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Who benefits from training and R&D: The firm or the workers?

A study on panels of French and Swedish firms

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Abstract

The present paper offers a novel study of the effects of intangible assets on wages and productivity. Training, R&D, and physical capital are all taken into account, and their joint effects examined. We use panels of firms in order to control for unobserved fixed effects and the potential endogeneity of training and R&D, and have been able to obtain data for two different countries, France and Sweden, in order to explore the effects of institutional or national specificity. The estimation of productivity and wage equations allows us to show how the benefits of investment in physical capital, R&D and training are shared between the firm and the workers. Although the workers obtain significant benefits, the study shows that the firm obtains the largest return on the investments it makes. This is true not only for physical capital and R&D, but also for training. It suggests that firms can rationally invest in training and that the issue of under-investment in training should be re-examined.

Keywords: Training, R&D, productivity, wages
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1. Introduction

Economists have long recognized the role of intangibles assets like knowledge and human capital as the engine of economic development. A large number of theoretical and empirical studies show that human capital, accumulated by education and training, and knowledge on new products and processes, generated by R&D activities, is the main source of growth in output in the long run (for qn extensive study, see Aghion and Howitt, 1998). The R&D investment literature has focused on the effects of spillovers: a firm is likely to get only a part of the benefits of innovations it generates because other firms and consumers will also benefit through knowledge spillovers and various forms of externalities. Thus, the private rate of return will be less than social rate of return that will lead to underinvestment in R&D activities. However, this literature does not pay sufficient attention to the fact that the employees of the innovating firms may also share these benefits (this issue is partly covered by the rent sharing literature; see for an excellent example, van Reenen, 1996).

The focus of the literature on investment in training (firm sponsored training) is the effect on workers' wages and careers. However, the primary aim of training is productivity increase. This bias comes from the dominant position of human capital theory in labor market research that stresses the supply of labor. The bias has been reinforced at the empirical level by the availability of data on wages, and the lack of data on training expenditures. Human capital theory also implies that workers are paid their marginal productivity, even though this is true at best over a long period. Recorded increases of salaries with tenure were then interpreted as effects of (specific) training. As for general training, it could only be financed by the workers themselves. It should be immediately reflected in their wage as a result of perfect competition in the labor market. There would (by assumption) be no additional returns for the firm. Important policy conclusions follow from this view. Because of the externality, firms underinvest in training activities, and since workers are financially constrained, there is an under-provision of training in the economy, and a case for (costly) government subsidies, or a levy on firms to fund training, as in France.

The quantitative importance of training expenditures sponsored by firms and by governments implies a burden on the resources of the nations. This has raised demands for more direct measures of the productivity impact of training. There are debates about the efficiency of the training systems, and reforms of these systems are being debated for instance in France (Gauron, 2000). Simultaneously new theories have been developed to justify that firms can rationally sponsor general training because they can retain part of the returns[1]. However, there is little empirical work on how the benefits (productivity increases) are shared by the firm and its workers. The lack of panel data on training activities at the firm level is one reason (for a comprehensive survey, see Blundell *et al*., 1999).

The present study offers some novel findings on the effects of training and R&D activities on the productivity of the firm, and returns to these activities. *First*, it uses longitudinal information on training and productivity at the firm level. This allows us to control for unobserved fixed effects and the potential endogeneity of training. S*econd*, it deals simultaneously with the effects of another important intangible investment of the firm, namely R&D. *Third*, it computes the effects of these factors, as well as physical capital, on both wages and value added. This allows us to compute the shares of the benefits that accrue to the firm, and to the workers respectively when the firm invests in any one of these factors, taking the joint effects of the others into account[2]. *Fourth*, we are able to present results for two countries, France and Sweden, to provide some control for country or institution specificity. To the best of our knowledge, this is the first study that analyzes how the returns

[1] See Acemoglu and Pischke (1998, 1999a) for comprehensive reviews, and Ballot (1994) for a hypothesis based on the innovation rent.
[2] The only similar study we know of is Dearden, Reed, and Van Reenen (2000), but they use data at the sectoral level.

to tangible and intangible assets are shared by firms and their employees by using panel data at the firm level.

The main result we obtain is that firms indeed obtain the largest parts of the returns to their investments, but the firms' share is lower for intangible assets, R&D and training. In France and Sweden, respectively, the firms obtain a very high proportion of the returns to physical capital (91 and 92%), a large part of the returns to training (82 and 67%), and a significant part of the returns to R&D (68 and 46%) even though the total returns are quite different between the countries and between R&D and training.

Section 2 reviews briefly the literature on training and productivity since the issue of the returns to training is less well explored than the returns to R&D or physical capital. Section 3 describes the data. The empirical model and estimation results are presented in Sections 4 and 5, respectively. Main findings are summarized in Section 6.

2. The previous literature

Becker's influential study on human capital (Becker, 1964) has led to the accumulation of a voluminous literature on firms' and workers' investment in human capital, especially in the form of general and specific training. This literature has shown that the human capital stock of the firm accumulated through training activities is one of the main factors of production (for an extensive range of studies, see Lynch, 1994) . Although the importance of human capital as a factor of production is strongly emphasized by almost all researchers, empirical studies have usually been confined to the analysis of the effect of training *on the wage rate* that is used as a proxy for productivity because it is *assumed* that the (real) wage rate will be equal to the marginal product of labor if the labor market is competitive. This assumption is, of course, very restrictive, and rules out the possibility that firms may invest in general training even if workers capture a part of the returns to that investment. As shown, among others by Acemoglu and Pischke (1998, 1999a and 1999b), Bishop (1991 and 1996), Loewenstein and Spletzer (1999), and Booth and Snower (1996), there is strong evidence that suggests that firms provide general training to their workers (the classical example is the German apprenticeship programs) and share the benefits of (general and specific) training with their workers.

One needs to estimate both the productivity and wage equations to find out if firms and workers really share the benefits of training, and, in this manner, of other types of investment. Early studies by Barron, Black and Loewenstein (1989), Holzer (1990), and Bishop (1991) are unique in that they use the Employment Opportunity Pilot Project (EOPP) Survey of Firms data set in which data on training were collected from employers and include information on both formal and informal training. A comparison of the effects of increased training on wage and productivity growth as estimated in these studies suggests that about half of the returns to training are received by workers. Bartel (1995), Barron, Berger and Black (1997), and Groot (1999) also estimated productivity and wage equations at the individual level and find substantial productivity effects. The main disadvantage of these individual-level studies is the use of (subjective) productivity scores assigned by employers in productivity equations.[3]

In recent years a number of researchers have sought to measure the effect of firm sponsored training on productivity using firm-level data. For example, Holzer *et al.* (1993) used data on firms that applied for training grants under the Michigan Job Opportunity Bank-Upgrade program in the late 1980s (three-year panel of data), and found that training has

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[3] For example, in the EOPP Survey of Firms, employers were asked the following question. "Please rate your employee on a productivity scale of zero to 100, where 100 equal to maximum productivity rating any of your employees in that position can attain and zero if absolutely no productivity by your employee". Therefore productivity increases after a change in the worker’s position cannot be estimated because productivity ratings are relative measures.

positive effects on the quality of output (measured by the overall scrap rates), but effects on sales and wages are not significant. Bartel (1994) found a positive effect of training on productivity in her cross sectional analysis on about 150 firms from the Columbia Business School Survey. Black and Lynch (1996) used the National Center on the Educational Quality of the Workforce National Employers' Survey (821 establishments in manufacturing and 525 in non-manufacturing in 1993). Results of estimating Cobb-Douglas production functions for manufacturing and non-manufacturing sectors indicate that the average educational level of the establishment has a positive effect on sales in both sectors, but training (defined as the number of workers trained in 1990 and 1993) has no effect; the proportion of time spent in formal off-the-job training has a positive effect in manufacturing, and computer training has a positive impact in non-manufacturing. The econometric study by Boon and van der Eijken (1997) on a balanced panel of 173 Dutch firms confirms the importance of training as an input. Barrett and O'Connell (2001) estimated a labor productivity growth equation for a cross section of 215 firms in Ireland (all sectors including manufacturing and services), and found that general training has a positive impact on productivity growth but specific training has no effect. They also estimated that the interaction between investment and general training variables has a positive coefficient, i.e., the impact of general training varies positively with the level of capital investment.

There are some studies that use more aggregated data at the industry level. For example, Blakemore and Hoffmann's (1989) time series analysis of quarterly data on US manufacturing show that the productivity increase is over twice the size of the wage increase caused by human capital accumulation as measured by job tenure. Dearden, Reed and van Reenen (2000) have investigated the effects of the proportion of trained workers on both productivity and wages in a panel of British industries. They estimated a production function with constant returns to scale to obtain the elasticity of value added per worker with respect to training (and other inputs), and a wage equation to obtain the elasticity of the wage rate with respect to training (and other inputs). These two elasticities allow them to calculate the net benefit of training for firms (or, to be more precise, for sectors) which is found to be positive, i.e., firms capture a part of returns to training.

In recent years, a number of researchers have sought to measure the effect of human capital on productivity and wages using matched individual-firm data (for example, see Hellerstein and Neumark, 1998; Hellerstein, Neumark, and Troske, 1999; and Margolis and Salvanes, 2001). These studies use a rich set of variables on workers' demographic characteristics and educational levels, but lack data on employer sponsored training.

Turning to the literature on French data, we should first note that no study seems to deal both with productivity and wages, and explore the issue of sharing. Carriou and Jeger's (1997) study covers over 10,000 French firms, for the period 1986-92. They estimate the impact of lagged training expenditures on value added for each year separately, and find it to be positive and significant. Delame and Kramarz (1997) also analyse longitudinal French data for 1982-87. Their contribution takes into account the individual features of the French environment. French firms are compelled by a 1971 law on training to spend a minimum percentage of the wage bill on training, or pay the equivalent tax to the Government. They distinguish between three categories of firms, those spending more than the legal minimum, those spending the minimum rate on training, and those spending less than the minimum on training and paying the difference as a tax to the Treasury. The effects of training on productivity are significant only for managers, engineers and technicians, and only for the first group of firms (which spend at least the minimum rate set by law). This classification is interesting, but the authors have chosen to replace the training expenditures by a dummy for training categories in the regressions. A fortiori, no stock of training is computed. The study may thus underestimate the effects of training.

Ballot and Taymaz (1998) have studied the effects of training and R&D on profitability by gathering data on France and Sweden, with the same variables at the firm level. The study is only focused on year 1989, but estimates simultaneously the determinants of current investment in training, profitability, and the average wage. They compute for each firm the capital stock represented by cumulated training investments in order to take into account the lagged effects of these investments. The results suggest that training has a positive effect on profitability, but that R&D has no positive effect. However the interaction between the two variables has a significant positive effect, at least in France. Firm sponsored training hence, would appear to be a significant source of profits as well as increasing wages. The limitations of the study arise from the modest size of the sample (about a hundred firms in each country), and the absence of longitudinal data on firms in order to control for firm specific unobserved characteristics. Ballot, Fakhfakh and Taymaz (1998) use a panel of French firms (1987-93) and show that both the training stock and the R&D stock have a significant impact on value added. The returns to training are very high, but the effects on wages are not studied. Several papers study the effects of training on wages. Goux and Maurin (1997, 2000) use a large sample of workers interviewed in 1993 to show that training does not have a very important effect if the wage policy of a given firm is controlled for. Fougère, Goux and Maurin (1998) find that training does not have a significant effect on wage careers. Beret and Dupray (1998) state that the selection effect explains most of the apparent impact of training on wages. These French papers on productivity effects and wage effects (separately), suggest that, contrary to what is currently believed, the firm may capture a large part of the returns to training.

As far as Sweden is concerned, Kazamaki-Ottersten, Lindh and Mellander (1999) have shown that training may reduce production costs significantly. Ballot, Fakhfakh and Taymaz (2001) confirm that training is a significant input in the production function and find a similar role for R&D. The effects on wages are not studied. Regner (1994) focuses on wage equations and finds no evidence that employees pay for training and no substantial effects of training on wages. Braunerhjelm and Eliasson (1998) found that human-embodied knowledge significantly increases productivity and profitability in Swedish manufacturing firms.

3. The Data

We have used comparable panel data sets of firms in France and Sweden. The French data set is a match of three sources for the same firms (Table 1). The first source is a panel of the "Human Resources Accounts" of 200 firms in the French industry, over the period 1981-93. This source also contains information on firm sponsored training, employment, hires, separations, and wages. Training is measured by the percentage of the wage bill devoted to continued training so that we are able to calculate annual training expenditures (at constant 1987 prices) and hours of training.

This indicator has a *flow* dimension. To make the best use of the available information, we have computed *stocks* by cumulating flows over 7 years, using the formulae of Ballot, Fakhfakh & Taymaz (2001).

$$H_{it} = \phi_{it} + \sum_{n=t-6}^{t-1} \left\{ \prod_{j=n}^{t-1} (1-\theta_{ij}) \right\} \phi_{in} \qquad [3]$$

where H_{it} is the training stock of the firm in year t, ϕ_{in} the training flow in year n and θ_{it} is the separation rate (indexed by firm and by year). Beside losses through separations, human capital certainly undergoes obsolescence as time elapses, but rates of depreciation are not known.

The second French source is based on the financial accounts of a very large sample of firms for the period 1987 to 1993, and contains some financial variables (value added and physical capital).

The third sample is based on the Structure of Employment surveys and gives the number of researchers in the firm as a measure of the stock of R&D. This measure is an improvement over the variable we used in Ballot, Fakhfakh and Taymaz (1998, 2001) that was the stock of R&D in the social accounts[4]. The Structure of Employment surveys cover the population of firms, or more precisely the population of plants (except the small plants), and we have been able to aggregate at the firm level.

The matched sample contains about 100 firms, and, owing to their large size (number of employees), they represent around 10% of French manufacturing employment. An important feature of the sample is the average decline of value added (-2%), and even turnover. This decline is mainly in the sub-period 1989-93, and dominates growth in 1987-89. The panel is unbalanced, and we have included, for our econometric work, firms that have made available their Human Resources Accounts for at least two years.

The Swedish data set is an unbalanced panel of 200 large firms or divisions of firms, collected by the Federation of Swedish Industries and the Industrial Institute for Economic and Social Research (IUI) for the period 1987 to 1993 (see Albrecht *et al*. 1992). The Swedish economy is characterised by large firms, so that the sample covers almost all the large firms and around 50% of total employment in Swedish manufacturing. The training variable relates to training expenditures. "Training stocks" have been computed by cumulating the training expenditures. Separation rates are not available for individual firms in the data set. We have experimented with various rates of depreciation, and found that the estimation results are not sensitive to such an aggregate rate of depreciation. However, to preserve the similarity with the French data, we have adopted a yearly depreciation rate of 10% that is in the range of the mean separation rates in Sweden[5].

4. The empirical model

A manufacturing plant *i* at time *t* is assumed to have a Cobb-Douglas production function of the form

[1] $Q_{it} = A_{it}K^{\alpha}_{it}L^{\beta}_{it}R^{\delta}_{it}H^{\gamma}_{it}e^{\varepsilon it}$

where Q is the value added, K the (fixed) capital stock, L labor, R the R&D stock, H the human capital (firm sponsored training) stock, and ε the i.i.d. error term. In logs and dividing by L we obtain the following equation:

[2] $ln q_{it} = ln A_{it} + \alpha \, ln k_{it} + \delta \, ln r_{it} + \gamma \, ln h_{it} + (\alpha + \beta + \delta + \gamma - 1) \, ln L_{it} + \varepsilon_{it}$

All lowercase variables now denote “per employee” values. In this specification, a positive (negative) coefficient of the employment variables will indicate increasing (decreasing) returns to scale.

The technology variable is defined as

[3] $ln A_{it} = A_i + \Sigma\lambda_t D_t$

where A_i's account for unobservable firm-specific affects and D_t are time dummies that are used to control for technical change and exogenous macroeconomic shocks.

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[4] A direct measure of R&D expenditures is not available. The French survey on R&D expenditures does not cover all firms for this period but essentially the firms that do R&D, and cannot therefore be used to match our data set based on the match of the first two samples.
[5] Holmlund (1984) (figure 2.4) finds a monthly separation rate of .9% (corresponding to an annual rate of 10.8%) in 1982 for white collars.

Previous studies (see Ballot, Fakhfakh and Taymaz (1998 and 2001) for France and Sweden and Barrett and O'Connell (2001) for Ireland) show that interactions between various assets could be important. Therefore, in some estimations we also allow for interactions between fixed capital, R&D and training variables (k*r, k*h, and r*h). Finally, we also estimate the dynamic form of the model that includes the lagged output as an explanatory variable[6].

Following Griliches and Mairesse (1997), we have used OLS, fixed effects, random effects and GMM to estimate the production function. GMM handles not only unobservable individual effects but also possible simultaneity (of different intangible capital for example). GMM estimators use variables in differences, to eliminate unobservable individual effects, and use lagged values (in levels) as instruments to correct for simultaneity bias. However, as emphasized by Griliches and Mairesse (1997), fixed effects and GMM estimators produce rather unsatisfactory results (low and often insignificant capital coefficient and unreasonably low estimates of returns to scale). Blundell and Bond (1998, 1999) show that the lagged levels of a series provide weak instruments for first differences. They suggest taking into account additional non-linear moment conditions which correspond to adding (T-2) equations in levels with variables in differences as instruments[7] (Ahn and Schmidt 1995). Blundell and Bond used Hall and Mairesse's (1996) data and added to equations in differences, equations in levels with lagged first-differences as instruments (Arellano and Bover, 1995). This so-called GMM-SYS estimator yields more reasonable results. Our estimation results also lead us to a similar interpretation of the merits of various estimators. Therefore, in Tables 4 and 5, we

[6] We used some characteristics of the labor force (average age, average tenure at the firm, and the proportion of female employees) for France but the estimates for other variables did not change much. In this paper, we report results with only production function variables to have comparability between France and Sweden. The Swedish model includes the number of hours worked per employee to have a better labor input variable.

[7] T-2 equations coming from the moment restriction: $E(\varepsilon_{it}\ \Delta\varepsilon_{it-1})=0$, where T is the number of years the firm is present.

present only the GMM-SYS estimation results (our preferred model) and OLS results for comparison purposes[8]. (Other estimation results are, of course, available upon request.)

Wage determination is modeled as a bargain between the firm and workers (see, for example, McDonald and Solow, 1981). The Nash bargain for risk neutral workers can be written as

[4] $U = [u(w)-u(w^*)]L$

where w is the (real) wage rate, w^* the fallback wage, and L the number of employees. The firm's profit function is defined as

[5] $\Pi = Q - wL$

where Q is real value added (the product price is normalized to 1). The fallback position of the firm is no profit. Then, the solution of the model is obtained by maximizing $U^{\phi}\Pi^{1-\phi}$ where ϕ is the relative bargaining power of the worker. At the interior optimum, the following first order conditions hold:

[6] w: $[\phi\, u_w / (u-u^*)] - (1-\phi)L / (Q - wL) = 0$

[7] L: $(\phi / L) + (1 - \phi)(Q_L - w)/(Q - wL) = 0$

where $u_w = du/dw$, and $Q_L = dQ/dL$.

The first equation can be simplified by using

[8] $u(w) - u(w^*) = (w-w^*)L$

to obtain the following equation:

[9] $w = (1-\phi)w^* + \phi\,(Q/L)$

[8] We use the DPD package for Ox [http://www.nuff.ox.ac.uk/users/ Doornik/].

The effects of investment in tangible (fixed capital) and intangible assets (R&D and human capital) on wages can be obtained by differentiating the first wage equation with respect to the stock of the asset, S (S = K, R, H), which is given by

$$[10] \quad w_S = [(1-\phi)\, w^*_S L + \phi_S (Q - w^*L) + \phi\, (Q_S - L_S (Q/L)\,] / L$$

This equation decomposes the impact of investment in S on the wage rate into three components: First, the wage rate increases as a result of an increase in the fallback (outside) wage of the worker. Second, the wage rate increases (decreases) if the investment in S makes workers' relative bargaining power stronger (weaker). Finally, the workers can share a part of the increase in output if they have a positive bargaining power to begin with, i.e., $\phi > 0$.

Even if the workers have no bargaining power, an investment in S may lead to an increase in wages if it increases the outside wage of the worker, w^*. This effect is, of course, discussed in detail in the human capital literature. For example, the investment in general training, once made, is sunk and it is embodied in the worker as human capital. Therefore, when the worker is employed by another firm his productivity will be the same, and his wage will be higher. If the worker gets all the benefits of investment in S as a result of the wage increase, then the firm will not have any incentive for investment. The firm will sponsor investment in S (S could be training or R&D or fixed capital) only if it can recoup its investment cost.

The increase in the outside wage as a result of investment in S depends, first of all, on the transferability of the asset embodied in workers to other firms. The asset could be human capital accumulated trough investment in training, or knowledge generated by R&D activities. If the knowledge and human capital are completely specific to the firm, then they will not be transferable to other firms, and will not have any effect on w^*. Even if the knowledge or human capital accumulated as a result of investment is general, the increase in the outside wage could be less than the increase in output so that the firm may find it profitable to finance investment. For example, Acemoglu and Pischke (1999b) show that a range of frictions (search and informational asymmetries, efficiency wages, complementarities between general and specific skills, union wage setting and minimum wages) may make investment in general training profitable for firms.

To summarize, we expect that investment in training increases the outside wage because a part of training could be general, that leads to an increase in the wage rate in the investing firm. A similar effect can be expected for investment in R&D as well because the knowledge, especially tacit knowledge, is embodied in workers who can use it productively in other firms.[9] Workers share quasi rents generated by innovation. On the other hand, this effect will be weak, or even absent for investment in fixed assets because they are embodied in machinery and equipment in which the firm has strong, well-defined property rights.

The change in workers' bargaining power induced by investment in S is the second factor that affects the wage rate. For example, if the bargaining powers of skilled and unskilled workers are different, an investment in training may increase the power of workers, and may lead to an increase in wages, because workers will get a larger share of the profit of the firm even if there is no change in the outside wage. This may be relevant if training is firm-specific so that it may not have any impact on the outside wage. On the other hand, investment in certain assets, for example, in machinery and equipment, may reduce workers' bargaining power.

Finally, the wage rate is increased by investment if workers have bargaining power, because they claim a part of the increase in profits generated by new investment. The

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[9] This effect may lead to a positive correlation between profits and wages in innovative firms even if workers have no bargaining power. For example, van Reenen (1996) shows that quasi rents generated by innovations are shared by workers in the British manufacturing firms. Our analysis indicates that if innovative activities enhance knowledge embodied in workers (which is certainly the case), then workers will have higher wages.

magnitude of this effect, of course, depends on the increase in the number of employees who share profits.

Our analysis shows that the wage rate (w) depends on the bargaining power of workers (ϕ), the outside wage (w^*), and the level of labor productivity (Q/L); see equation 9. Since the bargaining power and the outside wage may also depend on especially the intangible capital of the firm that is partly embodied in workers, the wage rate itself is determined by those variables that are used in the production function (Q). Therefore, the wage equation we will estimate is exactly the same as the productivity equation but the dependent variable is replaced by the (log) real wage per employee (for a similar specification, see Dearden, Reed and Van Reenen, 2000).

The estimated coefficients of the productivity and wage equations can be used to make inference about unobservable parameters, like the bargaining power. For example, if it is assumed that the labor supply is inelastic and tangible and intangible assets do not have any impact on bargaining power, than equation 10 becomes

[11] $w_S = [(1-\phi)\, w^*_S\, L + \phi\, Q_S\,] / L$

This equation can be re-written as follows:

[12] $wL\, \varepsilon_{wS} = (1 - \phi)\, w^*L\, \varepsilon_{w^*S} + \phi\, Q\, \varepsilon_{QS}$

where ε_{wS}, ε_{w^*S} and ε_{QS} are the S asset elasticities of the wage rate, the outside wage rate, and output, respectively. ε_{wS} is estimated from the wage equation, and ε_{QS} from the productivity equation. If the stock of intangible assets has no impact on the outside wage (this is a reasonable assumption given the fact that fixed assets are not embodied in workers), then bargaining power can be calculated from the estimated values of ε_{wK} and ε_{QK}:

[13] $\phi = (wL/Q)^*(\varepsilon_{wK} / \varepsilon_{QK})$

Then, the impact of investment in R&D and training on outside wage (i.e., ε_{w^*R} and ε_{w^*T}) can be calculated by substituting the value of bargaining power (equation 13) into equation 12.

5. Estimation Results

The production function (productivity) and wage equations were estimated for France and Sweden. We present first the OLS results for comparison purposes (see the first columns in Tables 2-5). Interaction variables have usually significant coefficients in productivity and wage equations for both countries (see columns 2-4). The lagged dependent variables also have statistically significant coefficients that may imply a partial adjustment process (column 5). The values of elasticities calculated at geometric mean values of variables do not change considerably in the dynamic models (compare values at columns 4 with those in columns 5) with the exception of the R&D variable in the French productivity equation. Therefore, we prefer to interpret the results on the basis of estimated parameters of the augmented static models (columns 4).

The effects of training and R&D are both positive and significant. The training and R&D elasticities of value added per employee are .184 and .050 for France, and .064 and .023 for Sweden, respectively. The interactions of training with R&D and (fixed) capital have positive coefficients, and the interaction between R&D and capital has a negative coefficient in France. In the Swedish case, the interaction between training and capital has a negative coefficient, and all other interactions have positive coefficients. These results show that training and R&D are complementary assets, and there could be some substitutability between fixed assets and R&D/training.

Turning to the effects on wages, we observe that both tangible and intangible capital is positively correlated with wages. The positive elasticity of wages with respect to capital intensity (9.8% for France and 3.8% for Sweden) indicates that a part of productivity gains from capital investment is passed on to the workers in terms of higher wages either because of the bargaining power of workers, or because of an increase in the outside wage of workers.

Training and R&D have also positive and statistically significant impact on wages, showing that the accumulation of human capital and R&D, even if the firm finances it, has favourable effects for employees. The magnitude of the elasticity of wages with respect to training is 11% for France and % 4.9% for Sweden, quite smaller than the elasticity of labor productivity with respect to training. The R&D elasticity of wages is about 5.4% for France and 2.9% for Sweden. These values are slightly higher than the R&D elasticity of labor productivity. 1% increase in the R&D stock leads to almost the same percentage increase in value added and wages in these countries.

Since we observe strong positive effects of tangible and intangible assets on both labor productivity and wages, we need to compute the *net* effect of each asset on firm profitability (as measured by the difference between value added and the total wage bill). The net effect can be calculated by deducting the returns received by workers from total increase in value added (the elasticity of labor productivity with respect to a given asset *minus* the elasticity of wages with respect to the same asset multiplied by the share of the wage bill in value added, around 30% for France, and 40 % for Sweden).

The workers' share in returns to investment in fixed capital, R&D, and training in France and Sweden is depicted Figure 1. Most of the benefits of tangible and intangible capital accrue to the firm. More precisely, French workers obtain less than 10% of the returns to physical capital, 18% of the returns to training, and 32% of the returns to R&D. The

Swedish workers get almost the same proportion of returns to physical capital (8%), but receive a larger part of returns to training and R&D (33% and 54%, respectively).

It is quite interesting to observe for both countries that workers' get a larger share of returns to R&D than returns to human capital that is almost completely embodied in workers. This finding cannot simply be explained by the rent sharing hypothesis because if workers have any bargaining power, they will get a part of profit irrespective of its sources. The relatively high share of workers in returns to R&D can stem from the non-rival characteristics of knowledge generated by R&D activities (Teece, 2000: 12-25). Knowledge is embodied in artifacts, rules, organizations, as well as workers. However, the knowledge embodied in workers is not exclusive as in the case of human capital; workers may share the same knowledge. Therefore, knowledge generated by R&D activities may have a stronger impact on outside wage than investment in training does.

The bargaining power of workers calculated from equation 13 is quite similar for France (0.091) and Sweden (0.082). These values are within the range of values that vary between 0.005 to 0.30 for various countries (for studies using different methods, see Abowd and Lemieux (1993), Blanchflower, Oswald, and Sanfey (1996), van Reenen (1996), Hildreth and Oswald (1997), Margolis and Salvanes (2001) and references therein).

6. Conclusions

The literature contains only separate studies of the effects of assets, and especially training, on productivity and wages, and estimates of productivity are very rare. The two types of studies already gave some hints that workers may not capture all benefits of training even if human capital is completely embodied in workers, and that firms get a high return from their investment in human capital. The present paper is the first to offer, at the microeconomic level, a coherent investigation of the effects of intangible assets on wages and productivity, and allows us to present estimates of the way the benefits are shared between the firm and the employees. It confirms that the firm obtains the largest part of the profits in the investments it makes. The results are similar for France and for Sweden, which suggest that they are robust enough to be observed in different institutional environments.

The workers also benefit from investments in tangible and intangible assets. This raises interesting questions about the mechanisms that allow them to obtain some rents. Insider power, union power and incentive constraints may come into play to generate such a sharing of the returns, and suggest more complex stories than the standard human capital theory based on perfect competition.

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Table 1. Descriptive statistics

Label	Variable definition	Unit	Mean	Min	Max
France (n=873)					
LPROD	Productivity, VA per employee	1000 FF	307.60	50.47	3903.00
CAPITAL	Fixed capital stock per employee	1000 FF	195.83	5.04	5580.00
TRAIN	Training stock per employee	1000 FF	12.58	0.32	47.32
R&D	Proportion of researchers	(%)	0.037	0.0001	0.33
EMP	Number of employees		5218	301	77448
WAGE	Annual Average Wage	1000 FF	91.18	48.94	183.06
Sweden (n=1182)					
LPROD	Productivity, VA per employee	1000 SEK	460.68	43.33	2710.64
CAPITAL	Fixed capital stock per employee	1000 SEK	370.57	22.74	5694.28
TRAIN	Training stock per employee	1000 SEK	7.41	0.17	69.67
R&D	R&D stock per employee	1000 SEK	36.45	0.13	1184.63
EMP	Number of employees		647	20	21828
HOURS	Number of hours worked per employee	1000 hours	1.56	0.16	2.57
WAGE	Annual Average Wage	1000 SEK	199.00	45.00	406.00

Table 2a. Determinants of labor productivity in France

	OLS		GMM-SYS		GMM-SYS		GMM-SYS		GMM-SYS	
	Coeff	t-value	Coeff	t-value	Coeff	t-value	Coeff	t-value	Coeff	t-value
CAPITAL	0.173	1.52	0.387	45.10**	0.376	74.60**	-0.371	14.10**	0.007	27.00**
TRAIN	0.025	0.15	0.087	6.17**	0.342	11.90**	-0.503	12.50**	0.080	1.94**
R&D	-0.134	1.58	0.078	13.40**	-0.061	4.64**	-0.110	5.71**	-0.063	2.79**
TRAIN*R&D	0.066	2.35**			0.059	9.16**	0.112	19.10**	0.025	4.31**
TRAIN*CAPITAL	0.080	2.79**					0.254	36.60**	0.012	1.57
R&D*CAPITAL	0.024	1.61					-0.023	5.45**	0.000	0.02
LPROD(-1)									0.877	75.55**
EMP	-0.006	0.32	-0.011	1.42	-0.022	4.73**	-0.025	6.32**	0.001	0.21**
Elasticities at mean values										
CAPITAL	0.263		0.387		0.376		0.319		0.289	
TRAIN	0.116		0.087		0.101		0.184		0.260	
R&D	0.129		0.078		0.078		0.050		-0.039	
n obs	538		533		533		533		439	
n firms	104		102		102		102		97	
Wald (joint)			2845**		9919**		7889**		6271**	
d.f.			4		5		7		8	
Sargan			86		195		93		76	
d.f.			80		100		140		149	
AR(1)			-0.510		-0.380		-0.190		-3.090**	
AR(2)			-1.170		-1.140		-0.310		-1.490	

Notes: All models include time and R&D dummies. The OLS model includes also sector dummies.

Table 2b. Determinants of wages in France

	OLS		GMM-SYS		GMM-SYS		GMM-SYS		GMM-SYS	
	Coeff	t-value	Coeff	t-value	Coeff	t-value	Coeff	t-value	Coeff	t-value
CAPITAL	0.146	3.33**	0.077	21.00**	0.073	33.10**	0.366	15.90**	0.036	4.26**
TRAIN	0.248	3.82**	0.125	55.80**	0.338	67.50**	0.662	26.50**	0.131	11.00**
R&D	0.031	0.96	0.079	42.20**	-0.054	20.60**	-0.193	23.80**	-0.021	3.30**
TRAIN*R&D	0.005	0.47			0.049	39.00**	0,057	17.00**	0.014	10.10**
TRAIN*CAPITAL	-0.023	2.01**					-0,071	11.40**	-0.008	3.75**
R&D*CAPITAL	0.008	1.37					0.025	17.10**	0.001	0.62
WAGE(-1)									0.755	41.80**
EMP	0.017	2.57**	0.006	1.28	0.010	3.50**	0.012	2.60**	0.006	3.34**
Elasticities at mean values										
CAPITAL	0.059		0.077		0.073		0.098		0.064	
TRAIN	0.124		0.125		0.137		0.110		0.154	
R&D	0.079		0.079		0.062		0.054		0.056	
n obs	538		533		533		533		441	
n firms	104		102		102		102		95	
Wald (joint)			5390**		9430**		14610**		32350**	
d.f.			4		5		7		8	
Sargan			80		86		88		72	
d.f.			80		100		140		149	
AR(1)			-1.710*		-1.740*		-1.990**		-2.560*	
AR(2)			-0.285		-0.320		-0.430		-1.230	

Notes: All models include time and R&D dummies. The OLS model includes also sector dummies.

Table 3a. Determinants of labor productivity in Sweden

	OLS		GMM-SYS		GMM-SYS		GMM-SYS		GMM-SYS	
	Coeff	t-value	Coeff	t-value	Coeff	t-value	Coeff	t-value	Coeff	t-value
CAPITAL	0.165	1.98**	0.200	12.90**	0.188	11.90**	0.207	4.17**	0.173	5.23**
TRAIN	0.067	1.60	0.099	6.32**	0.172	5.33**	0.066	2.25**	0.055	3.57**
R&D	0.104	2.40**	0.064	3.50**	0.150	3.40**	0.090	3.43**	0.106	7.72**
TRAIN*R&D	0.005	0.55			0.030	3.88**	0.007	1.22	0.009	3.22**
TRAIN*CAPITAL	-0.023	1.44					-0.021	2.12**	-0.009	1.59
R&D*CAPITAL	0.021	1.93*					0.033	6.36**	0.031	8.83**
LPROD(-1)									0.407	41.90**
EMP	0.003	0.27	-0.046	2.63**	-0.001	0.06	0.016	1.26	0.013	2.56**
HOURS	0.158	2.18**	0.076	0.62	0.158	1.85*	0.104	2.50**	-0.098	5.73**
Elasticities at mean values										
CAPITAL	0.165		0.200		0.188		0.201		0.193	
TRAIN	0.067		0.099		0.073		0.064		0.058	
R&D	0.104		0.064		0.003		0.023		0.052	
n obs	1178		1155		1155		1155		865	
n firms	272		249		249		249		209	
Wald (joint)			262**		311**		797**		6187**	
d.f.			6		7		9		10	
Sargan			97		111		158		166	
d.f.			83		103		143		164	
AR(1)			-3.481**		-3.498**		-3.507**		-4.249**	
AR(2)			-0.814		-1.115		-1.249		0.820	

Notes: All models include time and R&D dummies. The OLS model includes also sector dummies.

Table 3b. Determinants of wages in Sweden

	OLS		GMM-SYS		GMM-SYS		GMM-SYS		GMM-SYS	
	Coeff	t-value	Coeff	t-value	Coeff	t-value	Coeff	t-value	Coeff	t-value
CAPITAL	0.121	3.86**	0.038	3.19**	0.037	5.96**	0.081	4.27**	0.120	7.52**
TRAIN	0.092	5.82**	0.048	3.21**	0.059	6.00**	0.083	7.00**	0.149	19.20**
R&D	0.081	4.96**	0.039	2.35**	0.052	3.72**	0.069	6.39**	0.120	16.50**
TRAIN*R&D	0.010	2.78**			0.006	2.27**	0.008	3.76**	0.019	12.40**
TRAIN*CAPITAL	0.013	2.14**					0.008	2.13**	0.021	6.50**
R&D*CAPITAL	0.003	0.78					0.001	0.38	-0.005	3.62**
WAGE(-1)									-0.034	4.73**
EMP	-0.006	1.28	-0.002	0.17	0.003	0.51	0.002	0.39	-0.009	3.26**
HOURS	0.120	4.40**	0.291	1.61	0.161	3.63**	0.144	5.24**	0.078	8.85**
Elasticities at mean values										
CAPITAL	0.121		0.038		0.037		0.038		0.033	
TRAIN	0.092		0.048		0.039		0.049		0.063	
R&D	0.081		0.039		0.023		0.029		0.031	
n obs	1182		1160		1160		1160		869	
n firms	272		250		250		250		209	
Wald (joint)			87**		330**		747**		119**	
d.f.			6		7		9		10	
Sargan					90		131		171	
d.f.					103		143		164	
AR(1)			-3.106**		-3.163**		-3.145**		-2.494**	
AR(2)			1.282		1.309		1.378		0.411	

Notes: All models include time and R&D dummies. The OLS model includes also sector dummies.

Figure 1. Workers' share in returns to investment in fixed capital, R&D, and training