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The Spillover Effect of Training Within the Firm

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Abstract

Our study proposes a transmission of knowledge learnt during a formal training program to other employees of the firm. Thus, we present a model that highlights a double effect of training investment of a firm : a direct effect on trainees' productivity and an indirect effect on the productivity of the whole workforce, thanks to the spillover effect of training. Our analysis emphasizes the opportunity for the employer to extract a rent from this training externality in order to finance the costs of general training. An empirical study confirms some predictions of our model.

Key Words : Job training, Spillover effect, Human capital, Training costs

JEL Classification: J24, J31, D24,

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1 Introduction

Becker's model of human capital (1964) allows an economic analysis of the training mechanisms. In line with a pure and perfect concurrence framework, Becker takes into account the risk of poaching effect in its analysis. Indeed, the trainees may leave to another firm after the training program. Becker distinguishes general training, that is perfectly transferable (that raise individual productivity on the whole market), from specific training that is not transferable (that increases productivity only in the training firm). As a result, Becker proposes that general training is entirely financed by individual, although the costs of specific training may be shared between the employer and the employee. Nevertheless, these financing conditions are called into question. Empirical studies highlight that employer may finance general training (Barron J, Berger M. and Black D. (1999), Barron J., Black D. and Loewenstein M. (1989), Booth A. and Bryan M. (2002), Veum J. (1999), Loewenstein M. and Spletzer J. (1998a)). Then, theoretical models of imperfect concurrence are then proposed in the literature to explain the fact that employer finance general training. The idea of these model is to assume that employee are paid under their marginal productivity in other firms and as a result, employer may extract a rent from this to finance part of the general training. The reasons of the rent are various. Firstly, the rent may be explained by informational asymmetries, either about the training content (Katz E. and Ziderman A. (1990); Chang C. and Wang Y. (1996)) or about the abilities of the employee (Acemoglu D. and Pischke J-S. (1998)). Secondly, minimum salary (Acemoglu D. and Pischke J-S. (2003)), trade unions (Booth A. and Chatterji M. (1998) or transaction costs (Acemoglu D. (1997), Acemoglu and Pischke (1999b)), can lead to a compression of the wage structure, that allows to get a rent. Lastly, efficiency wages (Acemoglu D. and Pischke J-S. (1999a)), the guarantee of a future minimum wage (Loewenstein M. and Spletzer J. ((1998b)), or the heterogeneity of the firms (Stevens M. (1994)) minimize employee's mobility, and then the risk of a poaching effect.

Our study proposes another explanation of general training financed by employer: the spillover effect of training within the firm.

The literature on education considers a transmission effect between children of the same class (Benabou (1996)). Indeed, the children of the same class do not grow up independently. There are interactions i.e knowledge transmission between children that share the same environment. Moreover, several empirical studies highlight the effect of the average human capital of the firm on the individual wage ((Nordman (2002), Joumady and Ris

(2005)). The average human capital of the firm is often considered as a partial measure of the informal training, like the learning by watching. Thus, our article assumes also a diffusion of knowledge within the firm, as Lévy-Garboua (1994), and the originality of our study is about the source of informal training: a spillover effect of the formal training. Indeed, our paper proposes that knowledge learnt during a formal training can be transmitted to other employees within the firm.

Considering this transmission effect, our paper underlines a double effect of the training investment of the firm: a direct effect on trainees' productivity but also an indirect impact on the productivity of the whole workforce. Furthermore, if transmitted skills and competencies are firm specific, then we can consider a training externality within the firm. Becker's model and its predictions are modified with the introduction of a training externality. The employer can extract a rent from training externality to pay part of general training costs. We highlight another explanation of general training financed by employer.

In the section II of this article, we precise the assumptions of our model. Section III presents the model and its implication for the analysis of training mechanisms. Then, we propose to test some predictions of our model. The methodological framework of our empirical study is described in the section IV. The results are exposed in the section V, and we conclude in the section VI.

2 The assumptions

The output Y of a firm is defined by a Cobb Douglas function, with two inputs, the physical capital K , and the human capital H (1). The parameter A represents the specific characteristics of the firm, as its technology. $0 < \alpha < 1$ is the part of the physical capital in the output function and $0 < 1 - \alpha < 1$ is the part of the human capital in the output function.

$$Y_t = AK_t^\alpha H_t^{1-\alpha} \quad (1)$$

We assume that the firm do not recruit or lay off, to simplify the model. The study of D'Autume and Michel (1994) help us to model our assumptions.

2.1 Assumption 1

First of all, we assume that the human capital of the firm H is the sum of individual human capital h_i , weighted by the working time devoted to production of each individual i at the time t , $u_{i,t}$, according to a degree of complementarity, $1/\gamma$ (with $\gamma > 1$), between employees' human capital to product. μ is the human capital distribution of the labour force (2). Traditionally, the human capital of the firm is defined as a simple sum of individual human capital, and then it is assumed a perfect substitutability of individual human capital within the firm for the production Y . This assumption is nevertheless not realistic. Indeed, as D'Autume and Michel (1994) says, « the technician and the unskilled worker need each other to product ».

$$H_t = \left[\int_0^{\infty} (u_{i,t} \cdot h_{i,t})^{\frac{\gamma-1}{\gamma}} d\mu_t(h) \right]^{\frac{\gamma}{\gamma-1}} \quad (2)$$

2.2 Assumption 2

Secondly, our model takes into account informal training in the equation of human capital accumulation. Informal training contains several processes presented in Destré (2002). We focus on three of them : the learning by research and critical thinking, the learning by watching, and the learning by doing. The equation of individual human capital accumulation, $h_{i,t+1}$, is defined as follows (3).

$$h_{i,t+1} = f(1-d-u_{i,t}, h_{i,t}) h_{i,t}^{\beta} (\bar{h}_{i,t})^{1-\beta} \quad (3)$$

The human capital of the employee i , at time $t+1$, depends on its initial human capital $h_{i,t}$, and on a stock of knowledge learnt informally. As Benabou (1996) represents the spillover effect between children of the same neighbourhood with the average human capital of the neighbourhood, we propose the average human capital of the firm, \bar{h} , as a measure of the informal knowledge. These two components, $h_{i,t}$ and \bar{h} are weighted by a function $f(\cdot)$ representing the returns of formal job training. d is the working time devoted to the diffusion of knowledge between employees and $1-d-u_{i,t}$ is the working time devoted to job training between t and $t+1$. The training returns $f(\cdot)$ are increasing and concave with the working time

devoted to training. $\frac{\partial f(.)}{\partial 1-d-u} > 0$ and $\frac{\partial^2 f(.)}{\partial (1-d-u)^2} < 0$. Moreover, the training returns are heterogeneous according to individuals, i.e. according to their human capital levels. We also assume that human capital does not depreciated with time. The parameter $0 < \beta < 1$, represents the part of the human capital in the human capital accumulation and $0 < 1 - \beta < 1$ is the part of informal training in the human capital function. It refers to the organization of the firm, and its method of production (team or individual method), that may favour or slow down the exchanges between employees.

2.3 Assumption 3

Thirdly, we assume, as Benabou (1996), that, \bar{h} , the average human capital of the firm, is a CES function (4), i.e. a geometric mean of individual human capital, according to a degree of complementarity $1/\rho$ between human capital levels.

$$\bar{h}_t = \int_0^{\infty} [h_{i,t}^{\frac{\rho-1}{\rho}} d\mu_t(h)]^{\frac{\rho}{\rho-1}} \quad (4)$$

This expression emphasizes the effect of human capital heterogeneity within the firm in the human capital accumulation. Indeed, according to the complementary of the human capital, the transmission effect of knowledge can be more or less possible. Indeed, when $(1/\rho)$ grows to $+\infty$, \bar{h}_t is a Min function, where as says Benabou (1996) “one bad apple spoils the bunch”, and when $1/\rho$ decreases to $-\infty$, \bar{h}_t is a Max function, where “the best individual sets the standard” (Benabou (1996)). Finally, we assume as Benabou (1996) that the distribution of human capital $\mu_t(h)$ is and remains lognormal, with m the arithmetic mean and σ the standard deviation (5).

$$\ln h_{i,t} \rightarrow N(m_t, \sigma_t) \quad (5),$$

Then the average human capital of the firm can be expressed as (6) :

$$\bar{h}_t = \exp\left(m_t + \frac{(\rho-1)}{2\rho} \sigma_t^2\right) \quad (6)$$

2.4 Assumption 4

Finally, knowledge learnt during a formal training may be spread to other employees. Nevertheless, we assume that these knowledge are not transferable to other firms for two reasons. Firstly, even if training is general, skills and competencies transmitted informally to colleagues, are more likely directly applicable to product, and are then more specific to the firm. Secondly, we can think as Katz and Ziderman (1990), that these knowledge are hard to observe for other employers and then they are not transferable on the market, as specific training.

3 The model

3.1 Proposition 1

a) Employees' productivity are interdependent within the firm. Indeed, there is a common component in employees' marginal productivity. The equation (7) underlines firstly that individual marginal productivity depends on the global human capital of the firm, H_t , and consequently on the complementarity of individual productivities to product. Secondly, employee's productivity depends on its own accumulated human capital that is influenced by the average human capital of the firm, and thus by other employees' productivities.

$$\frac{\partial Y}{\partial u_{i,t}} = A(1-\alpha)K_t^\alpha H_t^{\frac{1}{\gamma}-\alpha} u_{i,t}^{\frac{-1}{\gamma}} h_{i,t}^{\frac{\gamma-1}{\gamma}} = mp_{i,t} \quad (7)$$

b) There is a double effect of training investment of the firm : a direct effect by increasing trainees' productivity and an indirect effect by modifying the average human capital of the firm.

Proof (b) : Individual human capital is defined with (3) :

$$h_{i,t+1} = f(1-d-u_{i,t}, h_{i,t}) h_{i,t}^\beta (\bar{h}_t)^{1-\beta} \quad (3)$$

The equation of the average human capital is (6) :

$$\bar{h}_t = \exp\left(m_t + \frac{(\rho-1)}{2\rho} \sigma_t^2\right) \quad (6)$$

and according to the proprieties of lognormal distribution, we have (8) :

$$\ln \bar{h}_t = m_t + \frac{(\rho-1)}{2\rho} \sigma_t^2 \quad (8)$$

Then, with (3) and (8),

$$m_{t+1} = m_t + (1-\beta) \ln d + E(\ln f(1-d-u_{i,t}, h_{i,t})) + (1-\beta) \frac{\rho-1}{2\rho} \sigma_t^2 \quad (9)$$

$$\sigma_{t+1}^2 = \beta^2 \sigma_t^2 + \text{Var}(\ln(f(1-d-u_{i,t}, h_{i,t}))) \quad (10)$$

The arithmetic mean of human capital in a firm after the training investment, is increased firstly by the average return of training, $E(\ln(f(1-d-u_{i,t}, h_{i,t})))$, is increased or reduced secondly by the impact of inequalities within the firm, σ_t^2 , according to the degree of complementarity of individual human capital, $1/\rho$, and thirdly depends also on the working time devoted to knowledge diffusion with colleagues d . Concerning the dynamics of inequalities, there are repeated at a rate β^2 , and are increased by the inequalities of training returns $\text{Var}(\ln(f(1-d-u_{i,t}, h_{i,t})))$, that refer to disparities in access to training participation and to heterogeneity of training returns. Thus the dynamic of the average human capital of the firm is defined by the equation (11) and can be simplified with the equation (12).

$$\bar{h}_{t+1} = \bar{h}_t \cdot d^{(1-\beta)} \exp\left[\frac{\beta(\beta-1)(\rho-1)}{2\rho} \sigma_t^2\right] \cdot \exp\left[E(\ln f(1-d-u_{i,t}, h_{i,t})) + \frac{\rho-1}{2\rho} \text{Var}(\ln f(1-d-u_{i,t}, h_{i,t}))\right] \quad (11)$$

$$\bar{h}_{t+1} = \bar{h}_t \cdot d^{(1-\beta)} \exp\left[\frac{\beta(\beta-1)(\rho-1)}{2\rho} \sigma_t^2\right] \cdot E \quad (12)$$

$$\text{with } E = \exp\left[E(\ln f(1-d-u_{i,t}, h_{i,t})) + \frac{\rho-1}{2\rho} \text{Var}(\ln f(1-d-u_{i,t}, h_{i,t}))\right] \quad (13)$$

The average human capital of the firm is increased by E (13), after the training investment of the firm.

The individual human capital accumulation at time $t+2$, i.e after the training investment and the spillover effect is (14):

$$h_{i,t+2} = h_{i,t+1}^\beta (\bar{h}_{t+1})^{(1-\beta)} \quad (14)$$

With (3) and (12):

$$h_{i,t+2} = f(1-d-u_{i,t}, h_{i,t})^\beta \cdot h_{i,t}^{\beta^2} \cdot d^{2(1-\beta)} \cdot \bar{h}_t^{1-\beta^2} \cdot \exp\left[\frac{\beta(\beta-1)(\rho-1)}{2\rho} \sigma_t^2\right] \cdot E^{1-\beta} \quad (15)$$

This equation highlights the two effects of training investment of the firm: the direct effect $f(1 - d - u_{i,t}, h_{i,t})$ for the trainees, and the indirect effect $E^{(1-\beta)}$ for the whole labour force.

3.2 Proposition 2

Definition 1:

To analyse the mechanisms of training, Becker's model starts from the equality between the wage W and the marginal productivity MP of an individual: $MP = W$, or other says, the expenses and the receipts of the firm. When firm invests in training, the equilibrium condition of the intertemporal maximisation of the profit is as follows (17), and simplified with (18) according to Becker's model:

$$MP'_0 + \sum_{t=1}^{n-1} \frac{MP_t}{(1+r)^t} = W_0 + \sum_{t=1}^{n-1} \frac{W_t}{(1+r)^t} + C \quad (17)$$

$$MP'_o + G = W_o + C \quad (18)$$

with $G = \sum_{t=1}^{n-1} \frac{MP_t - W_t}{(1+r)^t}$, that represents the training returns of the firm and with

$C = MP'_0 - MP_0 + k$. C is the total training costs, composed of k , the direct training costs and the opportunity costs, $MP'_0 - MP_0$, i.e. the difference between the output obtained when the working time is devoted to production with the output realized when there is a part of the production time devoted to training. Becker considers this equilibrium condition at the individual and firm levels. There is no distinction between this two levels of analysis.

Proposition 2 :

a) We assume that trainees can spread knowledge learnt during the training programs to other employees of the same firm, and these knowledge are considered firm specific (assumption 4). Individual productivity may increase for free thanks to the spillover effect, and the individual and the employer have the advantage of a training externality. This externality E , must be considered in the intertemporal maximisation of the profit. Considering that all employees may get the training externality, it is better to express the equilibrium condition at the firm level, in order to emphasized the global effect of the training externality. The equilibrium condition is as follow (19)

$$\begin{aligned}
& \sum_{i=1}^{n_s} mp_{s,t} + \sum_{i=1}^{n_f} mp'_{f,t} + E^{\frac{(1-\beta)(\gamma-1)}{\gamma}} \left[\sum_{t=t}^{t+2} \sum_{i=1}^{n_s} \frac{mp_{s,t+2}}{(1+r)^t} + \sum_{t=t}^{t+2} \sum_{i=1}^{n_f} \frac{mp_{f,t+2}}{(1+r)^t} \right] = \\
& = \sum_{i=1}^{n_s} w_{s,t} + \sum_{t=t}^{t+2} \sum_{i=1}^{n_s} \frac{w_{s,t+2}}{(1+r)^t} + \sum_{i=1}^{n_f} w_{f,t} + \sum_{t=t}^{t+2} \sum_{i=1}^{n_f} \frac{w_{f,t+2}}{(1+r)^t} + \sum_{i=1}^{n_f} c(1-d-u_{f,t}) \quad (19)
\end{aligned}$$

The equilibrium condition of Becker's model (17) is modified with the training externality, and Becker's model is a special case of our model, when there is no training externality, i.e. no spillover effect of the formal training.

Proof (a): For a trainee, indexed f , his marginal productivity $mp_{f,t}$ before the training investment t , is expressed by (20). The equation (21) is trainee's marginal productivity, if there is no working time devoted to training, i.e when its working time is as a non trainee's working time (indexed s).

$$mp_{f,t} = \Omega_t \cdot u_{f,t}^{\frac{-1}{\gamma}} \cdot h_{f,t}^{\frac{\gamma-1}{\gamma}} = mp_{f,t} \quad (20) \text{ and } mp'_{f,t} = \Omega_t \cdot u_{s,t}^{\frac{-1}{\gamma}} \cdot h_{f,t}^{\frac{\gamma-1}{\gamma}} = mp'_{f,t} \quad (21)$$

$$\text{with } \Omega_t = A(1-\alpha)K_t^\alpha H_t^{\frac{1-\alpha}{\gamma}}$$

After the training investment, trainee's marginal productivity is expressed as follows (22).

$$mp_{f,t+2} = \Omega_{t+2} \cdot u_{f,t+2}^{\frac{-1}{\gamma}} \cdot [f(1-d-u_{f,t}, h_{f,t})^\beta \cdot h_{f,t}^{\beta^2} \cdot d^{(1-\beta)\beta} \bar{h}_t^{1-\beta^2} \cdot E^{1-\beta}]^{\frac{\gamma-1}{\gamma}} = mp_{f,t+2} \cdot E^{\frac{(1-\beta)(\gamma-1)}{\gamma}} \quad (22)$$

$$\text{with } \Omega_{t+2} = A(1-\alpha)K_{t+2}^\alpha H_{t+2}^{\frac{1-\alpha}{\gamma}}$$

So for a trainee, the equilibrium condition is (23), with the training costs, $c(1-d-u_{f,t})$, and

with $\frac{\partial c(1-d-u)}{\partial 1-d-u} > 0$ and $\frac{\partial^2 c(1-d-u)}{\partial (1-d-u)^2} > 0$. The training costs are a increasing and convex function of the time devoted to training.

$$mp'_{f,t} + \sum_{t=t}^{t+2} \frac{mp_{f,t+2} \cdot E^{\frac{(1-\beta)(\gamma-1)}{\gamma}}}{(1+r)^t} = w_{f,t} + \sum_{t=t}^{t+2} \frac{w_{f,t+2}}{(1+r)^t} + c(1-d-u_{f,t}) \quad (23)$$

For a non trainee, indexed s , marginal productivity before the training investment, $mp_{s,t}$, is expressed by (24). After the training investment, non-trainee's marginal productivity is as (25).

$$mp_{s,t} = \Omega_t \cdot u_{s,t}^{\frac{-1}{\gamma}} \cdot h_{s,t}^{\frac{\gamma-1}{\gamma}} = mp_{s,t} \quad (24)$$

$$mp_{s,t+2} = \Omega_{t+2} \cdot u_{s,t+2}^{\frac{-1}{\gamma}} \cdot [h_{s,t}^{\beta^2} \cdot d^{(1-\beta)\beta} \bar{h}_t^{1-\beta^2} \cdot E^{1-\beta}]^{\frac{\gamma-1}{\gamma}} = mp_{s,t+2} \cdot E^{\frac{(1-\beta)(\gamma-1)}{\gamma}} \quad (25)$$

So the equilibrium condition for a non trainee is (26):

$$mp_{s,t} + \sum_{t=t}^{t+2} \frac{mp_{s,t+2} \cdot E^{\frac{(1-\beta)(\gamma-1)}{\gamma}}}{(1+r)^t} = w_{s,t} + \sum_{t=t}^{t+2} \frac{w_{s,t+2}}{(1+r)^t} \quad (26)$$

As a result, on the one hand, the equilibrium condition of the firm corresponds to the receipts of the firm, that are the sum of non-trainees' marginal productivity before, t , and after the training program, $t+2$, plus the sum of trainees' marginal productivity before the training investment if they would not have been trained, mp' , and after the training program. On the other hand, the expenses of the firm contain the sum of the trainees' and non trainees' wage before and after the training program, plus the training costs that are composed of the direct costs and the opportunity costs, $mp'_{f,t} - mp_{f,t} \cdot n_f$ is the number of trainees in the firm, n_s is the number of non trainees, and r is the rate of actualisation. Then, the equilibrium condition of the firm is (27).

$$\begin{aligned} \sum_{i=1}^{n_s} mp_{s,t} + \sum_{t=t}^{t+2} \sum_{i=1}^{n_s} \frac{mp_{s,t+2} \cdot E^{\frac{(1-\beta)(\gamma-1)}{\gamma}}}{(1+r)^t} + \sum_{i=1}^{n_f} mp'_{f,t} + \sum_{t=t}^{t+2} \sum_{i=1}^{n_f} \frac{mp_{f,t+2} \cdot E^{\frac{(1-\beta)(\gamma-1)}{\gamma}}}{(1+r)^t} = \\ = \sum_{i=1}^{n_s} w_{s,t} + \sum_{t=t}^{t+2} \sum_{i=1}^{n_s} \frac{w_{s,t+2}}{(1+r)^t} + \sum_{i=1}^{n_f} w_{f,t} + \sum_{t=t}^{t+2} \sum_{i=1}^{n_f} \frac{w_{f,t+2}}{(1+r)^t} + \sum_{i=1}^{n_f} c(1-d-u_{f,t}) \end{aligned} \quad (27)$$

b) The equilibrium equation allows to determine the equilibrium amount of training investment of the firm $(1-d-u)^*$. This amount of training investment varies according to several parameters. It depends on the training costs and on individual marginal productivity, i.e, on the characteristics of the firm, the training returns, and the training externality. More precisely, we highlight the parameters that may be strong determinants of training externality and then of the training investment.

First of all, $1-\beta$, represents the part of informal training in the individual human capital accumulation, and refers to the organization of the firm. Indeed, according to the organization of the firm (team or individual work), the firm can favour or slow down the

exchanges between employees and then the effects of training externality. Consequently, the differences between small and large firms concerning the training investment can be explained by their organization and the capacity of large firm to promote exchanges.

Secondly, the degree of complementarity between individual human capital, i.e. the degree of human capital heterogeneity, can also favour to some extent the spillover effect. Then, the composition of labour force may also explain the differences in training investment between firms.

Finally, the parameter d is the working time devoted to informal training. The training externality is not infinite, because the time devoted to exchanges is a loss of output. Then, according to d , training externality and then training investment vary.

3.3 Proposition 3

Definition 2 :

Considering the equilibrium equation (19), the employer can determine trainees' and non-trainees' wages, before and after the training investment. Financing conditions of training are defined. We divide the equilibrium condition between trainees and non trainees, to determine their respective wages, according to the market conditions. Conveniently, we assume that trainees get the same wage, and non-trainees earn the same wage.

Proposition 3 :

a) Non-trainees can take advantage of training externality.

Their wages before the training is equal to their marginal productivity $mp_{s,t}$, that is their value on the market (28).

$$w_{s,t} = mp_{s,t} \quad (28)$$

After the training, their wage must equal at least their marginal productivity $mp_{s,t+2}$, because we remember that training externality is not transferable to other firms. Thus, the employer can decide to share a part b of the training externality with non trainees (29).

$$w_{s,t+2} = mp_{s,t} . b E^{\frac{(1-\beta)(\gamma-1)}{\gamma}} \quad (29)$$

b) The employer can finance general training.

For the trainees, the equilibrium condition is (30) with $(1-b)$, representing the part of the training externality that employer decide to share with trainees.

$$w_{f,t} + \sum_{t=t}^{t+2} \frac{w_{f,t+2}}{(1+r)^t} + c(1-d-u_{f,t}) = mp'_{f,t} + (1-b)E^{\frac{(1-\beta)(\gamma-1)}{\gamma}} \sum_{t=t}^{t+2} \frac{mp_{f,t+2}}{(1+r)^t} \quad (30)$$

Two cases are analysed. We present the first one.

Training is assumed general and trainees must be paid to their marginal productivity after the training: $mp_{f,t+2}$. They receive all the training returns, to prevent the poaching effect. Thus the wage before the training investment is (31) :

$$w_{f,t} = mp'_{f,t} - c(1-d-u_{f,t}) + \sum_{t=t}^{t+2} \frac{mp_{f,t+2}}{(1+r)^t} [(1-b)E^{\frac{(1-\beta)(\gamma-1)}{\gamma}} - 1] \quad (31)$$

Contrary to Becker that predicts the costs of general training must be entirely supported by employee, our model implies a share of the costs of general training between the employer and the employee thanks to the training externality.

c) Now, the second case is considered. We assume that trainees cannot pay the training costs, because of a minimum wage, or because of liquidity constraints. Trainees cannot have a wage cut before the training program. Then, trainees' starting wage is equal to their marginal productivity and the employer pay all the training costs. This case is also applicable to France, where employer are compel to finance the training investment up to a minimum amount. The equilibrium condition of the wage after the training is (32):

$$w_{f,t+2} = mp_{f,t+2} (1-b)E^{\frac{(1-\beta)(\gamma-1)}{\gamma}} - c(1-d-u) \quad (32)$$

Whereas the traditional analysis would consider that, in this case, the employer get all the training returns, our model proposes a share of the training returns between the employer and the employee, thanks to the training externality.

d) The share of the training externality depends on the risk of employee's mobility. When the employer shares a part of the training returns with a employee, then employee's mobility is reduced. Indeed, as training externality is firm specific, then the wage earned in the training firm is over the wage that can expect an employee with another firm. Thus, the optimal share of the training externality b^* depends on the risk of employee's mobility, and lead to three remarks.

First of all, as training externality allows to minimize the risk of poaching effect, it is then more likely, that employer prefers to share the training externality with trainees rather than with non trainees.

Secondly, among trainees, the employer will share more likely the training externality with trainees that get the highest training returns or that maximise the spillover effect. Indeed, employer want likely to keep in his firm employees who generate the highest training externality.

Finally, among non trainees, the employer will prefer to share the training externality with employees who have the most important rise of their productivity thanks to the training externality, in order to maximize their rent.

e) Our model proposes also some explication of the selection of training participants. First of all, the selection of the trainees, depends on the degree of complementarity of individual human capital $\frac{1}{\rho}$. Indeed, according to this parameter, it may be better for example to train the most qualified employees, because the spillover effect would be stronger. Secondly, it may also be better to train individuals that have the highest training returns.

4 The methodological framework

4.1 The surveys and the sample

Three French micro data surveys are used in our paper: *Labour Force Survey 2000* and *1999*. They follow individuals from the 1st of March 1998 to the 1st of March 2000. The survey *Adult Education Survey 2000* is a complementary survey of *Labour Force Survey 2000*. The participation to training programs since individuals finished school are reported and the training programs occurring from the 1st of January 1999 to the 29th of February 2000 are precisely described. Individuals interviewed in the three surveys are selected.

However, several restrictions are made in order to homogenize the considered population. First of all, the training programs for non-professional purposes and the training programs given partly in education institution and partly in the workplace are excluded. We

consider individuals aged between 15 and 65, who have a job since 1998, and who are employed in the private sector since 1998. Observations with missing or absurd responses are excluded from the sample. 5357 individuals are then considered.

There is 41% of women in our sample. The average tenure is of 12,5 years. 87% of the sample work full-time, and 95,5% has a permanent contract. There is 15,3% of unskilled workers, 34,7% of skilled workers, 10,3% of technician or supervisor, and 6,1% of executives, engineer. The profession of individuals is essentially production (36,5%) and trade (12,4%). The repartition of individuals according to the size and the industry of the firm is homogeneous.

4.2 The variables

First of all, the training programs should be briefly described in order to understand when and how training occurs. 28,1% of individuals in our sample have taken part in at least one training program from the 1st of January 1999 to the 1st of March 2000. Two thirds of the trainees have known only one training program, which is generally not certified (90,5%). Training duration is quite short (average: 66 hours). Most of training programs are on the employer's initiative (with or without the employees' initiative) (82,1%), are financed principally by the employer (90,8%) and have the objectives to adapt employees to their job (92%). We will focus on the training incidence as measure of training.

Secondly, we focus on the net monthly wage including bonuses of the individuals. The wages distribution reveals a growth of the average wage of 3,8% from 1999 to 2000.

Thirdly, the *Adult Education Survey* presents the following question to individual: "In your firm, are there other employees trained?" As answer, the respondent has the choice between "yes, whatever their qualification level", "yes, but only the most qualified", "yes, an other case", "no, never". The repartition of the answers for this question for our sample is presented in the table 1.

Table 1: Responses to the answer “In your firm, are there other employees trained?”

Other employees trained?	%
Yes, whatever their qualification level	50,01
Yes, but only the most qualified	9,31
Yes, other cases	7,04
No, never	31,08
Unknown response	2,56

The statistics emphasize that 66,36% of individuals are in 2000, in firm that trained other employees. Consequently, we propose to measure the training investment of the firm with a dummy variable equal to 1 if other workers are trained in the firm and 0 otherwise. This proxy of the training externality can be decomposed into three other dummies which specify if the firm provides training to the most qualified workers, to workers from every qualification level or to another case.

4.3 Descriptive statistics

Our study evaluates the effect of the participation to a training program occurring the 1st of January 1999 to the 29th of February 2000 on net monthly wages including bonuses in 2000. Trainees’ average wage is significantly higher than non-trainees’ average wage. Then the participation to a training program may certainly increase wage (table 2).

Table 2: Wage distribution according to training participation

		Wage 2000			Wage growth rate 99-00		
		<i>Standard</i>			<i>Standard</i>		
Variable		<i>Average</i>	<i>Median</i>	<i>deviation</i>	<i>Average</i>	<i>Median</i>	<i>deviation</i>
<i>Training participation</i>	Yes	10485,74	9482	4403,2	5,91	3,3	14,35
	No	8195,49	7500	3646,3	4,24	1,85	14,32

Secondly, the table 3 presents the average wage of individuals that are in firm that trained other employees, and the one that are in firm that do not trained other employees. Furthermore, we can also consider the average wage of the trainees and the non-trainees for each kind of firm. Firms that trained other employees offer significantly higher average wage than firms that do not trained other individuals. Then, these statistics may confirm the idea of a transmission effect of training, because the training investment of a firm appears to affect

the wages of the whole workforce. Besides, whatever the training investment of the firm, trainees still earn more than non-trainees.

Table 3: Wages of the trainees and the non-trainees in firm that trained other employees, and in firm that do not train other employees.

Wage 2000	Trainees			Non trainees			Total		
Firms	<i>Standard</i>			<i>Standard</i>			<i>Standard</i>		
	<i>Average</i>	<i>Median</i>	<i>deviation</i>	<i>Average</i>	<i>Median</i>	<i>deviation</i>	<i>Average</i>	<i>Median</i>	<i>deviation</i>
Trained other employees	10711,43	9749	4390,06	8954,98	8016	3823,85	9646,69	8616	4145,5
Do not trained	7532,73	6979	3408,87	7229,88	6800	3154,38	7247,86	6821,5	3169,89
Total	10485,74	9482	4403,2	8195,49	7500	3546,3	8839,77	7999	4008,34

Lastly, the following descriptive statistics (table 4) reveal a statistically differences of the average wages according to the qualified level of the trained employees. According to the complementary degree of human capital in the firm, the effect of the average human capital may be reduced. Thus, when firm provide training to individual that are from every qualification level, it is expected that the training diffusion is more important. The statistics illustrate this idea, because the wage of individuals that are in firms that train every kind of workers offer significantly higher wages.

Table 4: Wages in firms that trained other employees according to their qualification level.

Wage 2000	Trainees			Non trainees			Total		
Firms	<i>Standard</i>			<i>Standard</i>			<i>Standard</i>		
	<i>Average</i>	<i>Median</i>	<i>deviation</i>	<i>Average</i>	<i>Median</i>	<i>deviation</i>	<i>Average</i>	<i>Median</i>	<i>deviation</i>
Yes, whatever their qualification level	10817,17	9749	4418,49	9317,3	8299	4021,58	9997,79	8883	4271,28
Yes, but only the most qualified	10337,9	8733	4230,58	8183,71	7554,5	3178,9	8680,16	7999	3562,8
Yes, other cases	9480,54	8720	3965,92	8191,76	7583	3315,79	8431,06	7749	3476,46
Do not trained	7532,73	6979	3408,87	7229,88	6800	3154,38	7247,86	6821,5	3169,89
Total	10485,74	9482	4403,2	8195,49	7500	3546,3	8839,77	7999	4008,34

4.4 The strategy of the empirical evaluation

To test partially our model, on the one hand, we focus on the equilibrium condition (31).

$$w_{f,t+2} = mp_{f,t+2} (1-b) E^{\frac{(1-\beta)(\gamma-1)}{\gamma}} - c(1-d-u) \quad (31)$$

Indeed, in the case of France, the employer finances generally the training costs, as we highlight also with our sample. (90,8% of the training programs are principally financed by the employer). Then, in accordance with Becker's model, when the employer bears all the training costs, the employer gets also all the training returns. The empirical study of Goux D. and Maurin E. (1997) with the French data sets (FQP 93), reveals no significant impact of training on wage, and confirms thus this idea. Then, the aim of our analysis is to show that when there is a training externality within the firm, the trainees can get part of the training returns. On the other hand, we consider the equilibrium condition of the non-trainees (28). To confirm our model, we want to underline that when there is a training externality, non-trainees' wage can also increase after the training program.

$$w_{s,t+2} = mp_{s,t} .b E^{\frac{(1-\beta)(\gamma-1)}{\gamma}} \quad (28)$$

In order to test these two propositions, the logarithm of the wage in 2000 of individual i (W) is estimated in function of a dummy variable (T) equal to 1 if the individual has participated to a training program from 1999 to 2000 and 0 otherwise, of a training externality dummy (E), equal to 1 if other employees are trained in the firm and 0 otherwise, and of an interaction term between the training participation and the training externality (T^*E). Numerous control variables (X), that may determine simultaneity the training participation and the wage are introduced in the model, in order to control the selection bias of training.

$$\text{Log}W_{i,2000} = T_i\alpha + E_i\gamma + (T_i * E_i)\delta + X_{i,t}\beta + \varepsilon_{i,t} \quad (1)$$

Secondly, we can test the assumption that the spillover effect of training depend on the degree of complementary between individuals. Then, we evaluate how the externality effect varies with the qualification level of individuals. Fir that, we introduce in the model the divided measure of the training externality (when other trained workers are the most qualified ($E1$), are from all qualification levels ($E2$), and are from other cases ($E3$)), and their interaction with the training participation (T^*Ei).

$$\text{Log}W_{i,2000} = T_i\alpha + E1_i\gamma_1 + E2_i\gamma_2 + E3_i\gamma_3 + (T_i * E1_i)\delta_1 + (T_i * E2_i)\delta_2 + (T_i * E3_i)\delta_3 + X_{i,t}\beta + \varepsilon_{i,t} \quad (2)$$

Finally, in order to estimate the effect of training and the effect of the training externality, the endogeneity bias of the training measures must be controlled. Three main econometric strategies are proposed in the literature¹: First, the method of OLS assume that after the introduction of a wide variety of control variables that determine the wage and the training, the selection bias of training is deleted. Second, even if covariates (X) explain most of the selection process, it might be a part of error term that is still correlated to training, and is time-invariant. Then, the method of first differences may be considered, with the wage growth as the independent variable. Third, the method of instrumental variables, that include the two-step Heckman's procedure can be used, and allow to consider selection bias that are due to unobservable variables that are time-variant.

For our study, we apply the first method for the following reasons. To begin with, the last group of method requires instruments, i.e. variables that determine the training but do not affect the wage, and these kind of variables are very difficult to find for the study of training. Furthermore, because we evaluate the training effects on wage for one year, we can assume that the selection bias implied by the unobservable variables that are time-variant have a quite marginal impact on wages. To turn to the first differences method, several coins can be presented. Indeed, it is noteworthy that this method can under evaluate the impact of the variables because of measurement errors (Freeman (1984)). Besides, the training period in our study (1st January 1999 to 1st March 2000) does not correspond exactly to the period of wage growth (1st March 1999 to 1st March 2000), then estimates of training effect on wages may be again under evaluated. Lastly, our databases contain rich information, that allow introducing a wide variety of variables, which refer to several training mechanisms. The variables (X) that may affect the training participation and the wage of individual are selected in accordance with labor market theories². With human capital theory, the following individuals' characteristics are considered: the sex, the marital status, the nationality, the number of children and its square, the number of children under 6, the age and its square, and dummies for the education level. With the idea of internal market and job matching theory, these following variables are included : the working status in 1997, the training programs prior to 1999, the tenure and its square, the time working, the type of employment contract, the occupation, the position, the type of the residential area, the working days and conditions (Sunday, Saturday, night, evening, at home, flexible hours). Then, according to the theory of

¹ See the surveys of Angrist J. and Krueger A. (1999), Blundell R. and Costa-Dias M. (2000), Heckman J., Lalonde R. and Smith J. (1999), and Wooldridge J. (2002).

² Altonji J. and Spletzer J. (1991) and Harris R. (1999) present several determinants of training participation.

segmented markets, the firm size, the industry, the regional localization of the firm are taken into account. Lastly, in the assumption that the human resources strategies determine the training programs, these following variables are selected: the setting up (in the department or team of the worker) of a new working organization, the setting up of a new equipment or a new production technique, the setting up of a time working reduction, and the existence of a training program in the firm. Consequently, we assume that most if not all of the selection bias is controlled with the introduction of these variables.

5 The results

First of all, estimations of model (1) are presented in the table 5. The interaction term between training and its externality highlights a strong and significant impact (5,9%) of the externality on the trainees' wage, although the externality does not have a significant effect on non-trainees' wage. This result means that employer prefers to share the training externality with trainees, in order to minimize probably the risk of a poaching effect.

Table 5: Wage level Equations

	Model (1)	Model (2)
<i>Training</i>	- 0,0147 (0,0242)	- 0,0136 (0,0242)
<i>Other trained workers</i>	0,0155 (0,0095)	
<i>Every qualification level</i>		0,0318 (0,0107***)
<i>Most qualified</i>		0,0006 (0,0142)
<i>Other cases</i>		- 0,0122 (0,0154)
<i>Training*Other trained workers</i>	0,0594 (0,0255**)	
<i>Training*All qualification levels</i>		0,0486 (0,0258*)
<i>Training*Most qualified</i>		0,0892 (0,0350**)
<i>Training*Other cases</i>		0,0575 (0,0398)

Standard errors in parentheses. * Statistically significant at the .10 level; ** at the .05 level; *** at the 0.01 level

Secondly, the results of the model (2) reveal that the training externality increases significantly trainees' wage of 4,9% when the firm trains employees from every qualification level and of 8,9% when it is the most qualified employees that are trained. Consequently, it appears that the spillover effect is more important when it is the most qualified worker that are trained. Indeed, knowledge can be transmitted more easily from the most qualified individuals to less qualified workers.

Thirdly, concerning the non-trainees, their wages are significantly higher of 3,2% when the firm trains employees from every qualification level. That underlines that trainees

transmit knowledge to non-trainees, and as a result increase non-trainees' productivity. However, that is possible, only if the trainees' qualification level is not too different from the non-trainees' qualification level. The employer decides then to reward this rise of productivity.

This difference of externality effects according to the qualification level of the other workers trained, highlights that the differential of competencies between workers are an important parameter of the transmission effect.

Lastly, the impact of training on wages is not significant. It seems that training does not affect wages when others workers are not also trained in the firm. Considering that employers mostly support the training costs, firms get most of the training returns. These results remind Goux D. and Maurin E. (1997)'s conclusion. Actually their estimates reveal no significant impact of training on wages by using French data sets (FQP 93). Nevertheless, employers can share the returns of training when a transmission effect of training can be noticed.

6 Conclusion

In the first place, our model highlights a double effect, direct and indirect, of training investment within a firm. The indirect effect, called a training externality, allows a productivity increase of the whole labour force. Consequently, our model, and the assumption of a training externality allows to justify why firms finance general training. Moreover, the differences of wage and training investments between small and large firms can be explained by differences in the process of knowledge diffusion of the firms. Indeed, according to the organization of the firm, exchanges between employees may be favour or slow down. Finally, our model proposes a heterogeneous effect of the training externality according to the qualification level of trainees and non trainees. Thus, the selection of trainees to participate to a training program appear strategic for the employer. Indeed, according to the policy of human resources management, the spillover effect of training is more or less promoted. Traditionally, we notice that employer trains the most qualified employees. Then in accordance with our model, we suggest that the most qualified employees allow to maximise the effects of the training externality.

In the second place, our empirical evaluation validates some predictions of our model for the French case. Every employees can benefit from training externality, and trainees earn more when there is a spillover effect of training within the firm. Furthermore, our results highlight that employer prefers to share the returns of the training externality with the trainees rather than with the non trainees, probably in order to minimize the risk of poaching.

Future researches will focus on two points. First of all, we can analyse the effects of the training externality on the dispersion of wage. Indeed, as training is usually provided to the most qualified workers, training investment increases wage inequalities. But what about the effects of training externality on wage inequalities? Indeed, according to the share of the training externality between trainees and non trainees, wage inequalities may be reduced or increased. With the methodology of Fields (2003), we can then evaluate the exact contribution of the training externality on the wage dispersion. Secondly, our empirical evaluation may be biased because of unobserved heterogeneity concerning individual characteristics and firm characteristics. Our empirical evaluation allows to present first results, and to give some idea of the training externality effects. However, it would be better to test our model with a more suitable database, as the future databases Adult Education Survey 2006, and CVTS-3 that match individual and employer observations.

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