$ being the consumption of the worker employed in the firm i at time t. Her budget constraint is $c_{i,t} = s_i(y_{i,t} - (1+r)k_{i,t})$. Life-time utility is then:

$$U_i = \sum_{t=0}^{T} \delta^t \left(s_i(y_{i,t} - (1+r)k_{i,t}) - \frac{1}{2}e_t^2 \right) \tag{2}$$

where δ is the discount rate and $e_{-1} = 0$.

2.1 Analysis of firm i

This concludes the description of the model. To simplify the analysis but without any loss of generality, we shall consider a three period version of the model with period $t = 0, 1, 2$. The time line of the model is as follows. At time 0, the firm is set up and the worker of the firm is hired. At time 1, the worker decides on e. At time 2, capital is hired and so production can take place. It is then sold and the surplus shared between workers and the firm's owners. The worker can consume at this time period. Because of the lag between the moment the firms organises the production and the time the worker decides on effort, it is impossible to write complete contracts and therefore a standard hold-up problem (Hart, 1995) arises: indeed the worker may prefer to maximise her own expected pay-off from the relationship with the firm, instead of the overall surplus (that is, both the worker's and firm's surplus). Therefore, the effort is optimal from the worker's standpoint, but not for the firm. For this reason, the firm's actual output will differ from the output she could potentially produce if there was no hold-up problem and so the firm will appear technically inefficient. Notice that in the whole process the two parties have symmetric information and there is no uncertainty about the parties' costs and utility functions. The only source of uncertainty is about the size of the worker's effort. Figure 1 shows the time line of the model.

Insert Figure 1 here

We analyze the model by backwards induction and assume perfect foresight. This means that we solve the model starting from period 2 till period 0. Finally, we derive the measure of technical efficiency and measure how it varies when there is an aggregate shock to the amount of financial resources the firm has access to. In period 2, the worker is not going to invest any effort as there is no future and production takes place:

$$y_{2,i} = ae_{1,i} - \frac{1}{2}e_{i,1}^2 + b\overline{k}_{2,i} + \gamma\overline{k}_{2,i}e_{1,i}$$

and the worker's profit-sharing bonus is:

$$s_i(y_{2,i} - (1+r)\overline{k}_{2,i})$$

In period 1, the worker faces the problem:

$$e^*_{1,i} = \arg\max \delta s_i(y_{2,i} - (1+r)\overline{k}_{2,i}) - \frac{1}{2}e^2_{i,1}.$$

The first order condition is:

$$\delta s_i(a - e_{1,i} + \gamma\overline{k}_{2,i}) - e_{1,i} = 0$$

and her optimal effort choice is[4]:

$$e^*_{1,i} = \frac{\delta s_i(a + \gamma\overline{k}_{2,i})}{1 + \delta s_i}.$$

We can denote the worker's maximised payoff by $V^* = -\frac{1}{2}e_1^{*2} + \delta y^*_{2,i}$. In period 0, the worker faces a similar problem:

$$e^*_{0,i} = \arg\max \delta s_i(y_{1,i} - \overline{k}_{1,i}) - \frac{1}{2}e^2_{i,0} + \delta V^*$$

and she chooses similarly. Thus:

Proposition 1 *(Effort). Assume that $a > -\gamma\overline{k}_{i,t+1}$. The worker chooses effort*

$$e^*_{t,i} = \frac{\delta s_i(a + \gamma\overline{k}_{i,t+1})}{1 + \delta s_i} \text{ for } t = 0, 1.$$

where effort is increasing in s_i. Moreover,

$$\frac{\partial e^*_{t,i}}{\partial \overline{k}_{i,t+1}} < 0$$

if $\gamma < 0$ and positive otherwise.

The interpretation is straightforward. The worker makes his effort decision based on her expectations about the availability of credit in the future. If she anticipates that more credit is going to be available in the future and thus more rented capital equipment is going to be available she may or may not decide to spend more effort. In particular, she spends less effort if its marginal productivity is lower in an environment with more capital equipment available ($\gamma < 0$).

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[4] The SOC is satisfied.

2.2 Technical efficiency

The industry is populated with firms with different input characteristics $\{e_i, k_i\}$ and therefore technical efficiency would be higher in some firms than in others. We denote by $\widehat{y}_t$ the output produced in period t by the best practice technique firm, supported by a combination of high s_i and lax external credit constraints (high $\overline{k}$). We can measure technical efficiency in firm i in period t as the ratio between the actual level of output, produced at time t by the firm i, and the potential industry output, which could be produced at time t (Farrell, 1957), or:

$$TE_{i,t} = \frac{y_{i,t}^*}{\widehat{y}_t}$$

where $y_{i,t}^* = ae_{i,t-1}^* - \frac{1}{2}\left(e_{i,t-1}^*\right)^2 + b\overline{k}_{i,t} + \gamma\overline{k}_{i,t}e_{i,t-1}^*$ for $t = 1, 2$, that is, the output produced when the hold-up problem is present. The potential output, on the contrary, is the level of output the firm could produce without the hold-up problem.

Our main interest is to find out how technical efficiency in periods 1 and 2 in firm i is affected by a permanent, but unexpected change in the credit constraint in period 1. The fact that it is unexpected implies that it could not be taken into account when effort was decided in period 0. The fact that it is permanent implies that worker will wish to adjust the effort choice made in period 1, once she has observed the change in period 1. To simplify the analysis, we assume that $\overline{k}_{1,i} = \overline{k}_{2,i} = \overline{k}_i$ initially. It is also important to note that the change to financial availability of resources is specific to firm i, that is, the shock is firm-specific. Therefore, we can take the industry potential output as given.

Consider first what happens to technical efficiency in period 1. Since the effort has already been decided in period 0 based on expected credit conditions $(\overline{k}_i)$, we get:

$$\begin{aligned} \frac{\partial TE_{i,1}}{\partial \overline{k}_i} &= \frac{b + \gamma e_{i,0}^*}{\widehat{y}_1} \\ &= \frac{1}{\widehat{y}_1}\left(b + \gamma\frac{\delta s_i(a + \gamma\overline{k}_i)}{1 + \delta s_i}\right) < 0. \end{aligned}$$

Next, consider period 2. After the change has been observed in period 1, it is incorporated in the expectations and the worker adjusts her effort choice to accommodate the new environment in period 2. The change in technical efficiency is period 2 is therefore given by:

$$\frac{\partial TE_{i,2}}{\partial \overline{k}_i} = \frac{1}{\widehat{y}_1}\left(\left[a - e_{i,1}^* + \gamma\overline{k}_i\right]\frac{\partial e_{i,1}^*}{\partial \overline{k}_i} + b + \gamma e_{i,1}^*\right).$$

Using the FOC from the worker's effort decision problem we get:

$$\begin{aligned}
\frac{\partial TE_{i,2}}{\partial \overline{k}_i} &= \frac{1}{\widehat{y}_1}\left(\left[\frac{e^*_{i,1}}{\delta s_i}\right]\frac{\partial e^*_{i,1}}{\partial \overline{k}_i} + b + \gamma e^*_{i,1}\right) \\
&= \frac{1}{\widehat{y}_1}\left(e^*_{i,1}\left[\frac{1}{\delta s_i}\frac{\partial e^*_{i,1}}{\partial \overline{k}_i} + \gamma\right] + b\right) \\
&= \frac{1}{\widehat{y}_1}\left(\gamma(a+\gamma\overline{k}_i)\left[\frac{\delta s_i(2+\delta s_i)}{(1+\delta s_i)^2}\right] + b\right)
\end{aligned}$$

by substitution of the optimal effort decision at time 1. It is clear that when the credit constraint is relaxed, technical efficiency increases in both period if $\gamma \geq 0$. The next proposition shows that this need not be the case when $\gamma < 0$.

Proposition 2 *(Technical efficiency). Assume that* $a^2 > \frac{4\overline{k}_i(1+\delta s_i)b}{\delta s_i}$ *and assume that* $\gamma < 0$*. Suppose that there is an unexpected permanent relaxation of the credit constraint in period* 1*. There exist four critical values* $0 > \overline{\gamma}_2 > \overline{\gamma}_1 > \underline{\gamma}_1 > \underline{\gamma}_2 > -\frac{a}{\overline{k}_i}$ *such that*

1. Technical efficiency in period 1 is decreasing when the credit constraint is relaxed for $\gamma \in (\underline{\gamma}_1, \overline{\gamma}_1)$ and non-decreasing otherwise.
2. Technical efficiency in period 2 is decreasing when the credit constraint is relaxed for $\gamma \in (\underline{\gamma}_2, \overline{\gamma}_2)$ and non-decreasing otherwise.

Proof. The statements follow from the two derivatives given above. First, consider technical efficiency in period 1. It is decreasing in $\overline{k}_i$ if and only if:

$$q_1(\gamma) \equiv -\gamma^2\overline{k}_i - \gamma a - h_1 > 0$$

where $h_1 = \frac{(1+\delta s_i)b}{\delta s_i}$. Note that $q_1(0) = q_1(-\frac{a}{\overline{k}_i}) < 0$ and that the quadratic equation has two real roots in the interval $[\frac{-a}{\overline{k}_i}, 0]$ if $a^2 > 4\overline{k}_i h_1$ and zero otherwise. Let the two roots be $\underline{\gamma}_1$ and $\overline{\gamma}_1$ and part 1 of the proposition follows immediately. Second, consider technical efficiency in period 2. It is decreasing in $\overline{k}_i$ if and only if:

$$q_2(\gamma) \equiv -\gamma^2\overline{k}_i - \gamma a - h_2 > 0$$

where $h_2 = \frac{(1+\delta s_i)^2 b}{\delta s_i(2+\delta s_i)}$. Note that $q_2(0) = q_2(-\frac{a}{\overline{k}_i}) < 0$ and that the quadratic equation has two real roots in the interval $[\frac{-a}{\overline{k}_i}, 0]$ if $a^2 > 4\overline{k}_i h_2$ and zero otherwise. Let the two roots be $\underline{\gamma}_2$ and $\overline{\gamma}_2$ and part 2 of the proposition follows. Notice that $h_1 > h_2$. This implies that $0 > \overline{\gamma}_2 > \overline{\gamma}_1 > \underline{\gamma}_1 > \underline{\gamma}_2 > -\frac{a}{\overline{k}_i}$ and that $a^2 > \frac{4\overline{k}_i(1+\delta s_i)b}{\delta s_i}$ is sufficient for existence ■

We see that technical efficiency may fall as a consequence of access to more credit and that if it does so in period 1 then it necessarily falls in period 2. To understand this result, it is useful to note that a change in the credit constraint can affect the firm's output through three channels. First, the direct effect is obvious: if more credit becomes available in a given period, more capital can be rented and more can be produced. The second effect is an interaction effect and its direction depends on the sign of γ. If $\gamma < 0$, more credit would reduce output through this channel because it crowds out the productive value of effort; if $\gamma > 0$, more credit would enhance the productive value of effort. The third effect works through a change in effort in anticipation of changing credit conditions in the future. Thus, this effect cannot affect technical efficiency in period 1, but will have an impact on efficiency in period 2. Again the effect depends critically on the sign of γ. For $\gamma < 0$, the worker would want to spend less effort because the extra rented capital makes such effort less productive at the margin. As a consequence, output would fall in period 2. The opposite happens, of course, if $\gamma > 0$. The overall impact on output is then determined by the interaction between these effects.

For values of γ $[\gamma \in [\overline{\gamma}_2, 0]]$, technical efficiency increases in both periods because the interaction effect and the effort effect are small. For values of γ $[\gamma \in [\overline{\gamma}_1, \overline{\gamma}_2]]$, the effort effect is sufficiently large to ensure that technical efficiency in period 2 falls, while technical efficiency in period 1 increases for this same interval of γ because the interaction effect is not strong enough to dominate the direct effect. For γ yet lower, technical efficiency in both period falls as the interaction effect is now sufficient to overcome the direct effect. Interestingly, for γ very low $[\gamma \in [\frac{-a}{\overline{k}_i}, \underline{\gamma}_2]]$ technical efficiency increases in both periods. The reason is that effort is very low and the interaction effect is dampened for that reason. Thus, there is a non-monotonic relationship between γ and the impact of credit constraints on technical efficiency. The most realistic case is the one with $\gamma > \overline{\gamma}_1$. This is the case where the interaction effect in itself is not sufficient to overcome the direct effect (and thus technical efficiency in period 1 is enhanced by the availability of more credit) while the combination of the effort effect and the interaction effect is sufficient to reduce technical efficiency in period 2. In sum, the story is: a restriction in the available credit reduces output immediately, but the worker in anticipation of the lack of machinery in the next period puts more effort. This compensates for the lack of capital and in some cases may more than compensate. If so, technical efficiency improves in the next period.

Consider now the change in technical efficiency:

$$CTE_i = \frac{TE_2}{TE_1} = \frac{y^*_{2,i}}{y^*_{1,i}}.$$

Notice that before the unanticipated change $CTE_i = 1$. The change in TE is affected by the change in credit constraints as follows:

$$\frac{\partial CTE_i}{\partial \overline{k}_i} = \frac{-y_{2,i}^* \frac{\partial y_{1,i}^*}{\partial \overline{k}_i} + y_{1,i}^* \frac{\partial y_{2,i}^*}{\partial \overline{k}_i}}{\left(y_{1,i}^*\right)^2}.$$

Using the fact that $CTE_i = 1$, we can simplify as follows:

$$\begin{aligned} \frac{\partial CTE_i}{\partial \overline{k}_i} &= \frac{\frac{-\partial y_{1,i}^*}{\partial \overline{k}_i} + \frac{\partial y_{2,i}^*}{\partial \overline{k}_i}}{y_{1,i}^*} \\ &= \frac{1}{y_{1,i}^*}\left[\frac{s_i \delta}{(1+\delta s_i)}\right]\gamma(a+\gamma \overline{k}_i) \end{aligned}$$

Proposition 3 *(Change in Technical efficiency). Suppose that there is an unexpected permanent relaxation of the credit constraint in period* 1*. The change in technical efficiency between period* 1 *and* 2 *is negative if* $\gamma < 0$ *and positive otherwise.*

This implies that for all values of $\gamma < 0$, a tightening of the credit constraint will generate growth in technical efficiency. The intuition is that the impact of technical efficiency in the future is stronger than on contemporaneous technical efficiency because of the effort effect. Importantly, this result does not require a large negative γ to hold.

3 The empirical analysis: data and descriptive statistics

The key prediction from the model is that technical efficiency can increase over time as finance constraints get tighter in firms where there is a profit-sharing scheme. This theoretical prediction has been tested using an unbalanced panel of Italian traditional and cooperative firms from 1996 to 2001. The empirical analysis is divided into two parts: first, we derive the technical efficiency indexes by using Data Envelopment Analysis (DEA); then we regress these indexes on measures of finance constraints to analyse their impact on the technical efficiency growth for each sector.

The data-set we use has been extracted from AIDA[5], a database collecting Italian companies' annual reports as filed at the official registrars (local Chambers of Commerce). In addition to the information contained in the annual reports, the database reports information on location, the legal status and additional financial data. We have decided to focus on the firms belonging to the same sector, i.e. production and processing of wine[6] because the empirical

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[5] More information on this database can be found at http://www.bvdep.com/browse5.asp.

[6] This corresponds to the code A01131 of the Ateco 91 classification as provided by ISTAT (Italian Statistical Office).

analysis of efficiency requires that firms under consideration must be homogenous in that they use the same type of technology. The wine industry has been selected for several reasons: first its output mix is limited compared to other sectors, and therefore the firms in the industry should be more homogenous in terms of technology. In addition, it is the sector where cooperatives have the highest market share[7]. Finally, firms operating in the production and processing of wine require workers to have some firm-specific skills, consistently with what is described in the theoretical model[8]. Our data set is so composed by 158 firms observed over the period 1996-2001 corresponding so to 717 observations[9]. According to their legal status, 85 firms (corresponding to 413 observations over the whole time period) are cooperatives, while 73 firms (corresponding to 304 observations) are not.

In our production set, output[10] is measured by the company's sales plus the change in inventories deflated with the appropriate production index (ISTAT, 2002). Among the inputs, we include the intermediate consumption, the capital and the labour. Intermediate consumption is defined as the sum of materials and services while capital is the sum (at book value) of land, buildings, machinery and other fixed assets. Both variables have been deflated by the price index of material consumption and of investment goods for the beverage industry, respectively (ISTAT, 2002). All these variables (both of output and inputs) are expressed in 1995 million Italian liras. Labour is the number of employees at the end of the fiscal year. As for the proxies of finance constraints, a commonly used measure is the debt-to assets ratio (DAR) (Whited, 1992 and Ng and Schaller, 1996). This is the ratio between the firm's debt and the market value of its assets. So it could be interpreted as a measure of the firm's current demand for borrowing relative to its debt capacity. Indeed the higher the debt to asset ratio, the less external resources are available to the firm as its default's risk is too high and therefore less capital will be available to the firm.

Table 1 reports the sample statistics for the output, inputs and DAR for traditional firms and for cooperative firms, respectively. By giving a cursory look at the descriptive statistics, it is immediately noticeable that, on average, cooperatives produce more than traditional firms, use less capital and labour but use more intermediate consumption than traditional firms for each year under consideration. For traditional firms, output shows some marked jumps over time along with labour, while capital is consistently decreasing over the whole time period. Cooperatives' statistics show some yearly variability as well,

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[7] It was 55% in 1996 (van Bekkum and van Dijk, 1998).

[8] Human capital in agriculture is obvioulsy highly location-specific and so firm-specific, because land and weather conditions are different from place to place and this influences worker productivity (Pagano, 1992). Clearly the same is true for the production of wine.

[9] The panel is not balanced. Indeed, not all the firms are included in the database as, to be included, a company should ensure that operating revenue is equal to a minimum of 1 million euros.

[10] The data set gives no information on the firm's output mix: firms could be specialized in either high-end or low-end of the market or both types of products. However, generally cooperatives produce less higher quality wine than traditional firms (ISMEA, 2002).

even if not so dramatic as in the case of traditional firms[11]. DAR is decreasing over time for the cooperatives, but for traditional firms it has been increasing from 1996 to 1999 and then decreasing afterwards.

3.1 Measuring technical efficiency growth

To measure technical efficiency growth, we use Data Envelopment Analysis (DEA). DEA does not require an explicit functional form and constructs the production frontier (with respect to which a firm's efficiency is measured) from the observed input-output ratios by linear programming techniques. In our case, the distinctive advantage of the non-parametric approach is that, by not requiring a specific functional form for the production process, it allows to accommodate different functional relationships consistently with the theoretical model. In our specification, we have applied an output-oriented Data Envelopment Analysis with variable returns to scale (Banker et al., 1984) to each cross-section of firms and repeated for each year in our sample. DEA is done jointly in each year for cooperatives and for traditional firms, as firms with different types of ownership are still homogeneous in terms of technology as it is customarily assumed in the literature (see for example, Ferrier and Valdmanis, 1996).

The yearly average level of the output-oriented measures of technical efficiency for each group of firms is reported in Table 2. In addition, we report the average efficiency scores for the firms located in the two main areas of the country and the average efficiency scores for all the firms in the sample, along with its standard deviation, maximum, minimum and average values of efficiency for each quartile. The average level of technical efficiency is quite high with marked annual differences. Cooperatives' efficiency decreases in 1997 and 2000; traditional firms experience a decrease in productivity in 1997, 1999 and 2000. There is some slight difference in technical efficiency between firms located in the North-Centre and the South of Italy, but it is not very dramatic.

3.2 Technical efficiency change and finance constraints: the second stage

The results from the previous section show that firms experience different growth in technical efficiency according to their legal status. In this section, we analyse whether finance constraints are responsible for these movements. To this purpose, we regress the technical efficiency change indexes on DAR, after controlling for eventual environmental variables affecting the change in technical efficiency. We expect the coefficients of this variable to be positive and significant for the cooperatives, implying so that a restriction of financial resources affects positively a firm's technical efficiency change.

Among the environmental factors, we control for the firm's location. It is a well-established piece of evidence in the Italian literature that location

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[11] In a balanced panel data (composed by 35 cooperatives and 18 traditional firms) the picture is different since for traditional firms, output is increasing while capital is constant; for cooperatives output is almost constant and capital is increasing.

matters for firms' productivity. Indeed firms, located in different areas of the country, tend to show lower levels of productivity and efficiency. This is to be probably ascribed to the operation of local factors such as different infrastructure endowment, external economies linked to the local technological potential or level of industrialisation, the presence of organised crime, and so on. In our study we do not attempt to measure the impact of those factors separately. Rather, we control for them, using a dummy variable related to the geographic location of the firm; following common practice, we divide Italy in North-Centre and South. Among the regressors, we also introduce year dummies to control for yearly variability of phenomena such as the impact of weather on the vineyards and then wine quantity and quality (INEA, 2002). Finally, we control for dynamic adjustment processes by testing the significance of lagged values of technical efficiency and debt-to-asset ratio up to the second order.

Table 3 and 4 report the results of the second stage analysis, respectively for the cooperative and traditional firms. The regressions are done separately for cooperatives and for traditional firms in order to highlight the differences between these groups. Since the panel is not balanced, it was not possible to derive five indexes of technical efficiency change for all firms; however, the number of observations is still high for both regressions. Following common practice in these contexts, a log-linear functional form was adopted. As a test of serial correlation among the residuals, we have used the F-version of the Lagrange-multiplier test for first-order (or second-order) residual serial correlation in panel data (Baltagi, 2001). In any case, the t-ratios of the regression coefficients are always derived from variance-covariance matrices adjusted for heteroskedasticity and serial correlation through the Newey-West procedure. The fit of the regressions is more than acceptable for a second stage analysis: the adjusted R-squares are respectively 0.48 and 0.34 for cooperatives and traditional firms. The level of technical efficiency for the South is not statistically different from that of the North-Centre. This is not surprising in the light of the results from the first stage where there was not much difference between firms located in the two areas. For both cooperatives and traditional firms, first- and second-order lagged values of the level of technical efficiency enter significantly in the estimates, indicating the existence of a rather complex dynamic adjustment process. Yet, for traditional firms, significant serial correlation among the residuals is still detected by the LM statistic; first-order correlation is particularly important. For cooperatives, serial correlation is not significant. This result highlights the behavioural differences between cooperatives and traditional firms, and validates the choice of running separate regressions for the two groups. The yearly dummy variables are generally insignificant apart from the one related to 2000 and they have a negative sign. Finally, more interestingly from our standpoint, the natural log of the debt-to asset ratio of the previous year, log[DAR(-1)], influences positively the growth of technical efficiency for cooperatives. This does not happen in traditional firms, supporting the hypothesis that profit-sharing may be of help in counterbalancing a negative financial shock. The short-term impact of DAR on technical efficiency change is modest (0.06) but the long-term impact of DAR on the level of technical efficiency, as measured by the long-run elasticity, is higher (0.21). This long-run elasticity is significant for cooperatives, while it is small and not significant for traditional firms. A further remark on the significance of DAR is that apparently it does not stem from an inappropriate estimation procedure in the presence of endogeneity. Indeed, regressing DAR on DAR[-1] and lagged values of technical efficiency yields largely insignificant values for the coefficients on the technical efficiency terms[12]. The evidence then favours the characterisation of DAR as a long-run forcing variable with respect to TE implying that OLS is an appropriate estimator in the regressions from Tables 3 and 4. Finally, the analysis has been repeated after excluding the 10% of extreme observations with respect to the number of workers: 5% among the biggest and 5% among the smallest. The results are reinforced and they are not sensitive to the omission of these extreme observations[13].

4 Concluding remarks

In this paper, we have tested the hypothesis that profit-sharing can provide debt-constrained firms with a buffer against adverse macroeconomic shocks. In the last twenty years, there has been an increasing interest on the impact of asymmetric information in the credit market on firms' productive activities. Finance constraints may make a firm sensitive to adverse macroeconomic shocks with a negative impact on investment and production. In this case, profit-sharing schemes may help to counterbalance the effect of the negative financial shock. Indeed, by allowing employees to benefit from increasing firm's efficiency, profit-sharing may induce the employees to undertake the optimal amount of firm-specific investment necessary to enhance a firm's productivity.

To test this hypothesis, we have used a panel of traditional and cooperative firms from Italy specialised in the production of wine; the data-set covers the period 1996-2001. The empirical results show that cooperative firms experience positive technical efficiency change following a restriction of the available financial resources in the previous time period. In addition, this relationship does not hold for traditional firms where, on the contrary, technical efficiency may worsen after an increase in the previous time DAR. These results give support to the hypothesis that profit-sharing can help a firm to improve technical efficiency over time as it re-aligns the workers' interests with those of the firm.

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[12] These regression results are available on request.

[13] These regression results are available on request.

References

Baltagi B., (2001), Econometric Analysis of Panel Data (Second Edition), New York: Wiley.

Banker R. D., Charnes A., Cooper W. W., (1984), Some models for estimating technical and scale inefficiencies in Data Envelopment Analysis, Management Sciences, 30, 9, 1078-1092;

Blair M., (1995), Ownership and Control: Rethinking Corporate Governance for the Twentieth Century, Washington DC: Brookings Institute;

Blair M., (1999), Firm-Specific Human Capital and Theories of the Firm, in M. Blair and M. Roe (eds), Employees and Corporate Governance, Washington DC: Brookings Institute;

Cahuc P., Dormont B., (1997), Does profit-sharing increase productivity and employment? A theoretical model and empirical evidence on French micro data, Labour Economics, 4, 293-319, 1997;

Devereux M, .Schiantarelli F., (1989), Investment, Financial Factors and Cash-Flow: Evidence from UK Panel Data, NBER Working Paper, 3116;

Farrell M. J., (1957), The Measurement of Productive Efficiency, Journal of the Royal Statistical Society series A 120, 3, 253-290;

Fazzari S., Hubbard R. G., Petersen B. C., (1988), Financing Constraints and Corporate Investment, Brooking Papers on Economic Activity, 1, 141-195;

Ferrier G. D., Valdmanis V. (1996), Rural Hospital Performance and Its Correlates, Journal of Productivity Analysis, 7, 1, pp. 63-80;

Fried H. O., Lovell C. A. K., Schmidt S., eds. (1993), The measurement of productive efficiency: Techniques and applications, Oxford University Press, New York;

Gertler M., Gilchrist, S., (1993), The Role of Credit Market Imperfections in the Monetary Transmission Mechanism: Arguments and Evidence, Scandinavian Journal of Economics, 95, 1, 43-64;

Hart O., (1995), Firms, Contracts and Financial Structure, Clarendon Press, Oxford;

Hoshi, T.-Kashyap, A.-Scharfstein, D., (1992), Corporate Structure, Liquidity and Investment: Evidence from Japanese Industrial Groups, Quarterly Journal of Economics, 90, 33-61;

INEA, (2001), Annuario dell'agricoltura italiana, Napoli: Edizioni Scientifiche Italiane;

ISMEA, (2002), Filiera vino, Roma;

ISTAT, (2002), Numeri indici dei prezzi alla produzione e al consumo, Collana Informazioni, Nř 54, Roma;

Lombardi P., Mele M., (1993), Indagine sulla performance di un campione di cantine sociali che non effettua l'imbottigliamento attraverso diverse metodologie di analisi, in Pacciani A., Petriccione G. (eds.), La cooperazione agro-alimentare in Italia, Bologna: Il Mulino;

Ng, S.-Schaller, H., (1996), The Risky Spread, Investment and Monetary Policy Transmission: Evidence on The Role of Asymmetric Information, Review of Economics and Statistics, 375-383;

Pagano U., (1992), Organizational equilibria and production efficiency, Metroeconomica, 43, 1-2, 227-246;

Perotin, V. and Robinson, A., (1998), Profit-sharing and Productivity: Evidence from Britain, France, Germany and Italy, Advances in the Economic Analysis of Participatory and Labor-Managed Firms, 6, 135-160;

Robinson A., Wilson N., Zhang H., (2002), Employee Ownership and Firm-Specific Human Capital, paper presented at the 11th Conference of the International Association for the Economics of Participation (IAFEP), Bruxelles, 4-6 July 2002;

Stiglitz J., Weiss A., (1981), Credit Rationing in Markets with Imperfect Information, American Economic Review, 71, 3, 393-410;

Uvalic M., (1991), The Pepper Report: Promotion of Employee Participation in Profits and Enterprise Results in Member States of the European Community, Luxembourg;

Van Bekkum O., van Dijk G., (1998), Lo sviluppo delle cooperative agricole nell'Unione Europea, Ancona: Edizioni CLUA;

Whited T. M., (1992), Debt, Liquidity Constraints and Corporate Investment: Evidence from Panel Data, Journal of Finance, 47, 1425-1460;

Weitzman, M., (1995), Incentive Effects of Profit-Sharing and Employee Share Ownership: Theory and Evidence, Trends in Business Organisation, Kiel;