

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

Gérard BALLOT^{a1}, Fathi FAKHFAKH^b, Erol TAYMAZ^c

^a Université Panthéon-Assas (Paris II) and ERMES-CNRS, France

^b Université Panthéon-Assas (Paris II) and ERMES-CNRS, France

^c Middle East Technical University, Ankara, Turkey

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 are examined. We use panels of firms in order to control for unobserved fixed effects and the potential endogeneity of training and R&D, using data for France and Sweden. The estimation of productivity and wage equations allows us to show how the benefits of investment in physical capital, training, and R&D are shared between the firm and the workers. We found that firms indeed obtain the largest part of the returns to their investments, but their share is relatively lower for intangible assets (R&D and training) than for physical capital.

Keywords: Training, R&D, productivity, wages

JEL codes: J24, D24, O30

Acknowledgements: We are grateful to Francis Green, the Editor of the Journal, Cem Somel of METU and anonymous referees for their constructive comments and suggestions.

1. Introduction

Economists have long recognized the role of intangible assets such as 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, are the main source of growth in output in the long run (for an 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 other forms of externalities. Thus, the private rate of return will be lower than the social rate of return and this 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 benefits². Finally we should make it clear here that the firms' returns (or benefits) take the form of a higher productivity which may itself be shared between an increase in profits and a decrease in prices leading to higher market shares.

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 to increase productivity. This emphasis on wages comes from the dominant position of human capital theory in labor market research that stresses the supply of labor. It has been reinforced at the empirical level by the availability of data on wages, and the scarcity of data on training expenditures. However more data is now available, as we will see below. The human capital theory also implies that workers are remunerated according to their marginal product, even though this may hold on average over long periods. Recorded increases of wages with tenure are 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.

Training activities sponsored by firms and by governments impose burdens on the resources of nations. While new growth models have emphasized that aggregate human capital has an important role in explaining productivity and growth, empirical studies using aggregate data have yielded mixed results³ and have raised demands for direct measures on the productivity impact of human capital. Moreover the studies based on panel of countries use measures of education, not training, and these measures are often very crude. Since training expenditures are so costly, there are debates about the efficiency of the training systems, and the reform of these systems has become a contested political issue, 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 returns⁴. 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 is, to the best of our knowledge, the first that analyzes how the returns to tangible and intangible assets are shared by firms and their employees by using panel data at the firm level. The specific contributions are as follows. *First*, it uses longitudinal firm-level data on training and productivity. This allows us to measure the private rate of return to the firm's investment, all the more because we calculate training stocks at the firm level. Moreover, the panel data allow us to control for unobserved fixed effects and the potential endogeneity of training. *Second*, it deals simultaneously with the

effects of another important intangible investment of the firm, namely R&D, in order to distinguish its relative contribution. *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 partition of the benefits between the firm and the workers, when the firm invests in any one of these factors, taking the joint effects of the others into account⁵. *Fourth*, we are able to present results for two countries, France and Sweden. It is interesting to compare results for two countries with different institutional characteristics.

The main result we obtain is that firms indeed obtain the largest part of the returns to their investments, but the firms' share is lower for intangible assets, R&D and training, than for physical capital. In France and Sweden, respectively, the firms obtain a very high proportion of the returns to physical capital (about 90 %), a large part of the returns to training (65 – 70 %), and a significant part of the returns to R&D (50 and 75 %) even though the total returns are quite different between these two countries, and between R&D and training investments.

Section 2 reviews briefly the literature on training and productivity since the issue of the returns to training has not been as meticulously explored as have 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. The main findings are summarized in Section 6.

2. The literature

Becker's influential study on human capital (Becker, 1964) has spawned 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 Stevens (1994a and 1994b), Acemoglu and Pischke (1998, 1999a and 1999b), Bishop (1991 and 1996), Loewenstein and Spletzer (1999), and Booth and Snower (1996), firms provide general training as well as specific 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. The literature does not deal fully with the topic but offers some evidence that we will summarize first for the Anglo-Saxon data, and then for the French and the Swedish data.

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 accrued to workers. Bartel (1995), Barron, Berger and Black (1997), and Groot (1999) also estimated productivity and wage equations at the individual level and found substantial productivity effects. The main disadvantage of these individual-

level studies is the use in productivity equations of (subjective) productivity scores assigned by employers.⁶

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) found that training has a positive effect 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 of about 150 Canadian firms. 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 workers 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 in the production function. 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.

There are some studies that use more aggregated data at the industry level. Dearden, Reed and van Reenen (2005) have investigated the effects of the proportion of trained workers on both productivity and wages in a panel of British industries. Using GMM to control for endogeneity, 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 the aggregate of firms in a sector, which is found to be positive. This measure corresponds to the returns to training at the sectoral level rather than the private return on a firm's own training investment. The aggregate benefits are interesting because they capture externalities within a sector (although not between sectors) but they cannot be used to decide whether individual firms should invest in training or not. Conti (2005) replicates the British study on Italian data but does not find statistically significant effects when the GMM method is used for estimation.

Two new avenues of research have been opened in recent years. First 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.

Second, what looks like a major breakthrough, has been the theoretical analysis of Holmström and Milgrom (1994) on the "complementarity of incentives" which emphasizes the coherence of the incentive system to enhance performance. If incentive policies belong to different functions of the firm, there has been a particular empirical interest in the complementarities within the Human Resources Management practices. Such a management focusing on high skills and training, incentives (high wages and benefits, performance-related pay, group bonuses, profit sharing), and good labor relations has been termed the "high-commitment" or "high-performance" paradigm. It has been promoted by management specialists but has only recently been submitted to rigorous testing, starting with Ichniowski, Shaw and Prennushi (1997). However this hypothesis has also been criticized, at least as a fit-

for-all policy (Godard, 2004). Moreover it is difficult in this framework to evaluate the contributions of the different practices since they are numerous and often collinear. Clustering techniques are then used to measure the impact on performance and the specific role of training cannot be assessed⁷.

Turning to the literature on French data, we should first note that no study seems to deal both with productivity and wages, and to 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 analyze longitudinal French data for 1982-87. Their contribution takes into account the individual features of the French system. French firms are obligated by a 1971 law to allocate a sum amounting to at least a certain percentage of the wage bill on training, or to pay an equivalent tax to the Treasury. Delame and Kramarz categorize French firms as those spending more than the legal minimum on training, those spending the minimum, 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 more than the minimum rate set by the 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, 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 (2001) 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 two separate sets of French papers, on productivity and on wages, 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 in Sweden and France, and find a similar role for R&D, but they do not study the determination of wages. 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. 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 hours of training and the ratio of expenditure on training to the wage bill so that we are able to calculate annual training expenditures (at constant 1987 prices).

This indicator has a *flow* dimension. To make the best use of the available information, we have computed the *stock* of human capital, H, by cumulating flows over seven years, as follows:

$$[1] \quad H_{it} = f_{it} + \sum_{n=t-6}^{t-1} \left\{ \prod_{j=n}^{t-1} (1 - q_{ij}) \right\} f_{in}$$

H_{it} is the training stock of the firm in year t , f_{in} the training flow in year n and q_{it} is the separation rate (indexed by firm and by year). Our methodology is inspired by the techniques used to calculate physical capital, but the separation rate is here distinct for each firm and each year. The data set has therefore the advantage of attributing a higher level of training capital to firms in which turnover is low, for a given level of training expenditures. It takes into account essential and usually omitted determinants of firms' human capital⁸.

The second data set comprises the data on financial accounts of a very large sample of firms for the period 1987 to 1993 (value added, physical capital, etc.).

The third data set 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&D⁹. 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 plants to get the data at the firm level.

The matched sample contains about 100 firms, and, owing to their large size (in number of employees), they represent around 10% of French manufacturing employment (for descriptive statistics, see Table 1). An important feature of the sample is that all firms spend over the legal minimum at any time so that the minimum set by the law is not a binding constraint. Another feature of the data is the decline of average value added (-2%), and even turnover, over the sample period. The average value added declines mainly in the sub-period

1989-93, and dominates growth in 1987-89. Finally, 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.

< INSERT TABLE 1 ABOUT HERE >

The Swedish data set is an unbalanced panel of about 250 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).¹⁰ The Swedish economy is characterized 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 Sweden¹¹.

4. The empirical model

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

$$[2] \quad \ln q_{it} = \ln A_{it} + \alpha \ln k_{it} + \delta \ln r_{it} + \gamma \ln h_{it} + \beta \ln L_{it} + \varepsilon_{it}$$

where q , k , r , and h are value added, (fixed) capital stock, R&D stock, the human capital (firm sponsored training) stock per employee, respectively. L is the number of employees, and ε the error term. In this specification, a positive (negative) coefficient of the employment variable, L , will indicate increasing (decreasing) returns to scale.

The technology variable is defined as

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

where A_i 's account for unobservable firm-specific effects and D_t are time dummies that are used to control for technical change and exogenous macroeconomic shocks. Since OLS estimates are biased in the case of endogenous explanatory variables, we use GMM to control for possible endogeneity in R&D and training investment variables.

Previous studies for France and Sweden (Ballot, Fakhfakh and Taymaz, 1998 and 2001) and for Ireland (Barrett and O'Connell, 2001) show that interactions between various assets could be important. Therefore, we also allow for interactions between fixed capital, R&D and training variables (kr , kh , and rh) in some models.

Following Griliches and Mairesse (1997), we have used OLS, fixed effects, random effects and GMM to estimate the production function (see Arellano and Bover, 1995). GMM handles not only unobservable individual effects but also possible simultaneity (of different intangible capital variables 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, 2000) 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 instruments¹² (Ahn and Schmidt, 1995). This so-called GMM-SYS estimator yields more reasonable results. Our estimation results also lead us to a similar assessment on the merits of

various estimators. Therefore, in Tables 2 and 3, we present only the GMM-SYS estimation results (our preferred model) and OLS results for comparison purposes¹³.

The wage rate is determined by a bargain between the firm and workers. The Nash bargaining model indicates that the productivity of the firm (Q/L), the outside (fallback) wage rate (w^*), and the bargaining power of the workers (f) determine the wage rate as follows: (see Appendix for the model).

$$[4] \quad w = (1-f)w^* + f(Q/L)$$

If the workers do not have any bargaining power, they will not be any better off than the alternative. However, if the firm does not have any bargaining power, the workers will capture all output. Thus, any investment in tangible as well as intangible assets may lead to an increase in the wage rate through its effects on productivity, bargaining power, and outside wage of workers.

If the workers of a firm have any bargaining power, they will claim a part of the increase in profits generated by new investment, and raise their wage rates. However, even if the workers have no bargaining power, an investment in tangible and intangible assets may oblige the firm to raise its wages by increasing the outside wage. 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. If the worker, whose productivity has increased, is lured by another firm with the offer of a higher wage, then the former firm that trained the worker loses its investment. If the worker gets all the benefits of investment by a wage increase, then the firm will not have any incentive for investment. The firm will sponsor investment only if it can recoup its investment cost.

The increase in the outside wage as a result of investment in tangible and intangible assets, first of all, depends on the transferability of the asset embodied in workers to other

firms. The asset could be human capital accumulated through investment in training, or knowledge generated by R&D activities. If the knowledge or human capital is completely specific to the firm, then it will not be transferable to other firms, and it will not have any effect on the outside wage rate. 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.

We expect investment in training to increase the outside wage because a part of training could be general and this would lead 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 part of the knowledge is embodied in workers who can use it productively in other firms.¹⁴ Workers share 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 clear, well-defined property rights.

The change in workers' bargaining power induced by investment in tangible and intangible assets is another factor that affects the wage rate. For example, if the bargaining powers of skilled and unskilled workers are different, an investment in training unskilled workers may increase their bargaining power, and may lead to an increase in their wages, so the workers will get a larger share of the profit of the firm even if there is no change in outside wages. 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.

To summarize, the wage rate depends on the bargaining power of workers, the outside wage, and the level of labor productivity. 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. Therefore, we substitute those tangible and intangible capital variables for the bargaining power and the outside wage in the wage equation which becomes exactly the same as the productivity equation with the dependent variable replaced by the (log) real wage per employee (for a similar specification, see Dearden, Reed and Van Reenen, 2000 and 2005).

The bargaining power and the outside wage are certainly affected by other variables as well. It is well-documented in the literature that a number of variables, such as the structure of the product market, the level of unionization, the system of collective bargaining (firm-level, sectoral, national, etc.), the generosity of the unemployment benefit system, the unemployment rate and macroeconomic conditions play a role in determining the bargaining power and the outside wage (for a number of empirical studies that measure the bargaining power of workers, see Abowd and Lemieux (1993), Blanchflower, Oswald, and Sanfey (1996), van Reenen (1996), Hildreth and Oswald (1997), Margolis and Salvanes (2001) and Dobbelaere (2003) and references therein). In our estimation, these variables are controlled for, to some extent, only by using firm-specific fixed effects because of the lack of relevant firm-level data. Since our sample includes mainly large firms, firm-level variables like market power, the level of unionization, etc., are likely to be stable over time, and the firm-specific fixed effects may well capture their impact. Macroeconomic conditions (unemployment rate, unemployment benefit system, etc.) are the same for all firms, and their impact is controlled for by time dummies.

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 2-3). GMM-SYS results for the base model are presented in column 2. The coefficients of the log employment variable are statistically insignificant in all but in the productivity model for France. In other words, the technology used by our sample of Swedish firms exhibits constant returns to scale, whereas there are mild decreasing returns in France. There is no wage differential, after controlling for R&D and human capital, between small and large firms in both countries. Other variables (fixed capital, R&D, and training) have the expected impact on productivity and wages.

<INSERT TABLES 2 AND 3 ABOUT HERE >

The third model (in column 3, Tables 2-3) includes the interaction between human capital and R&D variables. The interaction variable has a positive (and statistically significant) coefficient in all models, indicating the importance of complementarities between human capital and R&D activities for productivity, and for wages as well. The fourth model includes interactions between R&D and fixed capital, and human capital and fixed capital. The inclusion of these interaction terms does not have a significant impact on the main variable with the exception of the human capital-R&D interaction variable in the Swedish productivity model whose coefficient now becomes insignificant. The human capital-fixed capital interaction variable has statistically significant and positive coefficients in the wage equations of both countries, but other interaction variables for the fixed capital do not exhibit a consistent pattern. This is likely to be a result of multicollinearity among interaction variables that lead to fragile estimates. Therefore, the third model (in columns 3) is our preferred specification.

The average training and R&D elasticities of value added per employee are estimated as 17.3 % and 5.4 % for France, and 7.3 % and 6.1 % for Sweden, respectively.¹⁵ The significant positive coefficient of the training-R&D interaction variable indicates that training (R&D) has a larger positive impact on productivity if the firm accumulates R&D capital (human capital).

Turning to the effects on wages, we observe that both tangible and intangible capitals are positively correlated with wages. The positive elasticity of wages with respect to physical capital intensity (7.7% for France and 3.0% 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 also have positive and statistically significant impact on wages, showing that the accumulation of human capital and R&D, even if the firm finances it, has favorable effects for employees. The magnitude of the elasticity of wages with respect to training is 13.1 % for France and 6.1 % for Sweden, somewhat smaller than the elasticity of labor productivity with respect to training. The R&D elasticity of wages is about 6.6 % for France and 3.5% for Sweden.

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 the 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 41 % for France, and 43 % for Sweden).

The workers' share in returns to investment in fixed capital, R&D, and training in France and Sweden is depicted Figure 1.¹⁶ Most of the benefits of tangible and intangible

capital accrue to the firm. More precisely, French workers obtain only 9 % of the returns to physical capital, 30 % of the returns to training, and 50 % of the returns to R&D. The Swedish workers get almost the same proportion of returns to physical capital (7 %), but receive about 35 and 25 % of the returns to training and R&D, respectively.

< INSERT FIGURE 1 ABOUT HERE >

It is quite interesting to observe that in both countries workers get a larger share of returns to R&D and training than returns to fixed capital. 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 and training can stem from the fact that knowledge and skills generated by R&D and training activities are largely embodied in workers, and they are transferable to other firms.

In order to test the robustness of our results, we have experimented with a number of additional variables and specifications. First, the human capital literature suggests that workers may be willing to accept lower wages during (general) training, and, therefore, share costs of training with the firm. In such a case, our estimates of returns to workers tend to be overestimated.¹⁷ We include the value of training in a given year (TRAINING FLOW) to control for the effect of wage cutting during periods characterized by higher training expenditures (see column 5 in Tables 2 and 3). Contrary to the hypothesized effect, current training has positive coefficients in both productivity and wage equations in both countries (it is not statistically significant in the Swedish wage equation). Our estimation results suggest that the data do not reveal any significant wage decline during the training periods, and, therefore, the estimated returns to workers of training activities are not likely to be seriously overestimated.¹⁸

Second, changes in the composition of the workforce as a result of innovation and/or external shocks could be associated with the wage increases. For example, the firm, after a successful innovation, can increase its productivity, and may replace (older) workers with (younger) workers who are well-educated in new technologies, and demand higher wages. Similarly, the firm may shed less productive/low-wage labor as a response to a negative external (demand) shock. In both cases, the productivity and wages in the firm will increase, although the workers do not share benefits of any type of investment with the firm. In such cases, our estimates for the returns to the workers are likely to be overestimated. We have data for labor turnover for French firms, and the impact of turnover on the estimated values of training and R&D coefficients was tested for that sample. We found that estimation results are not sensitive to the inclusion of the labor turnover variable, i.e., the effects of training (and R&D) do not seem to be overestimated in our models.

Third, the likelihood of getting training may depend on the initial human capital of workers. Those firms that train their workers may have a well-educated work force that would also have a higher productivity. If the initial human capital of workers does not change over time, the GMM difference estimator will control for the initial human capital. However, the initial human capital may change over time, for example, through labor turnover, if the retired/fired workers are likely to be less educated, and new workers are more educated. As noted earlier, we estimated the productivity and wage equations for France by including the turnover variable and found that it does not have any important effect on the estimates of the coefficients of the training and R&D variables. We experimented with some characteristics of the labor force that may be correlated with the initial human capital of workers (average age, average tenure at the firm, and the proportion of female employees) for France (unfortunately, comparable data are not available for Sweden), but the estimates for variables under consideration did not change much.

Finally, we also estimated the dynamic models that include the lagged dependent variable as an explanatory variable, to control for partial adjustment but the results were qualitatively the same.

6. Conclusions

The literature contains studies that deal separately with the effects of assets, and especially training, on wages and (usually subjective measures of) productivity. The empirical evidence suggests that workers may not capture all the benefits of training even if human capital is completely embodied in workers, and firms get a significant improvement in productivity in return to their investment in training. The present paper is the first to offer, at the microeconomic level, a coherent investigation of the effects of intangible assets, namely training and R&D capital, on wages and productivity, and to provide estimates on firm's and workers' shares in returns to investment in intangible assets. It confirms that the firm appropriates the largest part of the returns in the investments it makes. The results are similar for France and for Sweden, which suggest that they are robust enough to be observed under different institutional environments.

The paper presents new and puzzling results concerning the workers' share in returns to the firm's investment in tangible and intangible assets. First, investment in physical capital and R&D are expected to yield no benefit for workers because they are not embodied in them. The positive effects on wages of investment in physical capital and R&D raise questions about the mechanisms that allow the workers to obtain some rents. Insider power, union power and incentive constraints may come into play to generate such a sharing of the returns. The returns to firm-sponsored training for workers involve the opposite puzzle. As far as general training is concerned, workers are expected to get all the returns in the "standard"

model without any friction. It is true that workers can receive a part of returns to investment in specific training. Yet, the importance of general training in firm-sponsored training pointed at above and the high share of returns for workers suggests more complex stories than the “standard” human capital theory based on perfect competition. New theories of imperfect competition on the labour market in various forms as discussed by Stevens (1994a) and Acemoglu and Pischke (1999b) and the capacity of general training to generate innovation and oligopolistic rents as emphasized by Ballot (1994) and documented by recent econometric studies (see Ballot *et al.*, 2001) explain why firms can pay for general training and accept sharing the benefits with the workers.

The private “returns” to investment in training appear to be quite high, and raise new puzzles. There is a widespread complaint by firms that they do not find the skills they are looking for on the labor market. Why do they not train more if returns to training are quite substantial? One reason may be the lack of information on these returns and the fear of poaching of trained workers by other firms. This paper has the aim to induce more research on the returns to training in order to inform the firms and policy makers that in spite of poaching training is valuable. The second reason may be the lack of trainable workers on the labour market. All the studies show that firms select for training workers who have some initial education. If these hypotheses are validated, they suggest that public policy should be redirected from general levies on firms as in France (or general subsidies) towards programs of intensive training to workers with low initial education. Further work that distinguishes the types of workers by initial education and computes the returns to training with this added distinction is needed.

A caveat is in order before concluding the paper. The data sets used in this study include only large firms that employ a significant proportion of employees in French and Swedish manufacturing industries. Further research is needed to check if the same results are

valid for small firms as well.¹⁹ This extension is difficult because small firms do less formal training, but they often do a lot of informal training, which is not easily measured by surveys.

References

- Abowd, J.M. and Lemieux, T. (1993), "The effects of product market competition on collective bargaining agreements: The case of foreign competition in Canada", *Quarterly Journal of Economics*, 108: 983-1014.
- Acemoglu, D. and Pischke, J.-S. (1998), "Why do firms train? Theory and evidence", *Quarterly Journal of Economics*, 113: 79-119.
- Acemoglu D. and Pischke, J.-S. (1999a), "Beyond Becker: Training in imperfect labour markets", *Economic Journal*, 109: F112-F142.
- Acemoglu D. and Pischke, J.-S. (1999b), "The structure of wages and investment in general training", *Journal of Political Economy*, 107: 539-572.
- Aghion, P. and Howitt, P. (1998), *Endogenous Growth Theory*, Cambridge, Mass.: MIT Press.
- Ahn, S.C. and Schmidt, P. (1995), "Efficient estimation of models for dynamic panel data", *Journal of Econometrics*, 68: 5-28.
- Albrecht, J.W *et al.* (1992), *MOSES Data Base*, Research Report 40, Stockholm: IUI.
- Arellano, M. and Bover, O. (1995), "Another look at the instrumental-variable estimation of error-components models", *Journal of Econometrics*, 68: 29-52.
- Ballot G. (1994), "Continuing education and Schumpeterian competition: Elements for a theoretical framework", in R. Asplund (ed.), *Human capital in an economic perspective*, Physica Verlag.
- Ballot, G., Fakhfakh, F. and Taymaz, E. (1998), "Formation continue, recherche et Développement, et performance des entreprises", *Formation et Emploi*, 64, 43-55.
- Ballot G., Fakhfakh F. and Taymaz, E. (2001), "Firms' human capital, R&D and performance: A study on French and Swedish firms", *Labour Economics*, 8: 443-462.
- Ballot G, Bresson G., Fakhfakh F. and Hammoudi A.(2001), *Investissement en capital humain et R&D, formes de l'innovation et exportations*, Commissariat Général du Plan, Mars.
- Barrett, A. and O'Connell, P.J. (2001), "Does training generally work? The returns to in-company training", *Industrial and Labor Relations Review*, 54:647-662.
- Barron, J.M., Black, D.A. and Loewenstein, M.A. (1989), "Job matching and on-the-job training", *Journal of Labor Economics*, 7: 1-19.
- Barron, J.M., Berger, M.C. and Black, D.A. (1997), *On-the-job training*, Kalamazoo: W.E. Upjohn Institute for Employment Research.
- Bartel, A.P. (1994), "Productivity gains from the implementation of employee training programs", *Industrial Relations*, 33: 411-425.

- Bartel, A.P. (1995), "Training, wage growth, and job performance: Evidence from a company database", *Journal of Labor Economics*, 13: 401-425.
- Becker, G. S. (1964), *Human capital: A theoretical and empirical analysis, with special reference to education*, New York: Columbia University Press and the NBER.
- Beret, P. and Dupray, A. (1998), *Valorisation salariale de la formation continue en France et en Allemagne*, LEST WP 98/6.
- Bishop, J.H. (1991), *Employer training and skill shortages: A review of the state of knowledge*, Center for Advanced Human Resource Studies Working Paper 91-32, Cornell University.
- Bishop, J.H. (1996), *What we know about employer-provided training? A review of the literature*, Center for Advanced Human Resources Studies Working Paper 96-09, Cornell University.
- Black, S.E. and Lynch, L.M. (1996), "Human-capital investments and productivity", *American Economic Review, Papers and Proceedings*, 86: 263-267.
- Blanchflower, D.G., Oswald, A.J. and Sanfey, P. (1996), "Wages, profits, and rent-sharing", *Quarterly Journal of Economics*, 111: 227-251.
- Blundell, R. and Bond, S. (1998), "Initial conditions and moment restrictions in dynamic panel data models", *Journal of Econometrics*, 87: 115-145.
- Blundell, R. and Bond, S. (2000), "GMM estimation with persistent panel data :An application to production functions", *Econometric Reviews*, 19 (3): 321-340.
- Blundell, R., Dearden, L., Meghir, C. and Sianesi, B. (1999), "Human capital investment: The returns from education and training to the individual, the firm and the economy", *Fiscal Studies*, 20: 1-23.
- Bosworth B. and Collins S.M., (2003), "The empirics of growth: an update", *Brookings Papers on Economic Activity 2003*, 113-206.
- Braunerhjelm, P. and Eliasson, G. (1998), "Intangible, human embodied capital and firm performance", in G. Eliasson, C. Green, and C. R. McCann (eds.), *Microfoundation of economic growth: A Schumpeterian perspective*, Ann Arbor: University of Michigan Press.
- Boon, M. and van der Eijken, B. (1997), *Employee training and productivity in Dutch manufacturing firms*, paper presented at the Panel Data Econometrics Conference, Paris, June 18-19.
- Booth, A. L. and Snower, D. (eds.) (1996), *Acquiring Skills: Market Failures, their Symptoms, and Policy Responses*, Cambridge: Cambridge University Press.
- Carriou, Y. and Jeger, F. (1997), "La Formation Continue Dans les Entreprises et son Retour sur Investissement", *Economie et Statistique*, 303: 45-58.
- Conti G. (2005), "Training, productivity and wages in Italy", *Labour Economics*, 12 (4): 557-576.
- Dearden L., Reed H., and Van Reenen, J. (2000), *Who gains when workers train? Training and productivity in a panel of British industries*, The Institute for Fiscal studies Working Paper 00/04.

- Dearden, L., Reed H., and J. Van Reenen, J. (2005), *The impact of training on productivity and wages: Evidence from British panel data*, Center for Economic Performance Discussion Paper No. 674, February.
- Delame, E. and Kramarz, F. (1997), "Entreprises et Formation Continue", *Economie et Statistique*, 127: 63-82.
- Dobbelaere, S. (2003), *Joint Estimation of Price-Cost Margins and Union Bargaining Power for Belgian Manufacturing*, Working Papers of Faculty of Economics and Business Administration, Ghent University.
- Fougère, D., Goux, D. and Maurin, E. (2001), "Formation continue et carrières salariales: Une évaluation sur données individuelles", *Annales d'Économie et de Statistique*, 62: 49-69.
- Gauron, A. (2000), *Rapport sur la formation professionnelle continue*, Conseil d'Analyse Economique.
- Godard J. (2004), "A critical assessment of the high-performance paradigm", *British Journal of Industrial Relations*, 42(2), 349-378.
- Goux, D. and Maurin, E. (1997), "Les entreprises, les salariés et la formation continue", *Economie et Statistique*, 306, no 6: 13-26.
- Goux, D. and Maurin, E. (2000), "Returns to firms provided training: Evidence from French workers-firm matched data", *Labour Economics*, 7: 1-19.
- Griliches, Z. and Mairesse, J. (1997), "Production functions: The search for identification", in S. Strom (ed.), *Essays in Honour of Ragnar Frisch*, Econometric Society Monograph D series, Cambridge: Cambridge University Press.
- Groot, W. (1999), "Productivity effects of enterprise-related training", *Applied Economics Letters*, 6: 369-371.
- Guest D.A., Michie J., Conway N. and Sheehan M. (2003), "Human resource management and corporate finance in the UK", *British Journal of Industrial Relations*, 41(2): 291-314.
- Hellerstein, J.K. and Neumark, D. (1998), "Wage discrimination, segregation, and sex differences in wages and productivity within and between plants", *Industrial Relations*, 37: 232-260.
- Hellerstein, J.K., Neumark, D. and Troske, K.R. (1999), "Wages, productivity, and worker characteristics: Evidence from plant-level production functions and wage equations", *Journal of Labor Economics*, 17: 409-446.
- Hildreth, A.K.G. and Oswald, A.J. (1997), "Rent-sharing and wages: Evidence from company and establishment panels", *Journal of Labor Economics*, 15: 318-337.
- Holmlund, B. (1984), *Labor Mobility, Studies of Labor Turnover and Migration in the Swedish Labor Market*, Stockholm: IUI.
- Holmström B., and Milgrom P. (1994), "The firm as an incentive system", *American Economic Review* 84(4), September, 972-991.
- Holzer, H.J. (1990), "The determinants of employee productivity and earnings", *Industrial Relations*, 29: 403-422.

- Holzer, H.J., Block, R.N., Cheatham, M. and Knott, J.H. (1993), "Are training subsidies for firms effective? The Michigan experience", *Industrial and Labor Relations Review*, 46: 625-636.
- Ichniowski, C., Shaw K., and Prennushi P. (1997), "The effects of human resource management practices on productivity: A study of steel finishing lines", *American Economic Review*, 87 (3), 291-313.
- Kazamaki-Ottersten, E., Lindh, T. and Mellander, E. (1999), "Evaluating firm training, effects on performance and labour demand", *Applied Economic Letters*, 6: 431-437.
- Loewenstein, M. A. and Spletzer, J.R. (1999), "General and specific training: Evidence and application", *Journal of Human Resources*, 24: 710-733.
- Lynch, L.M. (ed.) (1994), *Training and the Private Sector*, NBER Comparative Labor Market Series, Chicago and London: University of Chicago Press.
- Margolis, D.N. and Salvanes, K.G. (2001), *Do firms really share their rents with their workers?* Norwegian School of Economics and Business Administration Working Paper No. 11/2001, Oslo.
- McDonald, I.M. and Solow, R. (1981), "Wage bargaining and employment", *American Economic Review*, 71: 896-908.
- Regner, H. (1994), *The impact of on the job training on the tenure-wage profile and job mobility - does the distinction between general and firm specific human capital really matter?* Mimeo, The Swedish Institute for Social Research, Stockholm.
- Stevens, M. (1994a), "A theoretical model of on-the-job training with imperfect competition", *Oxford Economic Papers*, 46: 537-562.
- Stevens, M. (1994b), "An investment model for the supply of training by employers", *Economic Journal*, 104: 556-570.
- Temple, J. (1999), "The new growth evidence", *Journal of Economic Literature*, 37: 112-156.
- Van Reenen, J. (1996), "The creation and capture of rents: Wages and innovation in a panel of U.K. companies", *Quarterly Journal of Economics*, 111: 195-226.

Appendix: Wage determination

Wage determination is modeled as a bargain between the firm and workers (see, for example, McDonald and Solow, 1981). The expected utility of a risk-neutral representative worker is defined as

$$[A1] \quad U_i = (L/N)w + ((N-L)/N)w^*$$

where L is the number of employed workers, N the total number of workers, w the (real) wage rate, and w^* the outside option (for example the unemployment benefit, or the real wage rate the worker could get elsewhere). The ratio L/N defines the probability that the worker would be employed. The objective of the union (and/or the group of workers) is to maximize their total utility:

$$[A2] \quad U = NU_i = Lw + (N-L)w^*$$

The Nash bargain for risk neutral workers can be written as

$$[A3] \quad U - U^*$$

where U^* represents the fallback position of workers, i.e., $U^* = Nw^*$.

The firm's profit function is defined as

$$[A4] \quad \Pi = Q - wL$$

where Q is real value added (the product price is normalized to 1). The fallback position of the firm is no profit. Then, the Nash bargaining solution can be found by maximizing the following Nash product (Ω) with respect to w and L :

$$[A5] \quad \max \Omega = (U - U^*)^f \Pi^{1-f}$$

where f is the relative bargaining power of the worker, $f \in \{0, 1\}$. Since $U - U^* = (w - w^*)L$, at the interior optimum, the following first order conditions hold:

$$[A6] \quad \partial\Omega/\partial w = 0 \Rightarrow f / (w - w^*) - (1-f)L / (Q - wL) = 0$$

$$[A7] \quad \partial\Omega/\partial L = 0 \Rightarrow (f / L) + (1 - f)(Q_L - w)/(Q - wL) = 0$$

where $Q_L = dQ/dL$.

Equation A6 can be re-written as follows:

$$[A8] \quad w = (1-f)w^* + f(Q/L)$$

Equation A8 defines the wage equation. The wage rate depends on the productivity of the firm (Q/L), the bargaining power of workers (f) and the outside wage (w^*). The effects of investment in tangible (fixed capital) and intangible assets (R&D and human capital) on wages can be obtained by differentiating the wage equation with respect to the stock of the asset, S ($S = K, R, H$), which is given by

$$[A9] \quad w_S = [(1-f)w^*_S L + f_S(Q - w^*L) + f(Q_S - L_S(Q/L))] / L$$

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., $f > 0$.

Table 1. Descriptive statistics

Label	Variable definition	Unit	Average	Min	Max
France (n=527)					
LPROD	Productivity, VA per employee	1000 FF	216,7	50,5	3494,6
CAPITAL	Fixed capital stock per employee	1000 FF	99,9	5,0	5580,0
TRAIN	Training stock per employee	1000 FF	10,5	0,3	47,3
TRAIN FLOW	Annual training expenditures per employee	1000 FF	2,8	0,5	8,8
R&D	Proportion of researchers	(%)	2,0	0,0	33,0
EMP	Number of employees		2596	303	77448
WAGE	Annual average wage rate per employee	1000 FF	89,3	49,9	179,2
Sweden (n=987)					
LPROD	Productivity, VA per employee	1000 SEK	461,0	51,3	2710,6
CAPITAL	Fixed capital stock per employee	1000 SEK	380,0	22,7	5694,3
TRAIN	Training stock per employee	1000 SEK	7,7	0,2	69,7
TRAIN FLOW	Annual training expenditures per employee	1000 SEK	2,0	0,0	24,2
R&D	R&D stock per employee	1000 SEK	36,9	0,1	1184,6
EMP	Number of employees		639	20	21241
WAGE	Annual average wage rate per employee	1000 SEK	201,2	45,5	406,4

Note: Geometric averages are used.

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	0,263	9,85 **	0,327	25,60 **	0,349	57,50 **	0,321	40,70 **	0,276	20,60 **
TRAIN	0,131	3,55 **	0,194	25,00 **	0,173	21,40 **	0,224	14,40 **	0,118	5,47 **
R&D	0,135	6,98 **	0,071	10,80 **	0,054	18,00 **	0,045	11,50 **	0,024	3,58 **
TRAIN*R&D	0,067	2,36 ***			0,150	25,20 **	0,125	13,80 **	0,122	10,40 **
TRAIN*CAPITAL	0,076	2,58 **					0,244	38,50 **	0,255	18,60 **
R&D*CAPITAL	0,026	1,69 *					-0,003	0,53	-0,002	0,22
EMP	-0,007	0,40	-0,028	4,63 **	-0,036	6,18 **	-0,013	1,62	-0,017	1,74 *
TRAIN FLOW									0,228	9,49 **
n obs	527		527		527		527		526	
n firms	101		101		101		101		101	
Wald (joint)	348,2 **		4186,0 **		7827,0 **		5052,0 **		968,4 **	
d.f.	8		4		5		7		8	
Sargan			80,5		83,8		90,6		91,4	
d.f.			80		100		140		160	
AR(1)	30,20 **		-2,25 *		-0,05		-0,20		-1,94 *	
AR(2)	21,77 **		-1,03		-0,72		-0,22		-0,04	

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

** (*) means statistically significant at the 1% (5%) level, two-tailed test.

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	-0,021	1,86	0,072	17,50 **	0,077	29,10 **	0,067	20,20 **	0,049	8,80 **
TRAIN	0,126	9,09 **	0,140	23,00 **	0,131	42,20 **	0,147	24,70 **	0,073	7,16 **
R&D	0,080	10,90 **	0,069	24,50 **	0,066	29,20 **	0,062	22,30 **	0,038	8,16 **
TRAIN*R&D	0,060	5,98 **			0,039	22,50 **	0,039	14,20 **	0,049	10,90 **
TRAIN*CAPITAL	0,000	0,01					0,011	3,11 **	0,024	6,29 **
R&D*CAPITAL	0,007	1,15					-0,013	8,97 **	-0,009	4,17 **
EMP	0,021	3,04 **	0,006	0,98	0,008	1,27	0,000	0,07	-0,001	0,11
TRAIN FLOW									0,159	13,20 **
n obs	527		527		527		527		526	
n firms	101		101		101		101		101	
Wald (joint)	674,1 **		3579,0 **		12710,0 **		2677,0 **		3086,0 **	
d.f.	8		4		5		7		8	
Sargan			83,6		90,8		82,6		85,2	
d.f.			80		100,0		140,0		160,0	
AR(1)	27,03 **		-1,47		-1,66		-1,52		-3,55 **	
AR(2)	19,14 **		-0,07		-0,29		-0,24		-0,11	

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

** (*) means statistically significant at the 1% (5%) level, two-tailed test.

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	0,208	11,30 **	0,179	11,20 **	0,176	11,40 **	0,173	14,60 **	0,177	18,10 **
TRAIN	0,081	4,63 **	0,073	3,87 **	0,073	4,87 **	0,065	5,82 **	0,046	6,30 **
R&D	0,057	5,10 **	0,063	5,81 **	0,061	6,83 **	0,055	11,40 **	0,060	13,40 **
TRAIN*R&D	0,005	0,48			0,018	3,42 **	-0,003	0,70	-0,002	0,38
TRAIN*CAPITAL	-0,025	1,37					-0,045	4,66 **	-0,040	5,23 **
R&D*CAPITAL	0,030	2,58 **					0,050	9,95 **	0,049	9,48 **
EMP	0,013	0,92	-0,017	0,90	-0,008	0,46	0,006	0,46	-0,011	1,05
TRAIN FLOW									0,011	3,81 **
n obs	987		954		954		954		954	
n firms	268		235		235		235		235	
Wald (joint)	247,7 **		181,7 **		210,8 **		489,7 **		735,6 **	
d.f.	8		4		5		7		8	
Sargan			84,9		107,9		151,1		173,8	
d.f.			80		100		140		160	
AR(1)	23,75 **		-3,21 **		-3,24 **		-3,27 **		-3,35 **	
AR(2)	16,20 **		0,04		-0,05		-0,45		-0,26	

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

** (*) means statistically significant at the 1% (5%) level, two-tailed test.

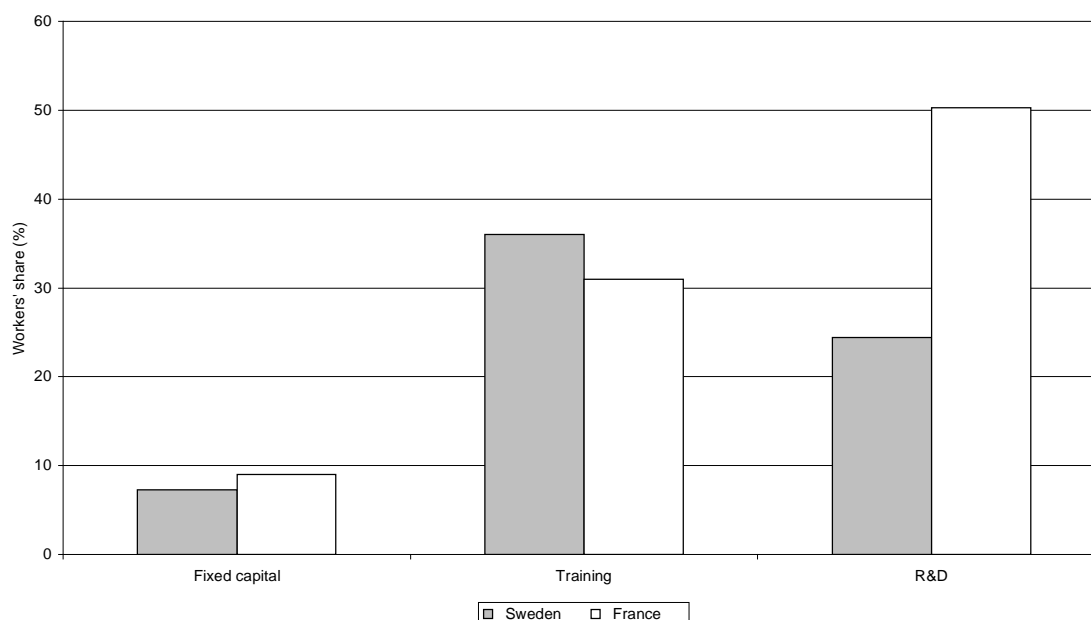
Table 3b. Determinants of wages in Sweden

	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	0,047	6,78 **	0,040	9,98 **	0,030	4,88 **	0,035	8,80 **	0,034	11,00 **
TRAIN	0,048	7,20 **	0,029	4,15 **	0,061	10,50 **	0,063	13,90 **	0,065	19,90 **
R&D	0,032	7,67 **	0,063	9,04 **	0,035	11,50 **	0,035	15,50 **	0,036	20,60 **
TRAIN*R&D	0,010	2,66 **			0,009	4,30 **	0,011	6,77 **	0,009	6,74 **
TRAIN*CAPITAL	0,016	2,34 **					0,014	4,48 **	0,013	4,39 **
R&D*CAPITAL	0,005	1,21					0,003	1,44	0,003	1,60
EMP	-0,001	0,19	-0,011	1,56	-0,004	0,57	-0,006	1,50	-0,017	5,03 **
TRAIN FLOW									0,002	1,78
n obs	987		954		954		954		954	
n firms	268		235		235		235		235	
Wald (joint)	233,1 **		336,9 **		417,5 **		926,2 **		1444,0	
d.f.	8		4		5		7		8	
Sargan			81,5		110,1		140,7		158,0	
d.f.			80		100		140		160	
AR(1)	10,85 **		-2,36 *		-2,39 *		-2,42 *		-2,43 *	
AR(2)	6,86 **		1,30		1,28		1,21		1,23	

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

** (*) means statistically significant at the 1% (5%) level, two-tailed test.

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



¹ Corresponding author. ERMES, Université Paris II, 12, place du Panthéon 75005 Paris, Tel: +33.1.44.41.89.64, Fax: + 33.1.40.51.81.30, email: gerardballot@wanadoo.fr

² This issue is partly covered by the rent sharing literature; see for an excellent example, van Reenen (1996).

³ See Temple (1999) for a survey, and Bosworth and Collins (2003) for a recent reassessment.

⁴ See Acemoglu and Pischke (1998, 1999a) for comprehensive reviews of labour market imperfections, and Ballot (1994) for a hypothesis based on the innovation rent in the product market.

⁵ The only similar study we know of is Dearden, Reed and Van Reenen (2000 and 2005), but they use data at the sector level.

⁶ 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.

⁷ For a recent work, see Guest *et al.* (2003).

⁸ Besides these losses, training capital undergoes obsolescence as time elapses. Since we have no measure of the rate of depreciation, we have experimented with several uniform rates, and the results were not affected. Therefore we present results without obsolescence, but with depreciation due to separations.

⁹ “The proportion of researchers in the firm” is used as a measure of the stock of R&D, because no direct measure of R&D stock is available. In our previous studies (see Ballot, Fakhfakh and Taymaz, 1998 and 2001) we used “the stock of R&D” as defined in the social accounts. The main problem of the data in social accounts is the fact that it does not cover all R&D performers, and, hence, cannot be matched with other data sets we use.

¹⁰ The main source of the data for French firms is “Human Resources Accounts” (“*Bilans sociaux*”) that each firm employing more than 300 employees must fill in for the Labour Inspection in France. ERMES (Equipe de Recherche sur les Marchés, l’Emploi et la Simulation), <http://www.u-paris2.fr/ermes> has collected the Human Resources Accounts from a set of firms since 1983, and has matched it with other databases, financial accounts and the Structure of Employment surveys, that were provided by the National Institute of Statistics (INSEE). The Swedish data have been collected by IUI (Industriens Utredningsinstitut, <http://www.iui.se>) since 1987 by a special survey. The anonymised data set used in this study is available from the corresponding author upon request. We thank ERMES and IUI for giving us access to their proprietary databases.

¹¹ Holmlund (1984, figure 2.4) finds a monthly separation rate of 9% (corresponding to an annual rate of 10.8%) in 1982 for white collar employees.

¹² 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.

¹³ We use the DPD package for Ox [<http://www.nuff.ox.ac.uk/users/Doornik/>].

¹⁴ 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.

¹⁵ Since all variables are used as deviations from their sample averages, the coefficients of training and R&D variables measure output/wage elasticities at the geometric mean of the sample. The average rates of return on fixed capital, R&D and human capital can be calculated from output elasticities for sample averages (presented in Table 1). For example, the average rate of return on human capital, $\partial Q/\partial H$, is equal to $\eta_H(Q^a/H^a)$ where η_H is the estimated human capital elasticity of output, Q^a sample average of value added and H^a sample average of training stock.

¹⁶ We took into consideration the interaction effect of training and R&D in calculating workers' share in returns to investment in fixed capital, R&D, and training.

¹⁷ We thank Kathryn Shaw for her comments on these issues.

¹⁸ When the current training variable is included, we observe a significant decline in the coefficient of the human capital variable, because current training expenditures (TRAIN FLOW) account for about 25 % of the human capital stock (TRAIN) in France and Sweden (calculated from Table 1).

¹⁹ If small and large firms operate on the same production function (as it is normally assumed to be the case), then the productivity impact of training will be the same for small and large firms. The outside wage is likely to be independent of the firm size because it depends on the human capital of the worker. Thus, the impact of training on wages will be different for small and large firms only if the bargaining power of workers differs by firm size.