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Productivity, wages, and the returns to firm-provided training: who is grabbing the biggest share?

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Abstract
In spite of the importance of workplace training in human capital accumulation, relatively little is known on its returns for workers and firms. Our investigation tries to fill this gap by developing an alternative modelling that examines the determinants of firm productivity and wages, on the one hand, and the internal rate of return to firm training investments, on the other. Our estimates, obtained using a firm-level dataset in which we have detailed information on firm-provided training, indicate that an additional hour of training per worker implies some 0.1 percent increase in productivity. We also found that 2/3 of the gains in productivity are captured by firms and 1/3 by workers. In turn, the internal rate of return for an average firm in our sample is equal to 11 percent while for workers it is considerably higher at 24 percent. As expected, the dispersion across firms is very high, with 66 percent of firms having a positive internal rate of return for an annual depreciation rate of 35 percent.

Keywords: Firm-Provided Training, Internal Rate of Return, Human Capital, Productivity, Earnings.

JEL Codes: J24, J31, I2

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1. Introduction

The GDP growth in the last two decades in Portugal is both modest and mostly based on an intensive use of primary inputs, labor and capital. In other words, it seems that little has been done to increase the potential product growth, a key condition for economic sustainability in the near future.

A critical determinant of the growth of potential GDP is firm investment in human capital through formal training. However, and contrarily to the literature on the returns to schooling and labour market experience in general, comparatively little is known about the return rate to firm-provided training. In this investigation, we try to fill this gap by studying the determinants of firm productivity and wages, on the one hand, and by deriving an alternative measure of the internal rate of return for firms and workers, on the other.

Human capital theory was conceptually developed in the 1960s, and received a major empirical boost from Mincer's (1974) classical work. Studies on the impact of training are much more recent though. They have also been mostly focused on the wage gains of individual workers, which, in the Portuguese case, for example, have been estimated to be in the 10-20 percent range (Hartog, Pereira and Vieira, 2000, Budria and Pereira, 2004, and Saraiva, 2008).

But the gains from training are not exhausted by the returns for workers. A sizeable fraction of productivity gains is captured by firms in order to offset the corresponding costs (Bartel, 2000), which means that the impact of training on productivity is expected to exceed the growth in wages (Dearden, Reed and Reenen, 2006, and Ballot, Fakhfakh and Taymaz, 2006).

An even less documented aspect is the structure of training costs. Given the richness of our dataset, we are in a good position to disaggregate total costs into direct and indirect costs and hence estimate a better measure of the internal rate of return to training from the perspective of firms and workers. Thus, an additional contribution of the paper is to obtain a general formulation for the internal rate of return to training, namely one that not only uses the available data on training costs and worker and firm participation in training, but also the wage bill and other balance-sheet information, with these two pieces of data taken from *Balanço Social*, a comprehensive Portuguese statistical source described below.

We also develop a general model for the determination of the stock of training. Our approach allows us to circumvent some limitations found in the literature, namely those connected with the possibility of firms offering more training when the demand for output is low. Another novelty is related to the fact that in our implementation we control for firm and worker unobserved heterogeneity. This seems proper as unobserved heterogeneity of firms and workers is likely to be correlated with training participation.

Our modeling considers an augmented Cobb-Douglas production function, with the training variable treated as an additional input. Then, we derive the model for firm-level productivity and wages to finally obtain an analytical expression for the internal rate of return to training. This paper is therefore organized as follows. In the next section we present the modeling strategy to evaluate the relation between productivity (and wages) and firm-provided training. Then, we investigate the relationship between training costs and training intensity and present the framework required to compute the stock of training *and* the internal rate of return to training. Section 3 describes our longitudinal dataset and Section 4 presents the results. The main conclusions are drawn in Section 5.

2. Modelling

2.1 The impact of training on productivity and wages

Consider a Cobb-Douglas production function given by

$$Y_{jt} = AH_{jt}^{\alpha} K_{jt}^{\beta} F_{jt}^{\lambda} e^{\left(\eta Z_{jt} + u_{jt}\right)}, \tag{1.1}$$

where Y denotes the value added of firm j in period t, A is an efficiency parameter, H is hours of work, and K is the stock of capital. Z denotes the vector of firm characteristics, including the set of average characteristics of workers. F is the number of hours of training, here treated as an additional input as in Ballot, Fakhfakh and Taymaz (2006), for example.

By dividing equation (1.1) by *H*, we obtain *y*, that is, the hourly productivity of labour, y_{jt}, given by:

$$y_{jt} = AH_{jt}^{\alpha+\beta+\lambda-1}k_{jt}^{\beta} f_{jt}^{\lambda} e^{(\eta Z_{jt}+u_{jt})}, \quad (1.2)$$

where k denotes capital intensity and *f* the number of hours of training per hour of work.

In logarithms, equation (1.2) becomes:

$$Ln\ y_{jt} = Ln\ A + (\alpha + \beta + \lambda - 1) Ln\ H_{jt} + \beta Ln\ k_{jt} + \lambda Ln\ f_{jt} + \eta Z_{jt} + u_{jt}. \quad (1.3)$$

Following Hellerstein, Newmark and Troske (1999), Dearden, Reed and Reenen (2006) and Ballot, Fakhfakh and Taymaz (2006), we use a common set of regressors in the (log) real wage *and* productivity specifications. Thus, using equation (1.3), we have the (log) hourly average wage of workers in firm j in period t, $Ln\ s_{jt}$, given by:[1]

$$Ln\ s_{jt} = Ln\ A_s + (\alpha_s + \beta_s + \varphi - 1) Ln\ H_{jt} + \beta_s Ln\ k_{jt} + \varphi Ln\ f_{jt} + \eta_s Z_{jt} + \mu_{jt}. \quad (1.4)$$

Similarly to λ in model (1.3), φ in model (1.4) is expected to be positive, which means that the investment in training leads to higher productivity and wages. Whether λ is higher or lower than φ is another matter to which we shall come below.

2.2 Controlling for unobserved firm heterogeneity

The error term in equations (1.3) and (1.4) are not necessarily *i.i.d.* since they include the unobservable heterogeneity of firms and workers; and if there is correlation between observed and unobserved characteristics, the omission of relevant variables will certainly imply biased results in standard OLS regressions.

[1] We note that a similar specification can be derived using a standard DGP for individual (log) earnings. Thus, if individual (worker) earnings are a function of individual and firm characteristics, it follows that the average wage at firm *j* will depend on average worker characteristics, on the one hand, and firm characteristics, on the other.

We treat this limitation by admitting that the error term in equation (1.4) is composed by an *iid* error term, e_{jt}, plus the unobserved firm fixed effect, ψ_j, that is: $\mu_{jt} = \psi_j + e_{jt}$. Then, in matrix notation, (1.4) becomes:[2]

$$LS = X\theta + G\psi + e, \tag{2.1}$$

with G a $JT \times J$ matrix of dummies representing the set of firms (*J* is the number of firms in the sample) and

$$X\theta = \begin{bmatrix} 1 \ \ Ln\ H_{11} \ \ Ln\ k_{11} \ \ Ln\ f_{11} \ \ Z_{11} \\ 1 \ \ Ln\ H_{12} \ \ Ln\ k_{12} \ \ Ln\ f_{12} \ \ Z_{12} \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ 1 \ \ Ln\ H_{JN} \ \ Ln\ k_{JN} \ \ Ln\ f_{JN} \ \ Z_{JN} \end{bmatrix} * \begin{bmatrix} Ln\ A_s \\ \alpha_s + \beta_s + \varphi - 1 \\ \beta_s \\ \varphi \\ \eta_s \end{bmatrix}.$$

Multiplying (2.1) by M_G, with $M_G = I - P_G$ and $P_G = G(G^T G)^{-1} G^T$, we have:

$$M_G LS = M_G X\theta + M_G G\psi + M_G e. \tag{2.2}$$

By definition $M_G G\psi = 0$, which means we can obtain:

$$\hat{\theta} = \left(X^T M_G X\right)^{-1} \left(X^T M_G LS\right), \tag{2.3}$$

and (using 2.1):

$$\hat{\psi} = \left(G^T G\right)^{-1} G^T \left(LS - X\hat{\theta}\right), \tag{2.4}$$

or

$$\hat{\psi}_j = \left(G^T G\right)^{-1} G^T \left[Ln\ s_{jt} - \left(Ln\ \hat{A}_s + (\alpha_s + \hat{\beta}_s + \varphi - 1) Ln\ H_{jt} + \hat{\beta}_s\ Ln\ k_{jt} + \hat{\varphi}\, Ln\ f_{jt} + \hat{\eta}_s\ Z_{jt} \right) \right]. \tag{2.4'}$$

Adding $\hat{\psi}_j$ into (1.3), we finally have:

$$Ln\ y_{jt} = Ln\ A + (\alpha + \beta + \lambda - 1) Ln\ H_{jt} + \beta Ln\ k_{jt} + \lambda Ln\ f_{jt} + \eta Z_{jt} + \pi\hat{\psi}_j + u_{jt}, \tag{2.5}$$

[2] A full derivation of this model is provided in Lopes e Teixeira (2009). To be precise, $\hat{\psi}_j$ contains a firm specific effect plus an average (unobserved) worker effect.

while equation (1.4) becomes:

$$Ln\ s_{jt} - \hat{\psi}_j = Ln\ A_s + (\alpha_s + \beta_s + \varphi - 1)Ln\ H_{jt} + \beta_s Ln\ k_{jt} + \varphi Ln\ f_{jt} + \eta_s Z_{jt} + \mu_{jt}. \tag{2.6}$$

2.3 The stock of training

Let us consider the expression[3]

$$M_{jt} = F_{jt} + (1-\delta) M_{j,t-1}, \tag{3.1}$$

where the stock of training in firm *j* at the end of period *t*, M_{jt}, is given by the amount of training offered in *t*, F_{jt}, plus the stock of training at the end of period *t-1*, M_{jt-1}, adjusted by the depreciation rate, δ.

The introduction of δ is grounded on two reasons: a) the mobility of workers (worker separation generates a loss of firm-specific training); and b) human capital obsolescence. These two aspects are difficult to measure, and, in particular, although we have information on firm separation rates, we do not know who actually quits the firm (that is, whether leavers are training recipients or not). Our treatment is therefore *ad hoc*, and, accordingly, we assume different scenarios to evaluate how the results are sensitive to changes in δ.[4] To simplify, δ is also assumed constant across firms.

Using (3.1), we easily obtain:

$$M_{j,t} = F_{j,t} + (1-\delta) F_{j,t-1} + (1-\delta)^2 F_{j,t-2} + ... + (1-\delta)^l F_{j,t-l}, \tag{3.2}$$

where l denotes the number of years of accumulated training.[5]

In our dataset, we have longitudinal information on the percentage of training hours in total hours worked from 1995 to 1999. Further assuming that training before 1995 can be proxied by the 1995-1999 average, we have then, for *t=1999* (or *t=99*):

[3] For an identical approach see Boon and Eijken (1997) and Boon (2000).
[4] The benchmark depreciation rate is 35%: 20% due to worker separation and 15% to obsolescence (see Lillard and Tan (1986).
[5] Parameter *l* is proxied by firm age.

$$M_{j,99} = F_{j,99} + (1-\delta) F_{j,98} + ... + (1-\delta)^4 F_{j,95} + (1-\delta)^5 \left[\overline{F}_j + (1-\delta) \overline{F}_j ... + (1-\delta)^{l-5} \overline{F}_j \right], \qquad (3.3)$$

where $\overline{F}_j = \frac{1}{T} \sum_{t=1}^{T} F_{jt}$. T is the number of years in which the training variable is observed.

Further manipulation of (3.3) yields:

$$M_{j,99} = F_{j,99} + (1-\delta) F_{j,98} + ... + (1-\delta)^4 F_{j,95} + (1-\delta)^5 \overline{F}_j \left[1 + (1-\delta) + ... + (1-\delta)^{l-5} \right], \qquad (3.4)$$

which, by considering the geometric series with common ratio $(1-\delta)$ and initial value equal to 1, is equivalent to:

$$M_{j,99} = F_{j,99} + (1-\delta) F_{j,98} + ... + (1-\delta)^4 F_{j,95} + (1-\delta)^5 \overline{F}_j \left(\frac{1-(1-\delta)^{l-5}}{1-(1-\delta)} \right). \qquad (3.5)$$

For *t=98*, we have:

$$M_{j,98} = F_{j,98} + (1-\delta) F_{j,97} + ... + (1-\delta)^3 F_{j,95} + (1-\delta)^4 \overline{F}_j \left(\frac{1-(1-\delta)^{l-4}}{\delta} \right). \qquad (3.6)$$

We note that this approach allows us to solve for an important limitation in the literature. Indeed, since training is likely to be relatively more intense in periods of low output demand – that is, in periods where the foregone value of the time spent in training is low – OLS estimates of (2.2) are expected to underestimate the effects of training on productivity if the training variable in t is measured by its current (flow) level. By using the stock of training we can therefore reduce the corresponding bias.[6] Accordingly, the estimate of the stock of training obtained using model (3.5) will be alternatively added to specifications (2.2) and (2.3).

2.4 Training costs

Following Frazis and Loewenstein (2005), we use the Box-Cox transformation to investigate the appropriate functional form for the direct costs of training. Accordingly, we specified the training cost as a function of $(F^{\rho} - 1)/\rho$, where F denotes the training variable,

[6] Presumably, output demand/productivity shocks cannot be anticipated and hence training in *t-i* is not expected to be determined by productivity in *t*.

and obtained $\hat{\rho} = 0.09$, estimated by non-linear least squares. Given this evidence, we selected the following training cost function:

$$Ln\ C_{jt}^{F} = Ln\ \tau_0 + \tau Ln\ F_{jt} + \eta_c Z_{jt} + \upsilon_{jt}, \tag{4.1}$$

where C_{jt}^{F} denotes the direct training costs in firm *j* in period *t* and Z is the vector of firm characteristics. τ gives the elasticity of direct training costs with respect to hours of training.

To compute the foregone value of production arising from the fact that workers may receive training during working hours, we return to equation (1.1):[7]

$$Y = AH^{\alpha} K^{\beta} F^{\lambda} e^{(\eta Z + u)}$$

which is equivalent to

$$Y = A[H(F)]^{\alpha} K^{\beta} F^{\lambda} e^{(\eta Z + u)}, \tag{4.2}$$

where the negative *and* indirect effect of training on value added is obtained via the $[H(F)]^{\alpha}$ term.

Thus, from (4.2), we have:

$$\frac{\partial Y}{\partial H}\frac{dH}{dF} = \alpha \frac{Y}{H}\frac{dH}{dF}, \tag{4.3}$$

where $\alpha \equiv \frac{\partial Y}{\partial H}\frac{H}{Y}$ indicates the elasticity of production (value added) with respect to hours.

Based on (4.3), the derivative $\frac{dH}{dF}$ gives the relationship between hours worked and training hours, which is assumed to be negative as an increase in training hours lowers the number of hours spent in production. However, training does not necessarily take place during standard hours, and therefore the effect of training on hours is given by $\Delta H = \frac{R}{F}(-\Delta F)$, where R denotes the number of hours subtracted from production due to training ($R \leq F$). Thus, making $\frac{dH}{dF} \approx \frac{\Delta H}{\Delta F} = -\frac{R}{F}$ we have

$$\frac{\partial Y}{\partial H}\frac{dH}{dF} = \alpha \frac{Y}{H}\frac{R}{F} = \alpha \frac{R}{H}\frac{y}{f}. \tag{4.4}$$

[7] Subscripts *j* and *t* are omitted.

Given that for more than one half of the firms in the sample the training hours are less than 0.4% of total hours (which implies a small R/H for the great majority of firms), the indirect costs of training are in practice a small proportion of value added.

2.5 The internal rate of return to training (from the perspective of the firm)

In order to estimate the internal rate of return, we assume that training takes place in *t*, while productivity and the wage gains occur in the post-training period up to period *n*. Training costs are assumed to be paid in *t*.[8]

Let us assume then that

$$\sum_{i=1}^{n} \frac{NMgB_{t+i}}{(1+r)^i} = MgC_t, \tag{5.1}$$

where $NMgB$ is the marginal benefit of one additional hour of training, net of the possible wage increase obtained by workers. MgC is the increase in total costs (direct and indirect) resulting from an additional hour of training and r indicates the internal rate of return.

We further assume that $NMgB$ is obtained by subtracting the marginal increase in wages from the marginal product arising from one additional hour of training, that is:[9]

$$\sum_{i=1}^{n} \frac{NMgB_{t+i}}{(1+r)^i} = \sum_{i=1}^{n} \frac{1}{(1+r)^i} \frac{\partial Y_{t+i}}{\partial F_t} - \sum_{i=1}^{n} \frac{1}{(1+r)^i} \frac{\partial S_{t+i}}{\partial F_t}. \tag{5.2}$$

Using (1.1) and replacing F_t by M_t (with M_t given by equation 3.2), we have:

$$Y_t = AH_t^{\alpha} K_t^{\beta} \left[F_t + (1-\delta) F_{t-1} + (1-\delta)^2 F_{t-2} + ... + (1-\delta)^l F_{t-l} \right]^{\lambda} e^{(\eta Z_t + \pi \hat{\psi} + u_t)}. \tag{5.3}$$

Then, differentiating (5.3) with respect to F_{t-i} we have:

$$\frac{\partial Y_t}{\partial F_{t-i}} = \lambda (1-\delta)^i \frac{Y_t}{M_t} = \lambda (1-\delta)^i \frac{y_t}{m_t}, \tag{5.4}$$

[8] This notation follows Almeida and Carneiro (2009), with a major departure: the marginal benefit is net of the wage increase obtained by workers.

[9] We also make $\frac{\partial Y_{t+i}}{\partial F_t} \cong \frac{\Delta Y_{t+i}}{\Delta F_t}$ and $\frac{\partial S_{t+i}}{\partial F_t} \cong \frac{\Delta S_{t+i}}{\Delta F_t}$.

where m_t denotes the ratio between the accumulated number of training hours and (total) hours worked. Similarly to equation (5.4) we assume $\frac{\partial Y_{t+i}}{\partial F_t} = \lambda(1-\delta)^i \frac{y_t}{m_t}$, while for wages we have $\frac{\partial S_{t+i}}{\partial F_t} = \varphi(1-\delta)^i \frac{s_t}{m_t}$.[10] Thus, the present discounted value of net marginal benefits is given by:

$$\sum_{i=1}^{n} \frac{NMgB_{t+i}}{(1+r)^i} = \left(\lambda \frac{(1-\delta)}{(1+r)} \frac{y_t}{m_t} + ... + \lambda \frac{(1-\delta)^n}{(1+r)^n} \frac{y_t}{m_t}\right) - \left(\varphi \frac{(1-\delta)}{(1+r)} \frac{s_t}{m_t} + ... + \varphi \frac{(1-\delta)^n}{(1+r)^n} \frac{s_t}{m_t}\right), \quad (5.5)$$

which is equivalent to

$$\sum_{i=1}^{n} \frac{NMgB_{t+i}}{(1+r)^i} = \left(\lambda \frac{y_t}{m_t} - \varphi \frac{s_t}{m_t}\right)\left(\frac{(1-\delta)}{(1+r)} + ... + \frac{(1-\delta)^n}{(1+r)^n}\right). \quad (5.6)$$

Now, $\left(\frac{(1-\delta)}{(1+r)} + ... + \frac{(1-\delta)^n}{(1+r)^n}\right)$ is a geometric series with n terms, common ratio $\left(\frac{1-\delta}{1+r}\right)$ and initial value $\left(\frac{1-\delta}{1+r}\right)$, which yields:

$$\left(\frac{1-\delta}{1+r}\right)\left(\frac{1-\left(\frac{1-\delta}{1+r}\right)^n}{1-\frac{1-\delta}{1+r}}\right) = \left(\frac{1-\delta}{r+\delta}\right)\left(1-\left(\frac{1-\delta}{1+r}\right)^n\right). \quad (5.7)$$

Since n is unknown, we will analyse two scenarios, given by $n=1$ and $n \to +\infty$. In the first case, (5.7) becomes:

$$\left(\frac{1-\delta}{r+\delta}\right)\left(1-\left(\frac{1-\delta}{1+r}\right)\right) = \frac{1-\delta}{1+r}, \quad (5.8)$$

while in the second case we have:

$$\left(\frac{1-\delta}{r+\delta}\right)\left(1-\left(\frac{1-\delta}{1+r}\right)^{+\infty}\right) = \frac{1-\delta}{r+\delta}. \quad (5.9)$$

Finally, (5.8) and (5.9) are alternatively replaced in (5.6) to obtain the present discount value of net marginal benefits for firms.

We recall that total training costs contain direct costs and foregone output. The direct marginal costs of training can be obtained using (4.1), so that:

[10] We recall that, using (2.3), φ gives the elasticity of (log) average wage with respect to hours of training.

$$\frac{\partial C_t^F}{\partial F_t} = \tau \frac{C_t^F}{F_t}. \tag{5.10}$$

In turn, to obtain the marginal (indirect) cost we use (4.4).

Thus, for *n=1*, we have:

$$\left(\lambda \frac{y_t}{m_t} - \varphi \frac{s_t}{m_t}\right)\left(\frac{1-\delta}{1+r}\right) = \tau \frac{C^F_t}{F_t} + \alpha \frac{R_t}{H_t}\frac{y_t}{f_t}, \tag{5.11}$$

or,

$$\left(\lambda \frac{y_t}{m_t} - \varphi \frac{s_t}{m_t}\right)\left(\frac{1-\delta}{1+r}\right) = \tau \frac{C_t^F}{Y_t}\frac{y_t}{f_t} + \alpha \frac{R_t}{H_t}\frac{y_t}{f_t}, \tag{5.12}$$

which is equivalent to

$$\left(\lambda - \varphi s^y_t\right)\left(\frac{1-\delta}{1+r}\right) = \left(\tau c^y_t + \alpha w_t\right)\frac{m_t}{f_t}, \tag{5.13}$$

if one assumes $s^y_t = \frac{s_t}{y_t}$; $c^y_t = \frac{C_t^F}{Y_t}$ and $w_t = \frac{R_t}{H_t}$.

By further manipulating (5.13) we can then obtain a general formula for the internal rate of return for the case *n=1*:

$$r = \frac{\left(\lambda - \varphi s^y_t\right)\left(1-\delta\right)}{\left(\tau c^y_t + \alpha w_t\right)\frac{m_t}{f_t}} - 1. \tag{5.14}$$

If, alternatively, $n \to +\infty$, we have:

$$\left(\lambda - \varphi s^y_t\right)\left(\frac{1-\delta}{r+\delta}\right) = \left(\tau c^y_t + \alpha w_t\right)\frac{m_t}{f_t}, \tag{5.15}$$

or

$$r = \frac{\left(\lambda - \varphi s^y_t\right)\left(1-\delta\right)}{\left(\tau c^y_t + \alpha w_t\right)\frac{m_t}{f_t}} - \delta. \tag{5.16}$$

The expressions (5.14) and (5.16) show that the internal rate of return to training depends directly on the elasticity of value added with respect to training hours – the “gross gain” – and, inversely, on (a) the direct costs, (b) the foregone output, (c) the wage gains, and

(d) the depreciation rate. Since, by definition, the depreciation rate is less than one, the internal rate of return *r* in (5.16) is always higher than in (5.14).

2.6 The internal rate of return for workers

Given the nature of workplace training, we can easily assume that all direct training costs are fully paid by employers. On the other hand, we preclude the possibility of any wage reduction during the training period. In any case, training is not 'free' for workers if they sacrifice leisure time. Since the marginal utility of an additional hour of leisure is unobservable, we will use as a proxy the compensation of an additional hour of work.

Let us take α_s as the elasticity of the average wage with respect to hours of work so that we have:

$$\frac{\partial S_t}{\partial H_t} = \alpha_s \frac{S_t}{H_t}. \qquad (6.1)$$

Then, by multiplying the right-hand-side of (6.1) by $\frac{(F_t - R_t)}{F_t}$, we obtain the indirect costs of an additional hour of training from the perspective of the worker, that is:

$$\alpha_s \frac{S_t}{H_t}\frac{(F_t - R_t)}{F_t} = \alpha_s v_t \frac{s_t}{f_t}, \qquad (6.2)$$

with $v_t = \frac{(F_t - R_t)}{H_t}$.

On the other hand, the marginal benefits of training, MgB^L, are given by:

$$\sum_{i=1}^{n} \frac{MgB_{t+i}^L}{(1+r_L)^i} = \varphi \frac{s_t}{m_t}\left(\frac{(1-\delta)}{(1+r_L)} + \ldots + \frac{(1-\delta)^n}{(1+r_L)^n}\right), \qquad (6.3)$$

where r_L is the internal rate of return to training for workers.

Using (6.2) and (6.3) and following the procedure described in section 2.5, r_L is given by:

$$r_L = \frac{\varphi(1-\delta)}{\alpha_s v_t \frac{m_t}{f_t}} - 1, \qquad (6.4)$$

in the case of *n=1*, and by

$$r_L = \frac{\varphi\left(1-\delta\right)}{\alpha_s v_t \frac{m_t}{f_t}} \text{-}\delta, \tag{6.5}$$

if $n \to +\infty$.

Thus, the internal rate of return r_L depends directly on the elasticity of the hourly wage with respect to the proportion of hours spent in training (φ) and indirectly on the depreciation rate (δ), and the opportunity cost ($\alpha_s v_t$). As expected, the higher the percentage of training hours taken during working hours, the higher is the return to training for workers.

3. The Data

Our raw data is provided by *Balanço Social*, a dataset collected by *Gabinete de Estudos e Planeamento* (GEP) of the Ministry of Labour, Portugal. In particular, we will use two data points – 1998 and 1999 – covering 1,497 'training' firms. All firms in the sample have at least 100 employees, representing approximately 30% of the total Portuguese business sector workforce.

Balanço Social provides detailed information on a number of relevant variables for our study: value added, capital depreciation, labor costs, the wage bill, number of employees, hours of work, location, sectoral activity, and the legal form. The data basis also includes information on average characteristics of workers, namely age, gender, schooling, tenure, skill and the proportion of part-time workers.

A unique feature of *Balanço Social* is that it contains detailed information on training, namely the number of participants (by occupation level) and the number of training hours by type (on-the-job and off-the-job training). In addition, *Balanço Social* provides information on direct and indirect costs of training, the latter being directly obtained by the proportion R/H on the total wage bill.

As shown in Table 1, which summarizes the main descriptive training statistics, the proportion of training hours (on- and off-the-job) is approximately 1% of total hours of work, with most of the training hours taking place during normal working hours. On average, each worker spends approximately 18 hours per year in training, 29% of which in off-the-job training. However, as one might expect, the dispersion across firms in the sample is very high, with more than one half offering less than 8 hours of training per employee. Heterogeneity within firms is also quite substantial, with 95% of top managers and professionals participating in training, for example, while only 13% of unskilled workers are training participants.

Training costs amount to 1.7% of total value added, 47% of which are related to the off-the-job training category. Direct costs represents, on average, 0.87% of total value added. (This information is not reported in the table.)

Table 2 presents the mean and standard deviation of an extended set of firm-level variables grouped in two categories: firms with training hours above *and* below the median, respectively. Quite clearly, firms with a higher training intensity have a higher productivity level and higher wages. They are also larger in terms of size (employment) and skills.

4. Results and interpretation

4.1 The Impact of Training on Productivity and Wages

The results obtained from model (2.5) are presented in Table 3, column (1). The R^2 coefficient indicates that the model explains more than 60% of the variation in firm productivity. The parameter ($\alpha+\beta+\lambda-1$) is negative and statistically significant (at 0.1 level) which points to the presence of a decreasing returns to scale technology. In turn, the elasticity of (log) value added with respect to hours is equal to 0.72.[11]

[11] Using the results in Table 3, we have $\alpha+\beta+\lambda-1=-0.055 \Leftrightarrow \alpha=1-0.211-0.017-0.055=0.717$.

The impact of training on value added per hour is given by the training variable coefficient. Accordingly, if firms decide, for instance, to double the number of hours per worker – an increase from 1% to 2%, or a 18 hours of additional training – then the productivity will increase by 1.7%. In turn, 10 hours of additional training (per worker) will increase productivity by 0.9%. These effects compare with Almeida and Carneiro (2009), who claim that 10 additional hours of training per worker imply a 0.6-1.3% increase in productivity.[12]

Column (2) of Table 3 gives model (2.6) estimates, and as it is apparent the higher the proportion of training hours in total hours, the higher the (average) wage. This result suggests that workers do capture some of the gains from firm training. However, since the coefficient of the training variable in column (2) is smaller than the coefficient in column (1), it is clear that firms are grabbing a bigger slice of the pie.

As shown by Ballot, Fakhfakh and Taymaz (2006), one can derive a quick measure of the percentage captured by workers and firms: if the gross (marginal) gain associated with an additional hour of training is given by $\frac{dY}{dF} = \lambda \frac{Y}{F}$, and the (marginal) wage gain is given by $\frac{dS}{dF} = \varphi \frac{S}{F}$, then the worker and firm shares are given by $\frac{\varphi \frac{S}{F}}{\lambda \frac{Y}{F}}$ (or $\frac{\varphi s^y}{\lambda}$) and $\frac{\left(\lambda - \varphi s^y\right)}{\lambda}$, respectively.

Using these formulae, and assuming $s^y = 0.37$, $\lambda = 1.7\%$, and $\varphi = 1.5\%$, the worker share is 32.6%, while the firm share is 67.4%. These estimates compare easily with those obtained by Ballot, Fakhfakh and Taymaz (2006), who found, for Sweden, a worker share equal to 0.33.

It is interesting to note that the proportion of the gains captured by workers from firm-supplied training is substantially larger than in the case of a firm investment in capital, for

[12] We note that if unobserved firm heterogeneity is ignored, the training coefficient becomes much higher, at 0.026 *vis-à-vis* 0.017.

example. In this case, the corresponding worker share is given by $\frac{\beta_s s^y}{\beta}$, which implies a worker share of 4.2%.[13] In contrast, schooling implies a worker share of roughly 50%. This result is not surprising at all given the general content (or portability) of the investment in formal education.

Table 4 presents the summary statistics of the estimated stock of training hours, obtained by using the model presented in section 2.3. The average proportion of the stock of training in the total hours is 2.6%, which is 2.36 times higher than the ratio of the training hours flow to total hours. We also note that our modelling in section 2.3 seems to be quite robust as the correlation between the stock of training, obtained by considering a depreciation rate of 10%, and the training stock implied by a depreciation rate of 35% is 0.9608. On the other hand, if equation $(1-\delta)^5 \overline{F}_j \left(\frac{1-(1-\delta)^{l-5}}{\delta} \right) = 0$ in (3.5) holds – which is equivalent to ignoring the initial stock of training – the coefficient of correlation will be equal to 0.9973.[14]

Columns (3) and (4) from Table 3 replicate columns (1) and (2) using the estimated stock of training hours rather than the flow of training hours. The corresponding depreciation rate is 35%. As it is apparent, there is a modest increase in the impact of training both on productivity and wages which means that endogeneity of the training variable does not seem to be much of a problem.[15]

4.2 The determinants of the training costs

Table 5 presents the results from model (4.1). The coefficient of the training variable indicates that if firms, for example, double the intensity of training, the direct training costs will increase by 62%, showing an inelastic relationship between costs and training intensity.

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[13] In Sweden, according to Ballot, Fakhfakh and Taymaz (2006), $\frac{\beta_s s^y}{\beta}$ is equal to 7%.

[14] This is of course due to the fact that training obtained before 1995 is virtually negligible for a depreciation rate of 35%.

[15] As a matter of fact, we do not find any statistically significant correlation between aggregate sectoral productivity shocks and the training flow in a given year.

Capital intensity, size, ownership and the proportion of skilled workers have also a statistically significant impact on direct costs.

As mentioned earlier, the indirect costs of training are based on the estimated foregone output. *Balanço Social* gives a straightforward measure based on the product of R/H times the total wage bill. Since the productivity gains are not necessarily mirrored into higher wages, we decided to compute the foregone production by using the model developed in section 2.4. Thus, using the right-hand-side of (5.11) – *and* the sample means – we obtain an estimate of the percentage of indirect training costs in total training costs at 53.4%, that is:

$$\alpha \frac{R_t}{H_t}\frac{y_t}{f_t} \Big/ \left(\tau \frac{C^F_t}{F_t} + \alpha \frac{R_t}{H_t}\frac{y_t}{f_t}\right) = \alpha \frac{R_t}{H_t} \Big/ \left(\tau \frac{C^F_t}{Y_t} + \alpha \frac{R_t}{H_t}\right) = \frac{0.717 * 0.89}{0.62 * 0.9 + 0.717 * 0.89} = 0.534,$$

which seems to be a quite reasonable proportion, especially if we take into consideration that the estimate provided by *Balanço Social*, given by the (implicit) wage costs, is equal to 40%.

4.3 Estimates of the Internal Rate of Return

Since we do not observe how long the benefits of training will last, two extreme cases are next considered: in the first, we admit that benefits from firm training are totally exhausted after period *t+1* (the *n=1* case); in the second, the stream of benefits is, say, forever (the $n \to +\infty$ case).

Table 6 presents the descriptive statistics of the estimated internal rate of return, *r*, obtained by using (5.14) – for $n = 1$– and (5.16) – for $n \to +\infty$. In the $n = 1$ case, and assuming a depreciation rate of 35%, the mean of *r* is 43%. In this scenario, almost 66% of training firms have a negative internal rate of return as shown in Figure 1. There is also an obvious high dispersion in the distribution of *r*, which is due to (raw) firm heterogeneity as shown in Table 2, where the dispersion of firm productivity is quite substantial.

As expected, the mean of r is higher in the $n \to +\infty$ case, at 108%. The proportion of firms with a negative internal rate is also substantially smaller, at 34%, as shown in Figure 2. (If we assume that the benefits of training begin in the training period, the percentage of firms with a positive internal rate of return becomes obviously higher.) In turn, using the alternative value of 10% for the depreciation rate and assuming $n \to +\infty$, the internal rate of return would be positive for 90% of the firms. For the *n=1* case, we observe a positive internal rate for 55% of all firms in the sample.

We can also derive an *aggregate* internal rate of return using sample means. In this case, model (5.15) yields:[16]

$$\left(\lambda - \varphi s^{y}\right) + \left(\lambda - \varphi s^{y}\right)\left(\frac{1-\delta}{r+\delta}\right) = \left(\tau c^{y} + \alpha w\right)\frac{m}{f} \Leftrightarrow$$

$$\Leftrightarrow \left(0.018 - 0.017 * 0.37\right) + \frac{\left(0.018 - 0.017 * 0.37\right) * 0.65}{(r + 0.35)} = \left(0.62 * 0.009 + 0.717 * 0.0089\right) * 2.36 \Leftrightarrow$$

$$\Leftrightarrow 0.01171 + \frac{0.0076}{r + 0.35} = 0.0282 \Leftrightarrow r = 0.1106,$$

which is similar to the result obtained by Almeida and Carneiro (2009), at 8.9%.

Finally, in Table 7, we present the summary statistics for the internal rate of return from the perspective of the worker. Values are obtained by applying models (6.4) and (6.5) to a sample of firms in which the ratio v_t, given by $\frac{(F_t - R_t)}{H_t}$, is greater than 0.01%. For *n=1*, the average internal rate of return for workers is approximately 60%. For $n \to +\infty$, the average internal rate is much higher, at 125%. Similarly to the returns for firms, using sample means we obtain a substantially smaller internal rate of return for workers, at 24%.

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[16] Assuming that the benefits begin in the training period.

5. Conclusions

In this paper we derive a firm-level productivity (and wage) model as a function of workplace training. The results from our model specifications indicate that the investment in training has a positive and statistically significant impact both on productivity and wages of training firms. In particular, it is estimated that an additional hour of training per worker implies 0.09% increase in productivity. Moreover, our estimates indicate that 2/3 of the gains in productivity are captured by firms and 1/3 by workers.

We also derived a general model for the internal rate of return to training that takes into account the direct and indirect costs of training. Considering, again, the subset of training firms, and assuming a depreciation rate of 35%, the internal rate of return, at sample means, is 11%.

As expected, the greater the length of the post-training period, the higher the proportion of firms with a positive internal rate of return. In particular, under the limiting case that training benefits are exhausted just one period after training, the investment is positive for roughly 1/3 of the firms. For a longer stream of benefits, more than 2/3 of all firms have a positive internal rate of return, which of course suggests that excessive firm mobility, or a low rate of firm survival, may be counterproductive and generate underinvestment in formal firm training. Training is good for workers too. Taking the same subset of firms, the internal rate of return at sample means is 24% for workers, which is roughly twice as much as the return for firms. These are all non-negligible gains that should perhaps encourage policy makers to treat formal training as a good value for money.

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Table 1: Selected summary statistics of firm-provided training, 1998-1999

Variable	On-the-job training (1)	Off-the-job training (2)	Training (On- and off-the-job) (3)
Training hours per hour of work	0.008 (0.025)	0.003 (0.010)	0.011 (0.028)
Percentage of training hours on hours worked	n.a.	n.a.	0.829 (0.310)
Training hours per worker	12.83 (39.06)	5.32 (14.76)	18.16 (43.74)
Percentage of training costs in total value added	1% (1.85%)	0.8% (1.72%)	1.7% (2.74%)
Number of observations Number of firms	2,292 1,497	2,292 1,497	2,292 1,497

Notes: The reported means were computed from a sample containing only firms that have provided some training in the sample period. Standard deviations are given in parentheses.

Table 2: Summary statistics by type of firm

Variables	Firms with training hours above the median (1)	Firms with training hours below the median (2)
Productivity	36.06 (142.09)	16.94 (46.08)
Hourly wage	5.95 (4.1)	5.25 (5.82)
Capital	0.94 (1.52)	0.52 (0.73)
Hours (per worker)	1,747.24 (236.39)	1,798 (258.24)
Number of workers	591.6 (1,383.72)	341.5 (490.45)
Schooling	0.373 (0.267)	0.235 (0.204)
Tenure	0.396 (0.276)	0.366 (0.255)
Age	0.581 (0.139)	0.574 (0.126)
Gender (male)	0.648 (0.236)	0.629 (0.282)
Top managers and professionals	0.080 (0.098)	0.050 (0.058)
Other managers and professionals	0.082 (0.096)	0.051 (0.086)
Foremen and supervisors	0.061 (0.063)	0.064 (0.062)
Highly skilled and skilled personnel	0.448 (0.234)	0.422 (0.250)
Semiskilled personnel	0.204 (0.219)	0.231 (0.232)
Unskilled personnel	0.088 (0.153)	0.137 (0.188)
Full-time workers	0.908 (0.111)	0.873 (0.137)
Fixed-term contract workers	0.10 (0.137)	0.12 (0.222)
Foreign ownership	0.264 (0.412)	0.1643 (0.356)
Number of observations	1,220	1,035

Notes: Columns (1) and (2) report the mean and standard deviations of the corresponding variables by training intensity. The median is 0.4%. The description of variables is presented in Appendix Table A1.

Table 3: The impact of training on firm productivity and wages

Variables	Training measured in the current year: Productivity (1)	Training measured in the current year: Wages (2)	Training measured in the current and in previous years: Productivity (3)	Training measured in the current and in previous years: Wages (4)
Training	0.017	0.015	0.018	0.017
	(1.81)	(3.51)	(1.84)	(3.86)
Capital	0.211	0.024	0.210	0.021
	(16.98)	(4.39)	(14.65)	(3.36)
Hours	-0.055	-0.046	-0.044	-0.054
	(-2.13)	(-3.93)	(-1.57)	(-4.35)
Schooling	0.249	0.303	0.349	0.250
	(2.46)	(6.69)	(2.74)	(4.44)
Tenure	0.183	0.398	0.088	0.332
	(2.30)	(11.19)	(0.98)	(8.34)
Age	0.310	0.181	0.057	0.107
	(2.19)	(2.85)	(0.34)	(1.45)
Gender (male)	0.210	0.118	0.299	0.170
	(2.59)	(3.23)	(3.36)	(4.29)
Top managers and professionals	1.037	0.630	0.951	0.595
	(4.20)	(5.68)	(3.37)	(4.76)
Other managers and professionals	-0.072	0.432	-0.048	0.399
	(-0.36)	(4.76)	(-0.18)	(3.42)
Foremen and supervisors	0.131	0.172	-0.304	-0.219
	(0.53)	(1.55)	(-0.93)	(-1.51)
Highly skilled and skilled personnel	0.172	0.169	0.119	0.082
	(1.73)	(3.78)	(1.07)	(1.67)
Semiskilled personnel	0.089	0.145	0.071	0.093
	(0.85)	(3.08)	(0.60)	(1.78)
Productivity bonus	0.107	-0.316	0.194	-0.238
	(1.40)	(-9.22)	(2.06)	(-5.72)
Full-time workers	0.288	0.082	0.229	0.065
	(2.14)	(1.36)	(1.66)	(1.07)
Fixed-term contract workers	0.074	0.107	0.028	0.026
	(0.94)	(3.01)	(0.24)	(0.49)
Foreign ownership	0.102	0.048	0.058	0.068
	(2.97)	(3.09)	(1.52)	(4.07)
Medium/large firm	0.063	0.060	0.047	0.056

	(1.47)	(3.11)	(1.04)	(2.78)
Norte	-0.092	-0.116	-0.074	-0.121
	(-2.43)	(-6.83)	(-1.78)	(-6.59)
Centro	-0.197	-0.129	-0.221	-0.174
	(-3.83)	(-5.62)	(-4.16)	(-7.40)
Alentejo	-0.306	-0.130	-0.243	-0.073
	(-2.62)	(-2.47)	(-1.67)	(-7.40)
Algarve	-0.128	-0.084	0.051	-0.005
	(-0.98)	(-1.44)	(0.38)	(-0.08)
Firm unobserved heterogeneity	0.968		0.992	
	(14.00)		(11.92)	
Number of observations	1,834	1,834	1,400	1,400
F-statistic	51.372	97.33	45.149	90.601
$\overline{R}^2$	0.6093	0.7471	0.6354	0.7777

Notes: Columns (1) and (3) present the estimates from model (2.5), while columns (2) and (4) present the estimates from model (2.6). The model includes a constant, 27 industry dummies, and 2 dummies flagging the legal form of the firm. The *t-statistics* are given in parentheses. The description of variables is presented in Appendix Table A1.

Table 4: Summary statistics for the stock of training

Minimum	0.00003
Maximum	0.397
Mean	0.026
Median	0.015
Standard deviation	0.039
Number of observations	1,400

Notes: The reported statistics were computed from a sample containing only firms that have provided some training in the sample period. The selected depreciation rate is 35%.

Table 5: The determinants of training costs

Variables	Direct Cost of Training (1)
Training	0.623
	(35.04)
Capital	0.158
	(5.32)
Hours	0.353
	(6.71)
Schooling	0.758
	(4.03)
Tenure	-0.144
	(-0.99)
Age	-0.393
	(-1.54)
Gender (male)	0.204
	(1.35)
Top managers and professionals	0.635
	(1.42)
Other managers and professionals	1.148
	(3.14)
Foremen and supervisors	0.788
	(1.75)
Highly skilled and skilled personnel	0.513
	(2.85)
Semiskilled personnel	0.364
	(1.92)
Productivity bonus	-0.199
	(-1.98)
Full-time workers	0.081
	(0.33)
Fixed-term contract workers	-0.094
	(-0.64)
Foreign ownership	0.119
	(1.83)
Medium/large firm	0.198
	(2.44)
Norte	-0.166

	(-2.39)
Centro	-0.123
	(-1.30)
Alentejo	-0.027
	(-0.12)
Algarve	0.372
	(1.57)
Firm unobserved heterogeneity	0.760
	(5.95)
Number of observations	1,975
F-statistic	60.69
$\overline{R}^2$	0.6158

Notes: Column (1) corresponds to model (4.1). See notes to Table 3.

Table 6: Summary statistics of the internal rate of return to training (firm's perspective)

	$n = 1$	$n \rightarrow +\infty$
Mean	0.425	1.075
Median	-0.543	0.107
Standard deviation	3.877	3.877
Number of observations	841	841

Table 7: Summary statistics of the internal rate of return to training (worker's perspective)

	$n = 1$	$n \rightarrow +\infty$
Mean	0.602	1.252
Median	0.133	0.783
Standard deviation	1.486	1.486
Number of observations (firm-year)	159	159

Figure 1: The distribution of the internal rate of return for firms ($n = 1$)

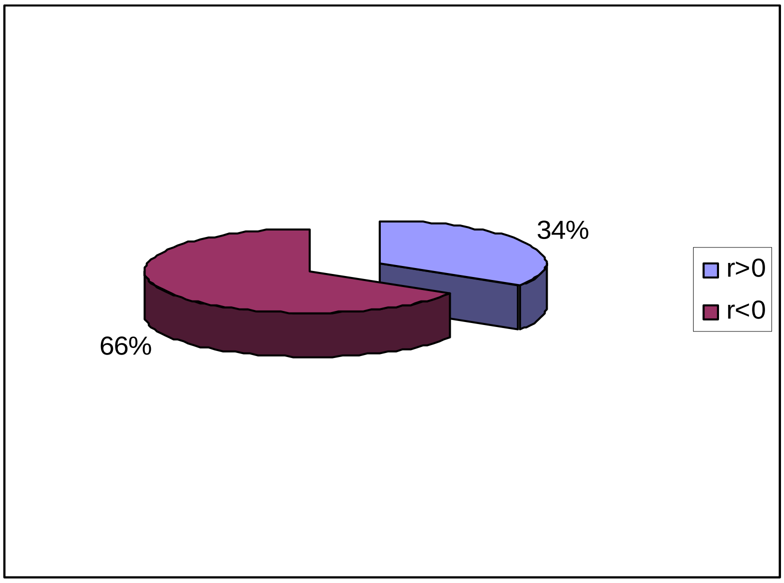
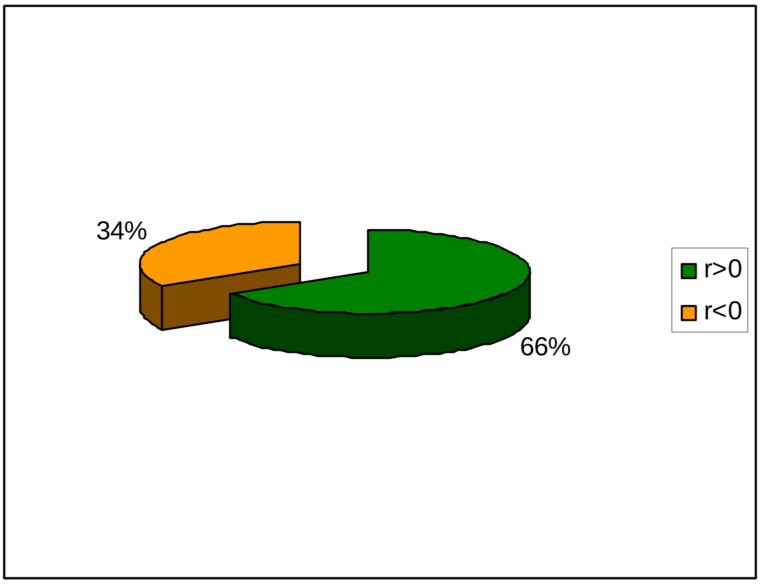


Figure 2: The distribution of the internal rate of return for firms ($n \to +\infty$)



Appendix Table A1: Description of Variables (at firm level)

Variable	Definition
Training	(Log) Hours of training per hour of work.
Productivity	Value added per hour of work.
Hourly wage	The wage bill (total earnings) divided by hours of work.
Capital	(Log) Capital stock per hour of work. The stock of capital is proxied by the annual volume of capital depreciation.
Hours	(Log) Number of contractual (standard) hours.
Schooling	Proportion of workers with at least a high-school degree.
Tenure	Proportion of workers with 10 or more years of service.
Age	Proportion of workers between 25 and 40 years old.
Gender (male)	Proportion of male workers.
Top managers and professionals	Proportion of top managers and professionals.
Other managers and professionals	Proportion of other managers and professionals.
Foremen and supervisors	Proportion of foremen and supervisors.
Highly skilled and skilled personnel	Proportion of highly skilled and skilled personnel.
Semiskilled personnel	Proportion of semiskilled personnel.
Unskilled personnel	Proportion of unskilled personnel.
Norte/Centro/Lisboa e Vale do Tejo/Alentejo/Algarve	Dummy: 1 if the firm is located in Norte/Centro/Lisboa e Vale do Tejo/Alentejo/Algarve; 0 otherwise.
Productivity bonus	Ratio between non-standard compensation and basic earnings.
Full-time workers	Proportion of full-time workers.
Fixed-term contract workers	Proportion of fixed-term contract workers.
Foreign ownership	Dummy: 1 if the firm is owned partial or totally by foreigners; 0 otherwise.
Medium/large firm	Dummy: 1 if the number of employees is more than 250; 0 otherwise.

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