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Training Externality and Earning’s Dispersion

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Abstract

We assume a training externality within the firm, because knowledge learnt during training program can be exchanged between workers of the same firm. Then, our paper investigates the spillover effect of training externality on earning’s dispersion. Firstly, our paper evaluates how training externality affects wage inequalities between and within workers who receive or do not received training. Secondly, the article proposes to test the idea that training externality might be a criterion of labor market segmentation. The results emphasize that training externality is a major determinant of wage inequalities between trainees and non-trainees. In particular, the training externality explains wage dispersion among trainees because employer can extract a rent from it to finance part of the training costs. Lastly, wage inequalities are better explained by the training investment of their firm than by their participation to a training program.

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1 Introduction

The human capital theory introduced by Becker G. assumes that education and continuing vocational training are determinants of wage growth and then of wage inequalities between individuals. The report of OECD (1999), which study training across OECD countries and mentioned by Hanchane et Silber (2006), highlights that "half of the earnings gap between those who received training and those who did not is due to the fact that firms providing training pay higher salaries in any case, the second half of the gap being related to factors that have a simultaneous impact on the probability of access to training and on earnings." (Hanchane and Silber (2006)). Besides, empirical studies reveal that training has generally a weak impact on wages (Goux and Maurin (1997)). Consequently, wage inequalities between workers are explained, slightly by training participation, highly by variables that determine training access and wage, and to a large extend by unobserved factors. Our paper proposes the whole training investment of the firm as determinants of wage inequalities.

Indeed, as literature on education considers a transmission effect between children of the same class (Benabou (1996)), our article investigates also knowledge and competencies exchanges between workers of the same firm. Consequently, training investment of a firm has a direct effect on wages by increasing trainee’s productivity but also an indirect impact on the productivity and the wage of the whole workforce. Assuming that this spillover effect is firm specific, then we can consider a training externality within the firm. The equilibrium condition of the wage determination proposed by Becker's model are modified, because the returns of training externality can be shared between the employer, the non trainees and the trainees.

After we confirm that the all training investment of the firm has an impact on the individual's wage, the aim of our paper is to evaluate how training externality may be a determinant of the earning's gap. Firstly, we wonder if training externality may increase or reduce wage inequalities between trainees and non-trainees. Secondly, we estimate the contribution of the training externality on the within variance of each sub groups. Among non-trainees, the wage can be higher in firms that provide much training, because the transmission effect of training may increase their productivity. Among trainees, the training returns may be higher, because employers may extract a rent from externality that can serve to finance part of the training costs. Lastly, we test the idea that training externality may be a criterion of labor market segmentation. Indeed, according to its organization or its technique of production, firms can favor or limit training externality, and then provide more or less training, and offer higher or smaller wages than average. For our study, we apply the methodology of Hanchane and Silber (2006), inspired of the Field’s technique that allow a decomposition of the variance.

In the second section of our article, we present the theoretical model that justifies the role of the training externality on wages and on earning’s dispersion. In the third section, the methodological framework of our study is described. The evaluation strategy is exposed in the fourth section and the results are presented in the fifth section. In a last section, we conclude and propose several further researches.
2 Model

2.1 The assumptions

The first assumption of our model consists to introduce the average human capital of the firm as a component of the labor factor in the output function. Indeed, Benabou R. (1996) highlights a spillover effect between children of the same classroom. Then, we can think that a spillover effect might also exist between employees of the same firm. The production $Y$ of a firm is defined with a Cobb-Douglas function, that have two inputs: the physical capital $K$, and the labor $L$. The parameter $A$ represents the firm specificity as its technology. $0<\alpha<1$ and $0<\beta<1$ corresponds respectively to the part of the physical capital and the labor, in the production function.

$$Y_t = A_t K_t^\alpha L_t^{1-\alpha} \ (1)$$

The stock of labor can be defined as a production function of two elements: the stock of human capital of the firm $H$, that is the education level of the workforce or its professional experience; and the average human capital of the firm $H$. We assume that the firm do not dismiss or recruit employees during this time period, in order to simplify the model. The parameter $0<\gamma<1$ is the part of the human capital that is involved by the average human capital, and refers to the organization of the firm and its method of production (team or individual work). Consequently, the human capital of a firm is not just composed of the sum of individual human capital, because there is a group dynamic. Besides, $T$ is the amount of the workforce attributed to training, then it represents the training investment of the firm between the time $0$ and $t$. Thus, $(1-T)$ is the time devoted to production during training program.

$$L_t = (1-T) H_0^{(1-\gamma)(1-\delta)} H_0^{\gamma(1-\delta)} T^\delta \ (2)$$

The second assumption of our model sets heterogeneous agents in terms of human capital, in the firm. One way to take into account this heterogeneity is to introduce the dispersion of the human capital in the analysis. By this way, we consider, as Benabou (1996), that the average human capital is a CES function, i.e. that the effects of $H$ depends also on the complementarity's degree, $\rho$, between the human capital levels of employees within the firm.

$$H_t = |E(h^{(1-\rho)})|^{1/(1-\rho)} \ (3)$$

Besides, if we consider that the human capital distribution of the firm is Log Normal

$$h \rightarrow \text{LogN}(m, \sigma) \ (4),$$

then according to its properties, the average human capital of the firm is expressed as follows.

$$H_t = \exp(m_t + (1-\rho) \frac{\sigma^2}{2}) \ (5)$$

The average human capital is an arithmetic mean of human capital $m$, which is augmented or reduced by the human capital differentials between employees in the firm $\sigma^2$.

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1 This production function of human capital is an adaptation of the model of Benabou (1996) for education, exposed by D’Autume and Michel (1994).
The two assumptions of our model imply that after the training program, the training investment $T$ has two effects within the firm: a direct effect on the human capital of the firm according to its efficiency $\delta$, and an indirect impact on the human capital of the firm by the intermediate of the average human capital, with an effect of $\gamma^2$.

The third assumption of our model is to assume that this indirect effect of training investment may be firm specific, i.e. that is not transferable to another firm. Indeed, even if the training program provides general knowledge, the part of it that is transmitted to colleagues, may rather refer to the way to apply these knowledge in practical at work, and thus may be more specific to the firm. Then, the employer can get a rent from training investment and may reduce the threat of a poaching effect from the other employers. We called this indirect effect of training investment, a training externality.

2.2 The link between training, productivity and wage

2.2.1 Becker’s model revised with the training externality

Becker’s model (Annex 2) allow to study more in details the training mechanisms, with the intertemporal maximization of the profit of the firm. Beckers start from the equilibrium condition of the profit of the firm, ($W=PM$), i.e. the equality between the wage and the marginal product, in other words, the expenses of the firm. The traditional analysis of training assumes then that this relation is equivalent at individual and firm level. Nevertheless, because our model consider the average human capital of the firm and assume heterogeneous workers, these two dimensions must be distinguished.

With our framework, this relation is considered at the firm level and we specify what are the different components of the expenses and the receipts of the firm. On one hand, the labor costs contain the wages of the trainees (the number of trainees: $n_f$), the wages of the non-trainees ($n_i$) and the training costs $C$, which are divided into direct costs and opportunity costs. The opportunity costs correspond to the difference between the output realized when all the working time is devoted to production and when part of the time is devoted to training. On the other hand, the receipts of the firm are composed of the marginal productivity of the non-trainees before and after the training program, and of the marginal productivity of trainees before the training program, if they would not participate to training $MP_c$, and after the training program. The following equilibrium condition is obtained:

$$
\sum_{i=1}^{n_i} W_{i,0} + \sum_{t=1}^{r} \sum_{i=1}^{n_i} \frac{W_{i,t}}{(1+r)^t} + \sum_{i=1}^{n_i} W_{i,0} + \sum_{t=1}^{r} \sum_{i=1}^{n_i} \frac{W_{i,t}}{(1+r)^t} + C(T) =

= \sum_{i=1}^{n_i} MP_{i,0} + \sum_{t=1}^{r} \sum_{i=1}^{n_i} \frac{MP_{i,t}}{(1+r)^t} + \sum_{i=1}^{n_i} MP_{i,0} + \sum_{t=1}^{r} \sum_{i=1}^{n_i} \frac{MP_{i,t}}{(1+r)^t} \quad (7)
$$

Lastly, we can simplify the formalization of the marginal productivity of each group at each period of time. Before the training program, we assume that the marginal productivity of the non-trainees and the trainees, if they would not received training, would be equivalent.

$$
\sum_{i=1}^{n_i} MP_{i,0} = \sum_{i=1}^{n_i} MP_{i,0} = MPA
$$

2 The annex 1 specifies how the human capital of the firm is modified after the training investment.
After the training program, the initial marginal productivity of the non-trainees and the trainees is augmented of \( H(T) \). This last term corresponds to the modification of the average human capital of the firm, due to training investment. Besides trainees received the training returns \( G(T) \).

\[
\sum_{i=1}^{n} MP_{s,t} = MPA + H(T) \quad \text{and} \quad \sum_{i=1}^{n} MP_{f,t} = MPA + H(T) + G(T)
\]

Consequently, the equilibrium equation becomes (8), and the employer may define its optimal amount of training investment \( (T^*) \).

\[
W_{s,0} + W_{s,1} + W_{f,0} + W_{f,1} + C(T^*) = MPA_s + MPA_f + H(T^*) + MPA_f + MPA_f + H(T^*) + G(T^*)
\]

2.2.2 The mechanisms of training externality on wages

We can decompose the effect of training investment between the non-trainees and the trainees, and determine their wage considering the risk of poaching.

For the non-trainees, their wage must be at least equal to their market value, \( MPA \), because we remain that the training externality is not transferable to other firms. Then, their wages before the training program equal their marginal productivity. Their wage after the training program corresponds to their marginal productivity added by the part \( b \) of the training externality, that the employer decide to share with them.

\[
WB_s = MPA_s + bH(T^*)
\]

For the trainees, the equilibrium condition becomes as follows, with \((1-b)\), that refers to the part of the externality that is shared with the trainees.

\[
WA_f + WB_f + C(T^*) = MPA_f + MPA_f + (1-b)H(T^*) + G(T^*)
\]

Two cases are analyzed. First of all, training is general and the individual are remunerated to their marginal productivity after the training program: \( MPA_f + G(T^*) \). They receive the returns of training. Consequently, the wage before the training program is:

\[
WA_f + C(T^*) = MPA_f + (1-b)H(T^*)
\]

Contrary to Becker that predict individuals support all the costs of general training, our model implies that the training costs may be shared between the employee and the employer because of the training externality.

Secondly, we can assume that the trainees cannot have a cut off of their wage at the beginning of the training program, because of minimum wages or liquidity constraints. Then, their wage before the training program is at their marginal productivity and the employer may support all the training costs. Their wage equilibrium after the training program is:

\[
WB_f + C(T^*) = MPA_f + (1-b)H(T^*) + G(T^*)
\]

Owing to the training externality, a part of the training returns may be shared with the employee.

2.3 Training, training externalities and the wage inequalities

We can briefly remain the study of Hanchane and Silber (2006), that apply an approach of Field (2003) and that allow them to measure the impact of training on the earning’s dispersion. Their estimations on French data sets “Formation Continue 2000” highlight on one hand that training increases wage inequality of around 5.5% because training
is provided to individual that have initially higher wages. On the other hand, the training participation of an individual cannot explain much of the wage inequality between workers, because “the within groups variance is much higher than that of the between groups so that the distribution of earnings of these two groups show a great degree of overlapping. [ ] As a consequence if labor market segmentation exists, it must be based on other criteria.” (Hanchane and Silber (2006)).

Our paper proposes to evaluate what is the contribution of training externality on wages dispersion.

Firstly, we analyze the impact of training externality on wage inequalities between trainees and non-trainees. Indeed, does training externality increase even more the inequalities between trainees and non-trainees, or on the contrary, does training externality allow the non-trainees do catch up their backwardness? Then we will conclude if the share of training externality is more in favor of trainees or non-trainees.

Secondly, the contribution of training externality within the trainees will specify if the training externality lead to a gap between trainees according to their belonging firms. Indeed, we will identify if training externality allow financing part of the training costs. On the other hand, the contribution of training externality within non-trainees, will underline in which extend non-trainees can also take financial advantage of training externality.

Thirdly, we will compare the earning’s dispersion between and within individuals according to the training investment of their firm. Indeed, if training increases the inequality between workers, what about training externality? Thus, we will conclude if the training externality may be a criterion of market segmentation.

3 The Data

3.1 The surveys and the sample

Three French micro data surveys are used in our paper: Enquête Emploi 2000 and 1999. They follow individuals from the 1st of March 1998 to the 1st of March 2000. The survey Formation Continue 2000 is a complementary survey of Enquête Emploi 2000. Training incidence since individuals finished school are reported and training program 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, training for non-professional purposes and training 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.

3.2 The variables

First of all, training 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 (mean: 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, wages distribution reveals that mean wage has grown 3,8% from 1999 to 2000. Nevertheless, the annual wages growth rate is high (mean: 4,7%) and might be explained by measurements errors in the individual wage.

Thirdly, the FC200 survey asks to individuals the following questions: “In your firm, are the 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 they other employees trained?”

<table>
<thead>
<tr>
<th>Other employees trained?</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes, whatever their qualification level</td>
<td>50,01</td>
</tr>
<tr>
<td>Yes, but only the most qualified</td>
<td>9,31</td>
</tr>
<tr>
<td>Yes, other cases</td>
<td>7,04</td>
</tr>
<tr>
<td>No, never</td>
<td>31,08</td>
</tr>
<tr>
<td>Unknown response</td>
<td>2,56</td>
</tr>
</tbody>
</table>

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 externality proxy can be decomposed into three other dummies which specify if firm provides training to the most qualified workers, to workers from every qualification level or to another case.

3.3 Descriptive statistics of the link of these variables

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

Table 2: Wage distribution according to training participation

<table>
<thead>
<tr>
<th>Variable</th>
<th>Wage 2000</th>
<th>Wage growth rate 99-00</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Median</td>
</tr>
<tr>
<td>Training participation</td>
<td>Yes</td>
<td>10485,74</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>8195,49</td>
</tr>
</tbody>
</table>

Secondly, the table 3 presents the mean 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 mean wage of the trainees and the non-trainees for each kind of firm. Firms that trained other employees offer significantly higher mean 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.

<table>
<thead>
<tr>
<th>Wage 2000</th>
<th>Trainees</th>
<th>Non trainees</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Median</td>
<td>Standard deviation</td>
</tr>
<tr>
<td>Firms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trained other employees</td>
<td>10711.43</td>
<td>9749</td>
<td>4390.06</td>
</tr>
<tr>
<td>Do not trained</td>
<td>7532.73</td>
<td>6979</td>
<td>3408.87</td>
</tr>
<tr>
<td>Total</td>
<td>10485.74</td>
<td>9482</td>
<td>4403.2</td>
</tr>
</tbody>
</table>

Lastly, the following descriptive statistics (table 4) reveal a statistically differences of the mean 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.

<table>
<thead>
<tr>
<th>Wage 2000</th>
<th>Trainees</th>
<th>Non trainees</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Firms</td>
<td>Mean</td>
<td>Median</td>
<td>Standard deviation</td>
</tr>
<tr>
<td>Yes, whatever their qualification level</td>
<td>10817.17</td>
<td>9749</td>
<td>4418.49</td>
</tr>
<tr>
<td>Yes, but only the most qualified</td>
<td>10337.9</td>
<td>8733</td>
<td>4230.58</td>
</tr>
<tr>
<td>Yes, other cases</td>
<td>9480.54</td>
<td>8720</td>
<td>3965.92</td>
</tr>
<tr>
<td>Do not trained</td>
<td>7532.73</td>
<td>6979</td>
<td>3408.87</td>
</tr>
<tr>
<td>Total</td>
<td>10485.74</td>
<td>9482</td>
<td>4403.2</td>
</tr>
</tbody>
</table>

4 Evaluation strategy

4.1 Impact of training externality on wages

Before to evaluate the effect of training externality on wage dispersion, we will estimate the effects of the training and the training investment of the firm on wages level.

Firstly, 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, and of a training externality dummy \((E)\), equal to 1 if other employees
Training Externality and Earning’s Dispersion

are trained in the firm and 0 otherwise (1). Numerous control variables \((X)\), that are assumed determine simultaneity the training and the wage are introduced in the model.

\[
\text{Log} W_{i,2000} = T_i \alpha + E_i \gamma + X_{ij} \beta + \epsilon_{ij} \quad (1)
\]

Secondly, we can test how the transmission effect of training varies with the qualification level of individuals. Then, we use the divided measure of training externality in our model (when other trained workers are the most qualified \((E1)\), are from all qualification levels \((E2)\), and are from other cases \((E3)\)). Moreover, we distinguish the trainees and the non-trainees, in order to evaluate to which extend the impact of training externality according to the qualification level of trainees may vary with these two subgroups. Then, an interaction term \((T^*Ei)\) between training participation and the externality dummy variables is introduced in the model.

\[
\text{Log} W_{i,2000} = T_i \alpha + E1 \gamma + E2 \gamma_2 + E3 \gamma_3 + (T^*E1) \delta + (T^*E2) \delta_2 + (T^*E3) \delta_3 + X_{ij} \beta + \epsilon_{ij} \quad (2)
\]

4.2 Impact of training externality on wages dispersion between trainees and non-trainees

In order to estimate the impact of training externality on wage dispersion, we remain the methodology of Hanchane and Silber (2006). The wage equation can be express as follows:

\[
y_i = \sum_{k=1}^{K} b_k X_{ki}
\]

where \(y_i\) is the logarithm of the wage of individual \(i\), \(X_{ki}\) is the value of the variable \(k\) of the individual \(i\), and \(b\) the average impact of the variable \(k\).

Fields (2003) has proven that:

\[
\sigma(y_i) = \sum_{k=1}^{K} [(b_k \cdot \text{Cor}(X_{ki}, y_i) \cdot (\sigma(X_{ki})))]
\]

Consequently, the relative contribution \(s_k(y_i)\) of the variable \(k\), to the total earnings dispersion \(\sigma(y_i)\) is:

\[
s_k(y_i) = [(b_k \cdot \text{Cor}(X_{ki}, y_i) \cdot (\sigma(X_{ki}))) / \sigma(y_i)] \quad (3)
\]

or \(s_k(y_i) = [(b_k \cdot \text{Cov}(X_{ki}, y_i)) / V(y_i)] \quad (3)\)

Firstly, we calculate the earning’s dispersion between trainees and non-trainees, and we estimate the relative contribution of training externality. To control the dispersion among trainees and non-trainees, we assume that all trainees earn the mean wage of trainees, \(y_{M,B}\) and that non trainees receive the mean wage of non trainees \(y_{M,A}\). The wage dispersion between the two groups is expressed as follows:

\[
V_{BET} = f (1-f) (y_{MA} - y_{MB})^2
\]

\(f\) represents the part of trainees in the sample and \((1-f)\) is the part of non-trainees. Considering the approach of Field (2003), the contribution \(s_{kB}(y_i)\) of the variable \(k\) to the between group variance is:

\[
s_{kB}(y_i) = [(b_k \cdot \text{Cov}(z_{KM}, y_M)) / V_{BET}(y_j)]
\]

Besides, as we know:

\[
\text{Cov}(z_{KM}, y_M) = f (1-f) (x_{KMB} - x_{KMA}) (y_{MB} - y_{MA})
\]

Then:

\[
s_{kB}(y_i) = [(b_k (x_{KMB} - x_{KMA}) / (y_{MB} - y_{MA})] \quad (4)
\]
Secondly, we can analyze the contribution of training externality on the within dispersion. For that, we will express the relative contribution of each variable to the wage dispersion of trainees, group B, and of non-trainees, group A.

\[ s_{k,\text{WITH}}(y_i),A = (b_k)\text{Cov}(z_{kj}, j \in A, y_j, j \in A) / V_A(y_j) \] (5)

\[ s_{k,\text{WITH}}(y_i),B = (b_k)\text{Cov}(z_{kj}, j \in B, y_j, j \in B) / V_B(y_j) \] (6)

The within groups variance is equal to the weighted sum of the variance within each of the two groups A and B, so:

\[ s_{k,\text{WITH}}(y_i) = \{ (1-f)(b_k)\text{Cov}(z_{kj}, j \in B, y_j, j \in B) / V_B(y_j) \} + \{ f(b_k)\text{Cov}(z_{kj}, j \in A, y_j, j \in A) / V_A(y_j) \} \] (7)

Lastly, we develop the same analysis but with the measured of training externality that vary with the qualification level of the other workers trained. So we can consider in one hand the dummy variable for the training externality (4a-5a-6a-7a), and on the other hand, the decomposed training externality (4b-5b-6b-7b)

4.3 Impact of training and training externality on total wages dispersion

We consider the total earning’s dispersion and we evaluate on one hand, what is the contribution of the between and within dispersion according to the training participation of individual, as Hanchane and Silber (2006) as done.

\[ V_{\text{OVERALL}} = \sigma^2(y_i) \]
\[ V_{\text{BET}} = f (1-f)(y_mA - y_mB)^2 \]
\[ V_{\text{WITH}} = f \sigma^2_A(y_i) + (1-f) \sigma^2_B(y_i) \]

Secondly, we apply this methodology but with two different subgroups: individuals that are in firms that train other workers and individuals that are in firm that do not train other workers. Then, we can analyze the part of the between and within dispersion of these subgroups in the overall variance and conclude if training externality may be a criterion of market segmentation. Furthermore, we can compare the results with the previous decomposition with training participation and we will wonder if training externality may be a better determinant of wage inequality than training.

Lastly, we repeat this approach to the two following subgroups: individuals from firms that train other workers from every qualification level, and individuals from firms that do not train other workers.

4.4 The econometric methods

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 literature: 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-

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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)) and we have previously noticed measurement errors in the wage. 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 theories. With human capital theory, the following individuals’ characteristics are considered: sex, marital status, nationality, the number of children and its square, the number of children under 6, age and its square, education dummy variables. With the idea of internal market and job matching, these variables are integrated: working status in 1997, past training programs, tenure and its square, time working, type of employment contract, occupation, job responsibilities, type of urban residence, Sunday working, Saturday working, night working, evening working, at home working, flexible working hours. Then, according to segmented markets, the firm size, the industry in 54 dummies, the regional localization of the firm are taken into account. Lastly, in the assumption that human resources strategies determine training programs, these following variables are selected: the setting (in the department or team of the worker) of a new working organization, the setting of a new equipment or a new production technique, the setting 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 this variables.

5 The results

5.1 The effect of training externality on wages

First of all, estimations of model (1) are presented in the table 5. The model (1) emphasizes an average effect around 3.8% of the training participation on wages. Furthermore, the results reveal a positive and significant impact of training externality on wages of 2.1%. Then we can confirm that there is a transmission effect of training between employees of the same firm.

The estimates of model (2) reveal that wages of non-trainees are affected positively and significantly (3.2%), by training externality when firm provides training to individuals from all qualification levels. Regarding trainees, the presence of other trained workers in the firm increases significantly and positively the wages. (4.9% when the workers from all

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qualification levels are trained, and 8.9% when the trained workers are the most qualified). Regarding trainees, the presence of other trained workers in the firm increases significantly and positively the wages. (4.9% when the workers from all qualification levels are trained, and 8.9% when the trained workers are the most qualified). Thus, training externality seems more efficient, when the most qualified workers are trained for the trainees, and when employees from all qualification levels are trained for the non-trainees. The selection of individuals, for whom training will be provided, appear strategic for employers. This difference of externality effects according to the qualification level of the other workers trained, highlight that the differential competencies between workers are an important parameter in order to increase the transmission effect. Besides, when the other trained workers are from every qualification level, then this differential component is not important, and we actually notice that the spillover effect is higher in this case.

Table 5: Wage level Equations

<table>
<thead>
<tr>
<th></th>
<th>Model (1)</th>
<th>Model (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training</td>
<td>0.0383 (0.0084***)</td>
<td>- 0.0136 (0.0242)</td>
</tr>
<tr>
<td>Other trained workers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Every qualification level</td>
<td>0.0318 (0.0107***)</td>
<td></td>
</tr>
<tr>
<td>Most qualified</td>
<td>0.0006 (0.0142)</td>
<td></td>
</tr>
<tr>
<td>Other cases</td>
<td>- 0.0122 (0.0154)</td>
<td></td>
</tr>
<tr>
<td>Training*Other trained workers</td>
<td>0.0214 (0.0092**)</td>
<td></td>
</tr>
<tr>
<td>Training*All qualification levels</td>
<td>0.0486 (0.0258*)</td>
<td></td>
</tr>
<tr>
<td>Training*Most qualified</td>
<td>0.0892 (0.0350**)</td>
<td></td>
</tr>
<tr>
<td>Training*Other cases</td>
<td>0.0575 (0.0398)</td>
<td></td>
</tr>
</tbody>
</table>

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

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 cost of training, firms get most of the returns of training. 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.

5.2 Impact of training externality on wages dispersion between and within trainees and non-trainees

We have emphasized that training externality has an impact on trainees and non-trainees, and with apparently a higher impact for trainees. Besides, among trainees, and non-trainees, training externality increases the wage. Nevertheless, in order to quantify how exactly training externality modifies the wage differential of trainees and non trainees, and of individuals among these two subgroups, we will turn to the effect of training externality on wage dispersion. The variables that have a higher impact than training externality on the wage inequalities between and within trainees and non-trainees are presented in the annex 3.

Firstly, the effect of training externality on the between variance is around 3.1%. Then the training externality, i.e., the total training investment of the firm, increases the earning gap between trainees and non-trainees. Besides, when the firm train workers from every qualification level, so when the training externality is the more intense, then earning
inequalities of the two groups raise of 5.8%. Consequently, even if training can increase the productivity of every workers, and especially non-trainees workers, its impact on wages will be in favor of trainees. Indeed, employers choose to take advantage of training externality to finance part of the training costs. As a result, trainees can receive some training returns. The training investment of the firm is another determinants of wage inequality between trainees and non-trainees.

Table 6: The relative contribution of training externality to earning’s dispersion between trainees and non-trainees

<table>
<thead>
<tr>
<th></th>
<th>(4a)</th>
<th>(4b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training Externality</td>
<td>3.0839</td>
<td>5.8439</td>
</tr>
<tr>
<td>Training Externality from all qualification levels</td>
<td></td>
<td>-0.1203</td>
</tr>
<tr>
<td>Training Externality from the most qualified</td>
<td></td>
<td>0.0963</td>
</tr>
<tr>
<td>Training Externality of other cases</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Secondly, if we analyze the effect of training externality on within dispersion, we notice that the training externality increases the wage inequality among the two groups of around 0.7%, and of 1.1% when workers from all qualification level are trained. Then, even if its impact is smaller on within dispersion than between dispersion, training transmission can also increase inequalities within each group.

Table 7: The relative contribution of training externality to the within earning’s dispersion

<table>
<thead>
<tr>
<th></th>
<th>(7a)</th>
<th>(7b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training Externality</td>
<td>0.6662</td>
<td>1.088</td>
</tr>
<tr>
<td>Training Externality from all qualification levels</td>
<td></td>
<td>-0.0042</td>
</tr>
<tr>
<td>Training Externality from the most qualified</td>
<td></td>
<td>-0.0394</td>
</tr>
<tr>
<td>Training Externality of other cases</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Thirdly, we can specify if the within inequalities due to training externality occur more among trainees or among non-trainees. The table 8 underlines that training externality increases the dispersion of earnings especially among trainees, of 1.3%, and 1.6% when workers from all qualification level are trained, versus 0.4% and 0.9% respectively for non-trainees. Actually, although training externality may have a higher impact on the non trainee’s productivity by definition, employers extract a rent from it in order to finance part of the training costs. Thus even if employer can share the returns of training externality with non-trainees, this part may be marginal.

Table 8: The relative contribution of training externality to earning’s dispersion within trainees and non-trainees

<table>
<thead>
<tr>
<th></th>
<th>Among Trainees</th>
<th>Among non-trainees</th>
<th>Among Trainees</th>
<th>Among non-trainees</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(5a)</td>
<td>(6a)</td>
<td>(5b)</td>
<td>(6b)</td>
</tr>
<tr>
<td>Training Externality</td>
<td>1.2925</td>
<td>0.4211</td>
<td>1.5977</td>
<td>0.8885</td>
</tr>
<tr>
<td>Training Externality from all qualification levels</td>
<td></td>
<td></td>
<td>-0.0171</td>
<td>0.0009</td>
</tr>
<tr>
<td>Training Externality from the most qualified</td>
<td></td>
<td></td>
<td>-0.1243</td>
<td>-0.00062</td>
</tr>
<tr>
<td>Training Externality of other cases</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
To turn to trainees, in firms that do not trained other workers, and because employer support most of the training costs, the trainees do not receive most of their training returns. Conversely, when there is a training externality, its returns may serve to finance part of the training costs, and the trainees may receive part of its training returns.

5.3 Impact of training externality on wages dispersion between and within firms that train or train not other workers

Considering the impact of training externality on wage dispersion, we can wonder if the total training investment of the firm, can be a good criteria of market segmentation, or at least a better criterion than individual participation to training. The table 9 illustrates the part of the between and the within variance to the overall variance. The two subgroups considered are in the first column the trainees and the non trainees, in the second column individuals of firms that train other workers and individuals of firms that do not train other workers, and in the third column, individuals of firms that train other workers from every qualification level and individuals of firms that do not train other workers.

<table>
<thead>
<tr>
<th>Type of Variance</th>
<th>Training</th>
<th>Training Externality</th>
<th>Training Externality from every qualification level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Variance</td>
<td>19.88 (100%)</td>
<td>19.88 (100%)</td>
<td>20.62 (100%)</td>
</tr>
<tr>
<td>Between Groups Variance</td>
<td>1.33 (6.69%)</td>
<td>1.90 (9.56%)</td>
<td>2.58 (12.51%)</td>
</tr>
<tr>
<td>Within Groups Variance</td>
<td>18.55 (93.31%)</td>
<td>17.98 (90.44%)</td>
<td>18.04 (87.49%)</td>
</tr>
</tbody>
</table>

The first column illustrates that the between variance of training represents 6.7% of the overall earning variance among workers, versus 93.3% for the within variance. As a result, because the between variance is much smaller than the within variance, the participation to a training program for an individual is not a good criterion of market segmentation, or an important determinant of wage inequalities.

To turn to the training externality, the results highlight also that the between variance of the training externality is much smaller (9.6%) than the within variance (90.4%). However, this difference is less important than for training participation. Consequently, the firm’s characteristic of an individual, concerning its training investment, is a better indicator of wage inequality than the training participation.

Lastly, if we consider the most intense form of training externality, i.e. when the firm train workers from every qualification level, then we notice that the between variance of training represents 12.5% of the overall earning’s dispersion. The training externality is even more a good determinants of wage inequalities.
6 Conclusion

Our empirical analysis seems to confirm the idea that the total training investment of a firm increases the productivity and the wage of the whole workforce. The existence of a training externality within the firm is validated. However most of the returns of the training externality appear to finance the training costs and allow the employer to share some of the training returns with the trainees. Consequently, instead of a convergence of the worker’s wages between trainees and non-trainees, the training externality accentuates wage inequalities up to 5.8%.

Moreover workers, trainees and non-trainees, from firms that train other workers compared to firms that do not train other workers, earn more, because even if its impact may be small, the training externality may be profitable to every workers. Thus, the inequalities among trainees and non-trainees are also increased with the training externality.

As a whole, the training investment of a firm can raise wage inequalities of workers to 12.5% and may be a major determinant of earning’s dispersion.

Further research will focus on the heterogeneous effect of the training externality. Indeed, we can wonder if the training investment of a firm can have a stronger impact on wage level and wage dispersion, according to the type of training provided. Similarly, we can think that training externality may be more or less important according to the organization of the firm, and its method of production.
7 References

8 Annexes

8.1 Annex 1: The modification of the average human capital of the firm after the training investment

We can identify more in details how the effect of training modifies the average human capital of the firm. The stock of labor of the firm at time 0, before the training program, and at time \( t \), after the training program are as follows.

\[
L_0 = H_0^{(1-\gamma)} \overline{H}_0^\gamma \tag{1}
\]

\[
L_t = (1 - T)L_0^{(1-\delta)}T^\delta \tag{2}
\]

And if we replace \( L_0 \) of (1) in (2), we obtain:

\[
L_t = (1 - T)H_0^{(1-\gamma)(1-\delta)} \overline{H}_0^{\gamma(1-\delta)}T^\delta \tag{3}
\]

Then, we can define the accumulation of the human capital:

\[
H_t^{(1-\gamma)} \overline{H}_t^\gamma = (1 - T)H_0^{(1-\gamma)(1-\delta)} \overline{H}_0^{\gamma(1-\delta)}T^\delta
\]

\[
H_t = \frac{(1 - T)H_0^{(1-\gamma)(1-\delta)} \overline{H}_0^{\gamma(1-\delta)}T^\delta}{\overline{H}_0^{\gamma(1-\delta)}T^\delta} \tag{4}
\]

Besides:

We can consider the logarithm of the human capital at time \( t \), and we set that the average human capital of the firm is the same at time \( t \), that at time \( 0 \). There is no diffusion of training; in order to obtain the equation of accumulation of the human capital:

\[
\ln H_t = \ln(1-T) + (1-\gamma)(1-\delta)\ln H_0 + \gamma(1-\delta)\ln \overline{H}_0 + \delta \ln T + \gamma \ln H_t - \gamma \ln \overline{H}_0
\]

\[
\ln H_t = \frac{\ln(1-T)}{(1-\gamma)} + (1-\delta)\ln H_0 - \frac{\delta \gamma}{(1-\gamma)} \ln \overline{H}_0 + \frac{\delta}{(1-\gamma)} \ln T \tag{5}
\]

In order to determine the equation of accumulation of the average human capital, we calculate, firstly, the mathematical esperance of \( \ln H_t \).

\[
m_t = (1 - \delta)m_0 - \frac{\delta \gamma}{(1-\gamma)} \ln \overline{H}_0 + \frac{\delta}{(1-\gamma)} E(\ln T) + E(\ln(1-T))
\]

Considering (6), we obtain (7):

\[
\overline{H}_t = \exp(m_t + (1 - \rho) \frac{\sigma_t^2}{2}) \tag{6}
\]

\[
m_t = \frac{(1-\delta)(1-\gamma) - \delta \gamma}{(1-\gamma)}m_0 - \frac{\delta \gamma}{(1-\gamma)}(1-\rho) \frac{\sigma^2}{2} + \frac{\delta}{(1-\gamma)} E(\ln T) + E(\ln(1-T)) \tag{7}
\]

Thus the arithmetic mean of the average human capital is modify by this way with the training investment.

Secondly, we calculate the variance of \( \ln H_t \):
\[ \sigma_t^2 = (1 - \delta)^2 \sigma_0^2 - \frac{\delta^2}{(1 - \gamma)^2} \text{Var}(\ln T) + \frac{1}{(1 - \gamma)^2} \text{Var}(\ln(1 - T)) \] (8)

Then, the accumulated of the average human capital is:

\[ \ln \bar{H}_t = \frac{(1 - \delta)(1 - \gamma - \delta \gamma)}{(1 - \gamma)} m_0 - \frac{\delta \gamma}{(1 - \gamma)} (1 - \rho) \frac{\sigma_0^2}{2} + \frac{\delta}{(1 - \gamma)} E(\ln T) + \frac{E(\ln(1 - T))}{(1 - \gamma)} + \]

\[ + (1 - \delta)^2 (1 - \rho) \frac{\sigma_0^2}{2} + \frac{\delta^2}{(1 - \gamma)^2} \text{Var}(\ln T) + \frac{1}{(1 - \gamma)^2} \text{Var}(\ln(1 - T)) \]

\[ \ln \bar{H}_t = (1 - \delta) m_0 - \frac{\delta \gamma}{(1 - \gamma)} m_0 - \frac{\delta \gamma}{(1 - \gamma)} (1 - \rho) \frac{\sigma_0^2}{2} + \frac{\delta}{(1 - \gamma)} E(\ln T) + \]

\[ + (1 - \delta)^2 (1 - \rho) \frac{\sigma_0^2}{2} + \frac{\delta^2}{(1 - \gamma)^2} \text{Var}(\ln T) + \frac{1}{(1 - \gamma)^2} \text{Var}(\ln(1 - T)) \] (9)

\[ \ln \bar{H}_t = (1 - \delta) \ln \bar{H}_0 - \frac{\delta \gamma}{(1 - \gamma)} m_0 - \frac{\delta \gamma}{(1 - \gamma)} (1 - \rho) \frac{\sigma_0^2}{2} + \frac{\delta}{(1 - \gamma)} E(\ln T) + \]

\[ + \frac{E(\ln(1 - T))}{(1 - \gamma)} \frac{\delta^2}{(1 - \gamma)^2} \text{Var}(\ln T) + \frac{1}{(1 - \gamma)^2} \text{Var}(\ln(1 - T)) \]

\[ \ln \bar{H}_t = \ln \bar{H}_0 - \delta \ln \bar{H}_0 + B \] (10)

\[ \bar{H}_t = \bar{H}_0 \bar{H}_0^{-\delta} B \] (11)

\[ \bar{H}_t = \bar{H}_0 D \] (12)

Thus the average human capital of the firm depends on the initial average human capital of the firm, the arithmetic mean as the inequalities weighted by the returns of training and the importance of the external effect, and the average amount of training investment and the variance of the training investment. \( D \) correspond to the modification of the average human capital of the firm after the training program, considering that is composed of \( B \) weighted by the initial average human capital.

8.2 Annex 2: Becker’s model for the analysis of training

Becker’s model is issued from the pure and perfect competition and starts from the profit maximization of the firm and its equilibrium conditions. To begin with, a first assumption of the model considers the equality between the wage \( W \) and the marginal productivity \( MP : MP = W \), or other says, the expenses and the receipts of the firm. Secondly, Becker takes into consideration in its model, the training investment of the firm, which modifies its equilibrium conditions. If we set that training occur at time 0, the receipts of the firm can be defined as the marginal productivity at time 0 and the sum of the actualized marginal productivities that happen in the future after the training program. The expenses are composed of the initial wage and the actualized wages of the future period of time, and the direct training costs \( k \). Consequently, the equilibrium condition of the intertemporal maximization of the firm is as follows:

\[ MP_o + \sum_{i=1}^{n} \frac{MP_i}{(1+i)^i} = W_o + k + \sum_{i=1}^{n} \frac{W_i}{(1+i)^i} \]

This expression is simplified by taking in consideration the difference between the future
actualized marginal productivity and the future actualized wages, as \( G = \sum_{i=1}^{n-1} \frac{MP_i - W_i}{(1+i)^t} \) with \( G \) that represents the returns of training for the firm. The following equation is obtained: \( MP_o + G = W_o + k \). Remaining that the term \( k \) does not represent all the total training cost, but only the direct one. Indeed, it exists also opportunity costs, because the time devoted to training is considered as a loss of output. Then, we set \( C \) the total training costs, composed of \( k \), and the opportunity costs. \( C = MP' - MP + k \). Then the equation is: \( MP_o + G = W_o + C \), with \( MP' \) that represents the marginal productivity without training. The difference between the returns and the costs of training emphasize that the profit maximization lead to the fact that the costs must equalize the returns, but not necessarily that the initial wage equals the marginal productivity.

Becker G. distinguishes for its analysis, general training, that is entirely transferable on the market and specific training, that is partially transferable. Considering the poaching effect, firms must for general training propose wage after the training program to the market value, i.e., to the marginal productivity of the individual. Then, the following equation is obtained: \( G = \sum_{i=0}^{n-1} \frac{MP_i - W_i}{(1+i)^t} = 0 \). The returns of training are null and the equilibrium condition is considered: \( W_0 = MP_0 - k \) or \( MP_0 = W_0 + k \). The initial wage of the individual is inferior to its marginal productivity because he will support the training costs. Besides, with consideration of the situation with or without training \( W_0 = MP_0 - C \), its initial wage corresponds to its marginal productivity without training minus the direct training costs, \( k \), minus the indirect costs implied by the fall of productivity during training program \( MP'_0 - MP_0 \).

For specific training, because the employee cannot valorize its training in concurrent firms, the wage that offer the firm can be independent of the provided training. The solution proposed by Becker is a share between the costs and the returns of training. The wage of the individual will be inferior to its marginal productivity at the beginning of the training program in order to finance part of the training costs. The wage will then raise with training but less than the marginal productivity because of the share of the training returns with the firm.
8.3 Annex 3: Contribution of variables to the within and the between variance

**Contribution of variables that have a higher impact than the training externality to the within dispersion**

<table>
<thead>
<tr>
<th></th>
<th>Within Trainees</th>
<th>Within Non trainees</th>
</tr>
</thead>
<tbody>
<tr>
<td>women</td>
<td>4,09</td>
<td>5,55</td>
</tr>
<tr>
<td>age</td>
<td>8,96</td>
<td>2,12</td>
</tr>
<tr>
<td>square of age</td>
<td>-5.6</td>
<td>-1.28</td>
</tr>
<tr>
<td>Graduate from university less than 2 years (Bts Dut)</td>
<td>1,88</td>
<td>1,84</td>
</tr>
<tr>
<td>Graduate from university more than 2 years of studies</td>
<td>4,08</td>
<td>1,49</td>
</tr>
<tr>
<td>Graduate from Colleges of university level specializing in professional training</td>
<td>2,81</td>
<td>1,25</td>
</tr>
<tr>
<td>tenure</td>
<td>4,82</td>
<td>2,13</td>
</tr>
<tr>
<td>square of tenure</td>
<td>-2,56</td>
<td>-0,62</td>
</tr>
<tr>
<td>partial time-working 30-35 h/week</td>
<td>1,54</td>
<td>1,33</td>
</tr>
<tr>
<td>partial time-working 15-30 h/week</td>
<td>8,56</td>
<td>16,07</td>
</tr>
<tr>
<td>partial time-working less than 15 h/week</td>
<td>1,12</td>
<td>6,65</td>
</tr>
<tr>
<td>technician foreman</td>
<td>3,38</td>
<td>4,05</td>
</tr>
<tr>
<td>expertise</td>
<td>20</td>
<td>11,14</td>
</tr>
<tr>
<td>residual</td>
<td>29,19</td>
<td>29,17</td>
</tr>
</tbody>
</table>

**Contribution of variables that have a higher impact than the training externality to the between dispersion**

<table>
<thead>
<tr>
<th></th>
<th>Between</th>
</tr>
</thead>
<tbody>
<tr>
<td>age</td>
<td>-12,59</td>
</tr>
<tr>
<td>square of age</td>
<td>10,51</td>
</tr>
<tr>
<td>Bachelor</td>
<td>3,97</td>
</tr>
<tr>
<td>Graduate from university less than 2 years (Bts Dut)</td>
<td>5,09</td>
</tr>
<tr>
<td>partial time-working 15-30 h/week</td>
<td>7,26</td>
</tr>
<tr>
<td>partial time-working less than 15 h/week</td>
<td>3,35</td>
</tr>
<tr>
<td>qualified worker</td>
<td>-4,01</td>
</tr>
<tr>
<td>technician foreman</td>
<td>9,95</td>
</tr>
<tr>
<td>expertise</td>
<td>16</td>
</tr>
<tr>
<td>The setting of new equipment or new production technique</td>
<td>3,42</td>
</tr>
<tr>
<td>residual</td>
<td>14,93</td>
</tr>
</tbody>
</table>