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# ABSTRACT

## Is Wage Compression a Necessary Condition for Firm-Financed General Training?*

It is well known that workers in Europe appear to receive more firm-provided general training than their counterparts in the United States. Moreover, there is considerable evidence that firms, in many cases, pay for the general training, contrary to the predictions of Becker (1964). In important recent contributions, Acemoglu and Pischke argue that it is through wage compression that unions and other labour-market institutions induce firms to invest in general training. We show that while wage compression can make firms more willing to pay for training, it does not constitute a necessary condition for firm-sponsored training.

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Keywords: absolute and relative wage compression, firm-financed general training

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# NON-TECHNICAL SUMMARY

Workers in Europe appear to receive more on-the-job general training than their counterparts in the United States (see for example OECD, 1995) and evidence suggests that in many cases firms pay for such general training. While there are many differences between a generic European and US labour market, most involve elements of imperfect competition. These elements of imperfect competition in the labour market have formed the focus of a recent literature aiming to isolate conditions under which firms may be willing to pay for general training.

Recently the idea has gained support that a more compressed wage distribution in Europe helps to account for the observed higher levels of training. The idea is basically that, with a compressed wage distribution, firms gain by giving workers training because this raises their productivity by more than wages, and consequently firms gain a return to their training investment. This line of thinking then leads us to focus on how trade unions and other labour market institutions induce firms to invest in general training.

We measure wage compression in terms of the ratio of productivity to wages, and argue that wage compression – defined as a negative relationship between this ratio and the level of training – is not a necessary condition for on-the-job training. We show that, in the absence of wage compression (or decompression), firms can nevertheless still gain from providing training to their workers as long as wages are lower than productivity. When a worker is paid half their output in the form of wages, the employer may gain from giving further training even if the training raises both output and wages in equal proportions, because the difference between the two will be greater. It follows that when the ratio of all wages, and the ratio of output per worker to wages, are kept constant, firms will nevertheless profit from giving their workers training. Wage compression, however, will induce firms to raise the level of training. An implication of our approach is that European labour market institutions, such as labour unions, can indeed have the effect of raising the level of training, but their existence is not a necessary condition for firms' investment in the general training of the workforce.

## I. Introduction

It is well known that workers in Europe appear to receive more on-the-job (general) training than their counterparts in the United States (see for example OECD, 1995). Moreover, there is considerable evidence that in many cases firms pay for such general training, contrary to the predictions of Becker (1964).[1] While there are many differences between a generic European and U.S. labour market, most involve elements of imperfect competition. These elements of imperfect competition in the labour market have formed the focus of a recent literature aiming to isolate conditions under which firms may be willing to pay for general training.[2]

In two important recent contributions, Acemoglu and Pischke (1999a, 1999b) – A-P from now on – argue that it is through wage compression that trade unions and other labour-market institutions induce firms to invest in general training. The point of our paper is to extend the insight of AP that the Becker result will be over-turned under certain conditions. We do this as follows. First, in Section II we make a semantic point, namely that their type of wage compression is actually not what is known as wage compression in common parlance. We believe that it is important to emphasise this, since otherwise there can be some confusion in the literature about what is meant in this context. However, our second point is a more substantive one, and is the main focus of our paper. In Section III, we show that the departure from the Becker framework highlighted in the contribution of Acemoglu and Pischke is in fact more general than implied by their analysis. In particular, we find that their additive formulation of the way that training affects productivity and wages focuses attention on just one set of institutional arrangements. While such an additive formulation has the attraction of simplicity, it can be interpreted as suggesting that firms will only pay for general training under a rather narrower set of institutional arrangements than is actually the case. For this

[1] Evidence of firms' financing general training, is provided by, *inter alia*, Acemoglu and Pischke (1999a), and Leuven and Oosterbeek (1999).

[2] See for example Stevens (1994) and Acemoglu and Pischke (1999a, 1999b).

reason, we extend their approach to show that one can also set up the model such that training now affects productivity and wages in a multiplicative (or log-additive) way. This has the advantages not only of being more plausible (for reasons that we state below), but also encompassing a wider range of institutional arrangements, including piece rates.

## II. Definitions of Wage Compression - A Semantic Point

Four conditions have to be satisfied for firms to be willing to pay for general training when workers are either credit constrained or would choose a lower level of training. These are:

1. There are labour-market frictions that make the productivity of a worker exceed his or her outside option. These generate economic rents.
2. The propensity to quit is strictly less than one (in discrete time). When the firm is certain that a worker will leave once trained, it is not willing to sponsor the training.
3. The firm's share of the joint surplus due to labour-market frictions is nonzero, i.e. the workers' bargaining power is less than one. If the firm cannot capture a part of the surplus from a job match so that the worker gets all the return to training, it is again not willing to pay for the training.
4. Finally, the marginal effect of training on productivity has to exceed (in absolute terms) the marginal effect of training on the outside wage. The implication is that the former also exceeds the marginal effect on the firm's own wage, since firms pay workers their outside options. A-P refer to this phenomenon as "wage compression" but we will call it *absolute wage compression* to distinguish it from more commonly used definitions of the term. What is implied is that by paying for increased training, a firm augments a worker's output by more than his or her wage, that is, profits are increasing in training intensity at low levels of training.

A-P state the last condition on absolute wage compression alongside the first three (A-P 1999b: F119-121). Aside from the labelling of this as 'wage compression', this condition is a natural one, in the sense that it says that firms only invest in general training if they benefit from doing so. However, we will show that this has less to do with what is normally called wage compression. Our objective here is to point out that wage compression in the normal usage of the term (Kaldor, 1963; and Katz and Murphy, 1992) is not a necessary condition for firm-sponsored general training.

We now define terms in a more precise manner. Assume that $Y(\tau)$ is output of a worker with training $\tau$, $W(\tau)$ is his or her wage, $P(\tau)$ denotes the difference between the two ($Y$-$W$) and $p(\tau)$ denotes the ratio of the two ($Y/W$).

*Definition 1*

*Absolute wage compression (decompression)* occurs when $P'(0) = Y'(0) - W'(0) > 0$ ($< 0$). This implies that profits per worker in absolute terms are increasing (decreasing) in $\tau$ over some range.

*Definition 2*

*Relative wage compression (decompression)* occurs when $p'(0) > 0$ ($< 0$). This implies that the ratio of output to wages is increasing (decreasing) in $\tau$. By taking logs we get

$$\frac{d \log p(0)}{d\tau} = \frac{d \log Y(0)}{d\tau} - \frac{d \log W(0)}{d\tau} > 0 \ (< 0)$$

that is the derivative of the log difference with respect to $\tau$ is increasing (decreasing) in $\tau$. In this case training increases output proportionately more (less) than wages.

To illustrate the difference between the two definitions, assume that, as a result of increased training, the productivity and wages of every worker doubles. In this case, we have

no change in the ratio of output to wages for any worker – there is neither relative wage compression nor decompression – and there is no change in relative wages or relative productivity levels. However, there *is* absolute wage compression, since the difference between output and wages is now higher for those who have received training compared to those who have not. In light of this example we think that the second definition - *relative wage compression* - comes closer to what is usually understood as wage compression. Indeed, this is manifested in the use of relative income as measures of the income distribution in empirical work on changes in the distribution of income (Katz and Murphy, 1992, is one example from this large literature).

## III. The Model: Two Formulations and their Relationship to Institutions

A-P describe their (absolute) wage-compression argument using the following figure:

[Insert Figure near here]

Here $\Delta$ represents (fixed) costs of moving between jobs, $f(\tau)$ denotes a worker's productivity as a concave function of training intensity, and $w$ denotes wages. Notice that $f(\tau) - w(\tau) = \Delta$ – which is a constant – and $f'(\tau) - w'(\tau) = 0$. The firm would therefore not benefit from training if $\Delta$ were independent of the level of training intensity.[3]

If, however, mobility costs are increasing in the level of training $\Delta'(\tau) > 0$, then the wage schedule will be flatter than the productivity schedule, since firms pay workers their outside options. Thus profits change by $f' - w' = \Delta'(\tau) > 0$, and the firm benefits from giving the worker more training. This is what A-P call wage compression – absolute wage compression in our terminology – the employer's absolute share in output is increasing in training. Note

[3] In their paper in the *Economic Journal* (Acemoglu and Pischke, 1999a, page F121), the authors describe the figure as follows: "Observe also that wage compression (relative to marginal product) is necessary for firm-sponsored training. Suppose the wage function were $w(\tau) = f(\tau) - \Delta$ as drawn by the dashed line in Fig.1. In this case, in contrast to a perfectly competitive labour market, the worker is paid less than his productivity, so there are rents and monopsony power. But because the gap between productivity and the wage is independent

that this does not imply that their relative share – which is the ratio of output to wages – is increasing.

It appears obvious at first sight that absolute wage compression is essential to the argument. Clearly we also need frictions, such as $\Delta > 0$, to create a surplus from the job match. Moreover, we need the firm to be able to extract some of the surplus – because it has nonzero bargaining power and the worker is not destined to leave for another firm with probability one. But in the absence of absolute wage compression, the firm does not benefit from financing further training.

For this reason, A-P go on to find reasons for absolute wage compression. They make the case that these may apply to a much greater extent in Europe than in the US, and hence explain the higher frequency of firm-sponsored on-the-job training, especially in Germany. These reasons for wage compression include asymmetric information about a worker's skills between current and prospective employers, the complementarity between firm-specific and general skills (alternatively between physical capital and general skills), efficiency wages, unions and minimum wages. The general conclusion of the A-P analysis is that firms may want to invest in the general skills of their employees when the wage structure is distorted in favour of less skilled workers. Labour-market frictions and institutions thus play a key role. However, we will show that such absolute wage compression arises quite naturally in a variety of compensation systems. We now consider the model in more detail.

Denote a worker's inherent productivity by $\bar{y}$. Then assume that training adds to workers' productivity ($Y$) in an additive fashion where $f(\tau)$ is a strictly concave function:

$$Y(\tau) = \bar{y} + f(\tau) \tag{1}$$

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of the skill level of the worker, the firm has no interest in increasing the worker's skills, and there is no firm-sponsored training".

Similarly assume that wages, in the absence of training, can be denoted by $\overline{w}$ where $w(\tau)$ is again a strictly concave function;

$$W(\tau) = \overline{w} + w(\tau) \tag{2}$$

and $\bar{y}$ and $\overline{w}$ can take any value. Profits from a worker having received training $\tau$ can then be written as

$$P(\tau) = Y(\tau) - W(\tau) = \bar{y} - \overline{w} + \left(f(\tau) - w(\tau)\right) \ . \tag{3}$$

Here, absolute wage compression occurs if $P'(0) > 0$. Now denote the probability that a worker stays on after training as (1-$q$), where $q$ is the propensity to quit and is taken to be a constant and independent of relative wages. The equality of the expected marginal profit from training – $(1-q)P'(\tau)$ – and the marginal training costs $c'(\tau)$ – where $c(\tau)$ is a strictly convex function and $c(0) = 0$ – gives the optimal level of training $\tau^*$:

$$P'(\tau) = Y'(\tau) - W'(\tau) = (1-q)\left[f'(\tau^*) - w'(\tau^*)\right] = c'(\tau^*) \tag{4}$$

It follows that $\tau^* > 0$ if and only if $P'(0) > 0$ which implies $f'(0) > w'(0)$.

Now, instead of assuming that training adds to both productivity and wages in an additive fashion, suppose that it adds in a multiplicative or log-additive way. We now change equations (1) and (2) so they become

$$Y(\tau) = \bar{y}\ f(\tau) \tag{1'}$$

$$W(\tau) = \overline{w}\ f(\tau) \tag{2'}$$

where we have set $f(\tau) = w(\tau)$ to emphasise that $f'(\tau) = w'(\tau)$ for all values of $\tau$. Thus the ratio of output to wages $p(\tau)$ is a constant and equal to $\bar{y}/\overline{w}$.

The question is whether it is more plausible for inherent ability (or skills) and acquired productivity through training to appear in an additive (equations (1) and (2)) or a multiplicative fashion (equations (1') and (2')). We think that the multiplicative interaction shown in equation (1') is more plausible. The difference between (1) and (1') is simple. The

first formulation implies that inherent abilities and trained productivity are perfect substitutes, so that the isoquants in the inherent ability-trained productivity ( $\bar{y}$ , $f(\tau)$) space are downward-sloping lines. We think this is unlikely to be the case. The alternative multiplicative formulation implies that they are imperfect substitutes, so that the upper-contour set becomes strictly convex.

We can extend this argument further to illustrate the differences. Suppose that two individuals with different levels of inherent abilities enter a training programme. According to the additive formulation, their productivities will converge the longer they stay in the programme. But according to the multiplicative formulation, the ratio of their productivities will stay constant while their absolute productivities rise. According to the additive formulation, we can put a novice into a computer class and sit him next to Bill Gates, and the abilities of the two will gradually converge since the latter will learn no faster. According to the multiplicative formulation, Mr. Gates will maintain his relative lead.

Returning to the algebra, note that the firm's profits from employing the worker now become, under the multiplicative formulation

$$P(\tau) = Y(\tau) - W(\tau) = (\bar{y} - \bar{w}) f(\tau) \qquad (3')$$

and the first-order conditions with respect to training are now

$$(1-q)\,(\bar{y} - \bar{w})\, f'(\tau^*) = c'(\tau^*)\ . \qquad (4')$$

It again follows that $\tau^* > 0$ if and only if $P'(0) > 0$ – there is absolute wage compression as emphasized by A-P – but which now only implies $\bar{y} > \bar{w}$. Thus the firm would benefit from increased training in the absence of relative wage compression, and would be willing to pay for it. It follows that absolute wage compression does not imply relative wage compression. Firms may be willing to train in the absence of relative wage compression – relative wage decompression $p'(0) < 0$ not excluded.

We can make this point more succinctly as follows. Relative wage compression is defined as $dp(\tau)/d\tau > 0$ where $p = Y(\tau)/W(\tau)$ which implies that

$$\frac{WY' - W'Y}{W^2} = \frac{W(Y' - W') - W'(Y - W)}{W^2} > 0. \qquad (5)$$

Since $W'(\tau) \geq 0$ and $Y(\tau) \geq W(\tau)$ it follows that relative wage compression implies absolute wage compression: $Y' > W'$. However, absolute wage compression does not have to imply relative wage compression.

Equations (1') and (2') are consistent with a variety of compensation systems. One example is piece rates – or output-based pay – where workers get paid $\overline{w}/\overline{y}$ for each unit of output produced. Since piece rates are often used to solve incentive (or moral-hazard) problems they entail a departure from perfect competition and $\overline{y} > \overline{w}$. But, independent of the difference between $\overline{y}$ and $\overline{w}$, if one worker is twice as productive as another, he or she is also paid twice as much. There is no relative wage compression, but note that equation (4') shows that a compensation system such as piece rates yields absolute wage compression as long as $\overline{y} > \overline{w}$.

The use of output-based pay is quite common. Salespeople on a straight commission receive output-based pay: if one salesperson is twice as productive as another, she also receives twice the salary which, by the way, does not have to equal the value of sales – the employer can and does normally profit from his employees. Top executives often receive compensation in the form of stocks or stock options. The value of the options depends on the executives' productivity – their effort and ability, inherent or acquired. Agricultural workers often earn piece rates – paid for each fruit they pick to take one example. So hiring workers to pick apples and allowing them to keep half the value of each apple implies absolute wage compression and firms would be willing to pay for the training of such workers. However,

this is not a situation of either what we have called relative wage compression or what most people would understand as wage compression.

To view commission-based pay to salespeople or piece rates in agriculture are examples of wage compression is, we believe, misleading. A salesman who is twice as effective as another receives twice the compensation. But note that if both of them double their sales – and hence their income – the absolute difference between their earnings is increased. Note also that if we assume that the commission is half the value of sales, the employer's profits from the more productive salesman are twice as big as those from the less productive one. Moreover, when both become twice as productive as before, the profits coming from the more productive salesman are increased more than those from the less productive one. There is absolute wage compression but not relative wage compression. For this reason we consider it misleading to use the phrase wage compression for $P'(0) > 0$ since all that it means is that the employer gains from giving his workers training over some range of $\tau$.

The absence of relative wage compression is also a plausible assumption for salaried workers and is again compatible with absolute wage compression. If one worker is twice as productive as another, arbitrage would tell us that he should receive twice the salary – hence making the output-to-salary ratio equal across the two workers.

Finally, we should point out that economic growth also leads to absolute wage compression. According to one of the stylised facts of growth (Kaldor, 1963) labour's share in output is approximately constant over long periods of time. We can write labour's share as $YL/WL$ which - using equations (1') and (2') - boils down to $\bar{y}/\bar{w}$ being constant while the difference between the two grows over time. According to equation (4') this implies absolute wage compression. We are thus lead to the conclusion that the incentive to train may be greater in the more advanced economies!

Now assuming that $\bar{y} > \bar{w}$ in equations (1') and (2'), relative wage compression comes up if we substitute $w(\tau)$ for $f(\tau)$ in equation (2') and set $f'(\tau) > w'(\tau)$ and $f(0) \approx w(0)$. We now show that this increases the level of general training desired by employers, but does by no means constitute a necessary condition. Relative wage compression shows up in the last term in equation (6) below.

$$(1-q)\ \left[(\bar{y}-\bar{w})f'(\tau^*)+\bar{w}\left(f'(\tau^*)-w'(\tau^*)\right)\right]\ =\ c'(\tau^*) \qquad (6)$$

First note that $P'(0) > 0$ – there is absolute wage compression – even when $f'(0) = w'(0)$ – there is no relative wage compression. However, it is clear that with relative wage compression $f'(0) > w'(0)$ the profitability of paying for workers' training is increased.

Relative wage compression is thus not a necessary condition for firms' willingness to pay for general training, but instead a factor affecting how much they are willing to pay. How important this factor is depends on the shape of the training function $f(\tau)$, the level of labour-market rigidity $\bar{y} - \bar{w}$, and the effect of training on wages $w'(\tau)$. In contrast, absolute wage compression does constitute such a necessary condition. However, we have shown that it is a feature of compensation systems such as piece rates, which one does not usually associate with any form of wage compression.

## III. Conclusion

In this paper we point out that the departure from the Becker framework does not require (relative) wage compression. What is needed is that training raises a worker's productivity by more than his or her wage in absolute terms. But we have shown that this also occurs with output-based pay, which has no implications for what we would normally understand as wage compression – namely relative wage compression. We think it is important to bring this to light, since factors such as the propensity to quit – hence job security and turnover – affect the level of firm-sponsored general training in the absence of trained wage compression.

In summary, in this paper we show that the departure from the Becker framework highlighted in the contribution of Acemoglu and Pischke is in fact much more general than implied by their analysis. In particular, we find that their additive formulation of the way that training affects workers productivity and wages focuses attention on just one set of institutional arrangements. While such an additive formulation has the attraction of simplicity, it can be interpreted as suggesting that firms will only pay for general training under a rather narrower set of institutional arrangements than is actually the case. For this reason, we extended their approach to show that one can also set up the model such that training now affects productivity and wages in a multiplicative (or log-additive) way. This has the advantages not only of being more plausible, but also encompassing a wider range of institutional arrangements, including piece rates.

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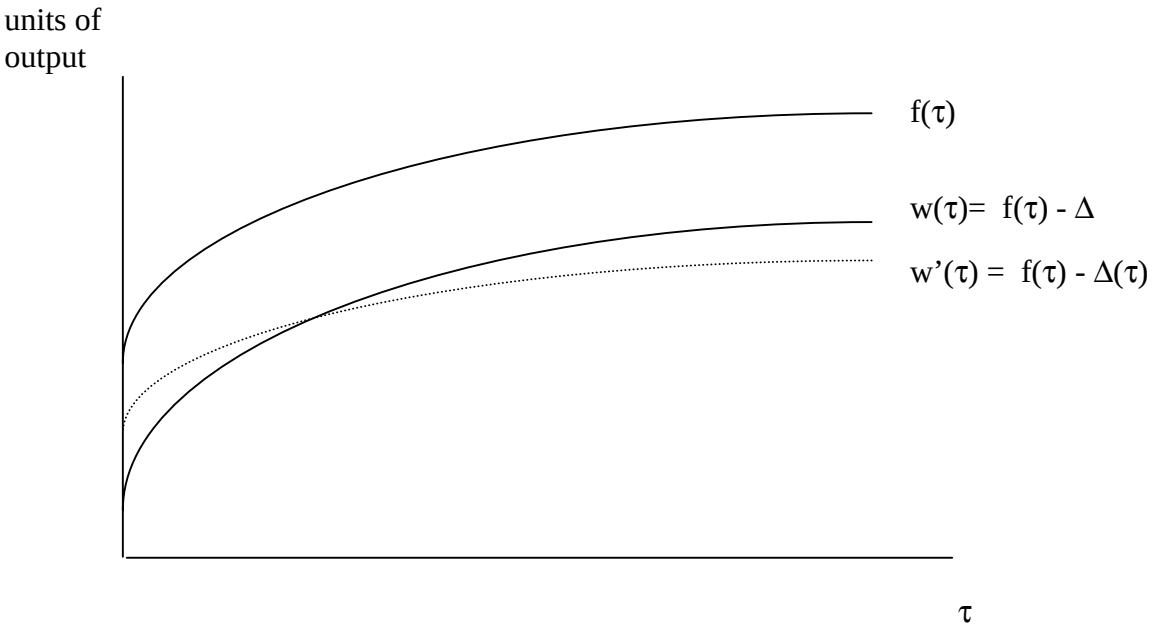


**Wage structure and training**

## Non-Technical Summary

Workers in Europe appear to receive more on-the-job general training than their counterparts in the United States (see for example OECD, 1995) and evidence suggests that in many cases firms pay for such general training. While there are many differences between a generic European and US labour market, most involve elements of imperfect competition. These elements of imperfect competition in the labour market have formed the focus of a recent literature aiming to isolate conditions under which firms may be willing to pay for general training.

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We measure wage compression in terms of the ratio of productivity to wages, and argue that wage compression – defined as a negative relationship between this ratio and the level of training – is not a necessary condition for on-the-job training. We show that, in the absence of wage compression (or decompression), firms can nevertheless still gain from providing training to their workers as long as wages are lower than productivity. When a worker is paid half her output in the form of wages, the employer may gain from giving her further training even if the training raises both output and wages in equal proportions, because the difference between the two will be greater. It follows that when the ratio of all wages, and the ratio of output per worker to wages, are kept constant, firms will nevertheless profit from giving their workers training. However, wage compression will induce firms to raise the level of training. An implication of our approach is that European labour-market institutions, such as labour unions, can indeed have the effect of raising the level of training, but their existence is not a necessary condition for firms' investment in the general training of the workforce.