



WILEY-
BLACKWELL

Beyond Becker: Training in Imperfect Labour Markets

Author(s): Daron Acemoglu and Jörn-Steffen Pischke

Source: *The Economic Journal*, Vol. 109, No. 453, Features (Feb., 1999), pp. F112-F142

Published by: Blackwell Publishing for the Royal Economic Society

Stable URL: <http://www.jstor.org/stable/2565588>

Accessed: 11/02/2009 11:08

Your use of the JSTOR archive indicates your acceptance of JSTOR's Terms and Conditions of Use, available at <http://www.jstor.org/page/info/about/policies/terms.jsp>. JSTOR's Terms and Conditions of Use provides, in part, that unless you have obtained prior permission, you may not download an entire issue of a journal or multiple copies of articles, and you may use content in the JSTOR archive only for your personal, non-commercial use.

Please contact the publisher regarding any further use of this work. Publisher contact information may be obtained at <http://www.jstor.org/action/showPublisher?publisherCode=black>.

Each copy of any part of a JSTOR transmission must contain the same copyright notice that appears on the screen or printed page of such transmission.

JSTOR is a not-for-profit organization founded in 1995 to build trusted digital archives for scholarship. We work with the scholarly community to preserve their work and the materials they rely upon, and to build a common research platform that promotes the discovery and use of these resources. For more information about JSTOR, please contact support@jstor.org.



Royal Economic Society and Blackwell Publishing are collaborating with JSTOR to digitize, preserve and extend access to *The Economic Journal*.

<http://www.jstor.org>

BEYOND BECKER: TRAINING IN IMPERFECT LABOUR MARKETS*

Daron Acemoglu and Jörn-Steffen Pischke

In this paper, we survey non-competitive theories of training. With competitive labour markets, firms never pay for investments in general training, whereas when labour markets are imperfect, firm-sponsored training arises as an equilibrium phenomenon. We discuss a variety of evidence which support the predictions of non-competitive theories, and we draw some tentative policy conclusions from these models.

Many economists view the skills of the labour force (human capital) as the engine of growth, or at the very least, a major contributor to economic performance. Although the most common indicators of human capital measure the amount of formal schooling, on-the-job training may be at least as important in determining productivity. Most lines of business require specific skills which cannot be provided by general-purpose education. Similarly, new technologies and organisations require continuous learning, best accomplished by workplace training. It is therefore not surprising that policy makers are often interested in issues of worker training. For example, training of less skilled workers was a major policy initiative of the first Clinton administration, and the current Labour government in Britain has similarly made training and skills a key policy issue. Company training is also directly or indirectly subsidised in many countries.

The increase in the returns to a college degree and other skills, experienced in a number of OECD countries over the past 20 years, has also added a sense of urgency to concerns regarding skills. Many policy-makers and experts believe that low education workers can also benefit from the changes in the demand for skills if they receive training. College graduates may need more training too, because of the spread of recent technologies, such as computers.

Academic economists have also been interested in training for a long time. Pigou (1912) argued that firms would not have efficient incentives to invest in their workers' skills because trained workers can quit to work for other employers who can use these skills. Rosenstein-Rodan (1943), in his famous article on the 'big push', not only pointed out the importance of market demand, but also of skills, and noted that training of workers was a prerequisite for industrialisation, though unlikely to happen. These early contributions, therefore, emphasised the difficulties faced by a market economy in achieving the

* We thank Steve Machin, Jim Robinson and an anonymous referee for useful comments. Acemoglu acknowledges financial support from the National Science Foundation Grant SBR-9602116. Some of the data used in this paper have been obtained from the German Zentralarchiv für Empirische Sozialforschung at the University of Köln (ZA). The data for the study 'Qualifikation und Berufsverlauf' were collected by the Bundesinstitut für Berufsbildung and the Institut für Arbeitsmarkt- und Berufsforschung and documented by the ZA. Neither the producers of the data nor the ZA bear any responsibility for the analysis and interpretation of the data in this paper.

right level of investment in worker skills. The policy prescription from these studies was that government subsidies were necessary for on-the-job training as well as for schooling.

Current thinking on training, however, is shaped by the seminal work of Gary Becker, which reaches quite different conclusions. Becker (1964) drew a crucial distinction between general and specific skills. General skills are defined as those which are also useful with other employers. In contrast, specific skills increase the productivity of the worker only in his current job. Pigou's argument applies quite forcefully to general skills. In fact, in a competitive labour market where workers receive their marginal product, firms could never recoup their investments in general skills, so they will never pay for general training. However, Becker noted, workers themselves will have the right incentives to improve their general skills because in competitive markets, they are the sole beneficiaries of the improvements in their productivity. Moreover, workers can undertake such investments quite easily by accepting a lower wage than their productivity during the period of training. This argument appears to account well for the apprenticeship systems of earlier centuries, where apprentices often paid fees or worked for very low pay until they mastered a certain trade.¹ Becker also argued that training in specific skills was quite different because workers would not benefit from higher productivity when they changed jobs. Firms therefore could recoup their investments in specific skills and would be willing to share some of the costs of specific training investments.

An important conclusion of this work is that there need not be any market failure in training. As long as workers can pay for training, either out of their pockets or by taking lower wages, the right amount of investment would be undertaken. So insufficient investment in skills could only arise because workers are severely credit constrained. But in this case, the solution may be better loan markets rather than direct subsidies to training. Becker's seminal contribution, therefore, seriously questions the argument in favour of government regulation and subsidies for training.

Apart from its sharp policy prescriptions, this theory also makes a number of empirical predictions. Most importantly, as noted above, firms should never pay for investments in general training. Becker's theory instead explains the training investments we observe in practice either by pointing out that the skills are specific, or by arguing that the workers are effectively paying for these investments by taking a wage lower than their productivity. A body of evidence, however, questions the validity of this explanation. Most skills may be industry specific. For example, the know-how to use a printing machine is of limited use outside the printing industry. Nevertheless, these skills are 'general' because typically there are many firms in the same industry using similar technologies. Skills acquired in the course of a training programme therefore can be specific only if they relate to a technology or practice used solely in that firm. The evidence we discuss in the next section suggests that there are many

¹ See Hamilton (1996) for an application of this argument to apprentices in 19th century Montreal.

instances of training programmes where the content is general and firms bear a significant fraction of the costs. Consequently, Becker's theory appears not to provide a good description of a range of training practices. This conclusion is not only of academic interest as it also questions the policy prescriptions of the theory. Before any substantive conclusion can be reached, however, we need to understand why Becker's theory fails, or more explicitly, answer the question 'why do firms pay for training?'

In Section 2, we discuss recent research suggesting a number of reasons why firms may invest in the general skills of their employees. A key conclusion will be that credit problems faced by workers cannot by themselves account for firm-sponsored training. Labour market imperfections, that is deviations from the perfectly competitive market assumed by Becker, must be part of the story.

In Section 3, we outline the efficiency implications of the non-competitive theories discussed in Section 2, and derive potential policy recommendations. Section 4 presents other empirical patterns which are pertinent to the non-competitive theories of training. In particular, we trace out the impact of different institutional arrangements for training, and discuss evidence which seems to support some of the implications of the non-competitive theories. In Section 5 of the paper, we derive the implications of differences in training systems for other issues. Specifically, we suggest that different training practices might be a part of the explanation for why wage inequality increased in the United States but not in Germany. We also point out how training systems interact with different patterns of labour mobility and regulation regimes. We conclude in Section 6 by outlining a number of areas where future research is required.

1. Do Firms Pay For General Training?

In this section, we argue that a variety of evidence contradicts the predictions of the standard theory of training developed by Becker. To do this, we need to establish that there are instances of general training where firms not only provide, but also pay for training investments.

The first piece of evidence comes from the German apprenticeship system (see Steedman (1993), Soskice (1994), and Harhoff and Kane (1997) for more details). Apprenticeship training in Germany is largely general. Firms training apprentices have to follow a prescribed curriculum, and apprentices take a rigorous outside exam in their trade at the end of the apprenticeship. The industry or crafts chambers certify whether firms fulfill the requirements to train apprentices adequately, while works councils in the firms monitor the training and resolve grievances. At least in certain technical and business occupations, the training curricula limit the firms' choices over the training content fairly severely. For example, a trainer in a large bank told us that apprentices typically do not find the time to learn about the more company specific products during the apprenticeship.

Three studies estimate the net cost of apprenticeship programmes to employers in Germany. They survey training firms about their accounting costs

and apprentice productivity to assess the net cost of training. The most careful of these was conducted in 1991 by the Federal Institute for Vocational Training (Bundesinstitut für Berufsbildung) and is described in von Bardeleben *et al.* (1995). The first step is to calculate gross costs as the sum of the payroll costs of apprentices and training personnel, costs of material, equipment, and structures used in the training, and direct costs of any external training that the firm pays for. In addition, the studies assess apprentice output, by surveying supervisors about the jobs done by apprentices, and their productivity. A money measure of the output contribution is constructed by multiplying the time spent in productive activities with the payroll costs of a skilled worker and the relative apprentice productivity. This calculation assumes implicitly that the wages of skilled workers are set competitively, reflecting marginal products. If the firm has market power over these workers, marginal product may exceed wages, so this calculation would yield an underestimate of apprentices' contribution to output.

A second problem arises from the fact that in many, especially smaller establishments, most trainers are not engaged in training full-time, and also work in productive activities. The German study for 1991 takes two approaches to this problem. The first is to prorate the time spent on training by part-time personnel. As an alternative, the study excludes the costs of part-time trainers completely from the cost calculation, arguing that they would be employed at the training establishment anyway, at least in the short run (they refer to this as variable cost).

Table 1 illustrates the role of these assumptions using data from von Bardeleben *et al.* (1995) for Germany. Average total gross costs per apprentice per year amounted to almost DM 30,000. Excluding part-time trainers yielded a variable cost of only DM 18,000. The productivity of an apprentice, valued at skilled worker wages, amounted to about DM 12,000. Under the perfect market assumptions and using full costs, this yields a net cost of training of around

Table 1
Costs of Apprenticeship Training in German 1991 (German Marks per Year)

	By firm size (number of employees)				
	All firms	0–9	10–49	50–499	500+
(A) Total gross costs	29,573	27,473	28,176	30,344	35,692
(B) Variable gross costs	18,051	13,867	15,074	20,283	28,197
(C) Apprentice productivity	11,711	12,221	11,465	12,099	10,311
Perfect markets					
Total net costs ($A - C$)	17,862	15,252	16,711	18,245	25,381
Variable net costs ($B - C$)	6,340	1,646	3,609	8,184	17,886
Imperfect markets (50% markdown)					
Total net costs ($A - 2C$)	6,151	3,031	5,246	6,146	15,070
Variable net costs ($B - 2C$)	–5,371	–10,575	–7,856	–3,915	7,575

Source: von Bardeleben *et al.* (1995), Chart 27 and Table 12.

DM 18,000. Using variable costs, the net costs are only around DM 6,000. Instead, suppose that skilled worker wages are not set in perfect markets, but assume arbitrarily that marginal products are twice a skilled worker's wage. Net training costs would then be about DM 6,000 using full costs, but DM -5,000 using only variable costs. The latter number makes very conservative assumptions and we regard it as a lower bound for the net costs of training. However, even this very conservative estimate implies that the largest firms in Germany (those with more than 500 employees) have positive training costs of around DM 7,500 per worker. Overall, the evidence therefore suggests that even under conservative assumptions, large German firms bear a significant financial cost in providing general training to their apprentices. Similar studies exist for other countries. For example, Ryan (1980) examined welder apprentices at a US shipyard, and Jones (1986) looked at apprentices in British manufacturing. All of these studies find substantial net costs for training apprentices.

Another interesting example comes from the recent growth sector of the United States, the temporary help industry. The temporary help firms provide workers to various employers on short-term contracts, and receive a fraction of the workers' wages as commission. Although blue-collar and professional temporary workers are becoming increasingly common, the majority of temporary workers are in clerical and secretarial jobs. These occupations require some basic computer, typing and other clerical skills, which temporary help firms often provide before the worker is assigned to an employer. Workers are under no contractual obligation to the temporary help firm after this training programme. Most large temporary help firms offer such training to all willing individuals. As training prepares the workers for a range of assignments, it is almost completely general. Furthermore, it does not serve as a screening device for the temporary help agency as participation is voluntary. Although workers taking part in the training programmes do not get paid, all the monetary costs of training are borne by the temporary help firms, giving us a clear example of firm-sponsored general training. This was first noted by Krueger (1993) and is discussed in more detail in Autor (1998).

Other evidence is not as clear-cut, but suggests that firm-sponsored investments in general skills are widespread. A number of studies have investigated whether workers who take part in general training programmes pay for the costs by taking lower wages. The majority of these studies do not find lower wages for workers in training programmes, and even when wages are lower, the amounts typically appear too small to compensate firms for the costs (see Bishop (1996) and Barron *et al.* (1997) for a detailed discussion of this evidence). Although this pattern can be explained within the paradigm of Becker's theory by arguing that workers selected for training were more skilled in unobserved dimensions, it is consistent with firm-sponsored-training.

There are also many examples of firms that send their employees to college, MBA or literacy programmes, and problem solving courses, and pay for the expenses while the wages of workers who take up these benefits are not reduced. In addition, many large companies, such as consulting firms, offer training programmes to college graduates involving general skills. These

employers typically pay substantial salaries and bear the full monetary costs of training, even during periods of full-time classroom training.

We interpret these various pieces of evidence as suggesting that employers often pay for investments in the general skills of their employees. It is important, however, to emphasise that this evidence does not deny that there are many instances where Becker's theory provides a good stylised description of reality. In particular, workers often accept lower wages with the anticipation of steep age-earnings profiles (Rosen, 1972). An example of this would be an economist taking an assistant professor job at Harvard despite the higher salaries in other economics departments or business schools. Securities brokers, often highly qualified individuals with MBA degrees, also apprentice at a pay level close to the minimum wage until they receive their professional certification. Despite its explanatory power in a number of instances, however, the evidence that many firms do pay for general skills provides a challenge to develop new theories consistent with these patterns. In the rest of this paper, we discuss what general class of models can be consistent with these patterns, and whether they receive support from other empirical evidence.

2. When Do Firms Pay for Training?

How can we construct a theory which provides a better stylised description of training practices? We argue in this section that such a theory has to allow for labour markets that are not competitive.

2.1. *Training in Competitive Labour Markets*

To fix ideas, we consider a very simple setup. A worker is hired at time 0 during which he can be trained, and then he becomes productive at time 1. We normalise the productivity of the worker during time 0 to zero, and denote the output of the worker at time 1 by $f(\tau)$, where τ is his level of training. Training costs $c(\tau)$, there is no discounting, and all parties are risk-neutral. Fig. 1 draws these two functions. We assume that all skills are general in order to focus on the case of interest for our purposes, so the productivity of the worker is $f(\tau)$ in other firms as well.

We denote the wage of a worker with training τ at time 1 by $w(\tau)$. A competitive labour market corresponds to the case where many firms compete for the labour services of the worker at time 1, ensuring that $w(\tau) = f(\tau)$. If this were not the case, every firm would be willing to hire the worker, creating excess demand for his labour services. The significant feature is that the wage of the worker at the initial employer is no different than the wage the worker can obtain at a different firm, because all of his skills are general and there are no mobility costs. This immediately implies that the firm will not pay for the worker's training as it would not be able to recoup its investment costs.

So if the firm will not pay for training in a competitive labour market, will the worker? To answer this question, first consider the hypothetical case where the worker can choose the amount of training and has the resources to pay for

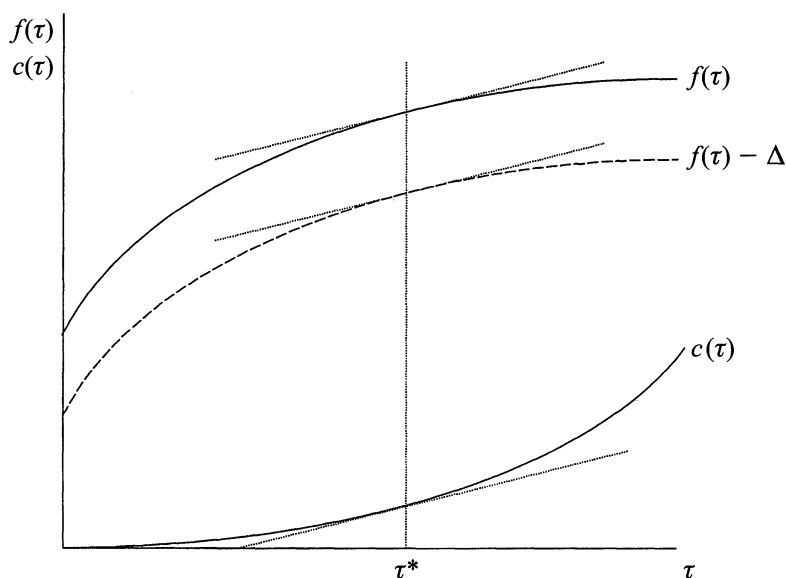


Fig. 1. *Training in Competitive Markets*

it. It is clear that in a competitive labour market, the worker is the residual claimant of the returns generated by the training investments. He will therefore choose the efficient amount of investment, given by $\tau^* > 0$ where $c'(\tau^*) = f'(\tau^*)$, as shown in Fig. 1. This is the outcome discussed by Becker. The market achieves the efficient level of training without firms making any investments in worker skills. There are, however, two important requirements for this to happen.

The first is that the worker must have the resources to invest in training. In the case we have just described, the worker is not productive during time 0. He must therefore make a payment to the firm to compensate for the expenses that the firm incurs. In practice, most on-the-job training is not full-time, so the worker can take part in some productive activities. This would enable him to bear the costs of training by taking a wage cut, rather than making a payment to the firm. Such wage cuts are costly, however, when credit markets are imperfect and workers have a desire for smooth consumption. For example, with a concave, time separable utility function, the worker would like to have the same level of consumption in both periods. Taking a wage cut at time 0, without a possible loan, would take him away from his desired consumption path. Hence, even when workers are productive during their training, efficient investment in skills requires perfect loan markets. These are unlikely to exist because of the inherent moral hazard and adverse selection problems. So the ability of workers to invest in training is likely to be limited in practice.

There is a second condition for workers to be able to invest in general skills. Training is in some respects different from schooling. Although workers can

take vocational courses, many skills are best learned by on-the-job training, combining production, learning-by-doing, and mentoring by more experienced colleagues. However, the employment relation gives the control over the worker's time to his employer. It is therefore possible for a firm to pay a low wage with a training promise, and then use the worker in regular production activities. This possibility could be avoided if what constitutes training were easily observed by courts, so that employment contracts could unambiguously specify the training obligations of the employer. Nevertheless, since important parts of the training programme are intangible, involving mentoring, advice and practice, it is quite hard to specify them in advance and monitor the firm's compliance in individual cases. This problem might be overcome in a dynamic world, where a firm that does not deliver on its training promises would develop a bad reputation. But, training practices inside the firm are hard to observe by outsiders, and returns to training depend on individual worker's ability and effort, making it hard to infer training from future earnings of workers. So this reputation mechanism is also highly imperfect. With this reasoning, for example, outside agencies and works councils in Germany monitor the curriculum and implementation of apprenticeship programmes and credential skills. We therefore view the contracting difficulties between firms and workers as an additional constraint on workers' ability to 'buy' training in the workplace.

Overall, this discussion suggests that, as pointed out by Becker, in competitive labour markets, firms will not pay for general training investments. Furthermore, although workers will have the right incentives to invest, a variety of obstacles may prevent them from choosing the right amount of investment.

An important conclusion which follows from this discussion is that the presence of credit market problems will not by themselves encourage firms to pay for general training investments. Although a number of authors have suggested that the reason why firms pay for general training investments is that workers are liquidity constrained, credit market problems are not sufficient to ensure firm-sponsored training in perfectly competitive labour markets. Motivated by this observation, we now turn to models of training in non-competitive (imperfect) labour markets.

2.2. *Training in Non-competitive Labour Markets*

To start with, let us consider Fig. 2, and assume that wages are given by $w(\tau)$ as drawn in the figure. We continue to assume that all skills are general. The function $w(\tau)$ specifies the wage that the firm has to pay a worker with training τ . The key feature is that wages are below the productivity of the worker, so the situation depicted in the figure is not consistent with a perfectly competitive labour market. Instead there are rents in the employment relation accruing to the employer (i.e. there is some monopsony power). To see why this is important for firm-sponsored training, notice that if the firm could never pay a worker below his productivity, it could not recover the up-front costs of training. We will discuss mechanisms leading to such rents below.

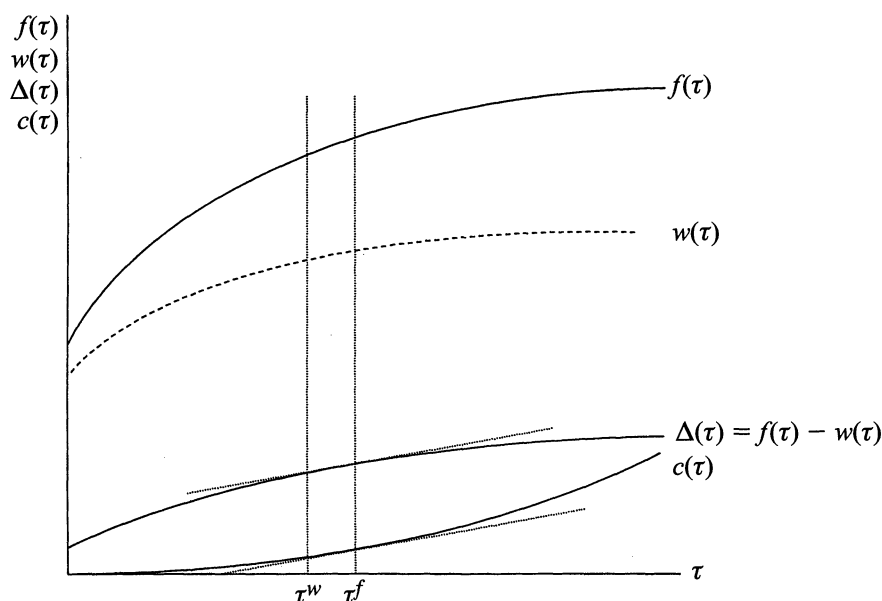


Fig. 2. *Training with a Compressed Wage Structure*

The second and more important feature is that the wage function is increasing in the level of training less steeply than productivity, so the gap between productivity and the wage, $\Delta(\tau)$, is higher at greater levels of skills. We refer to this as a *compressed wage structure*, since the return to skills for a worker is less than the one prevailing in a competitive labour market. The gap between the two curves in the figure, denoted by $\Delta(\tau)$, is the profit that the firm makes from employing the worker (gross of training costs, if any): its revenues are equal to $f(\tau)$, and its cost is equal to the wage, $w(\tau)$. Therefore, with the wage function drawn in Fig. 2, the firm prefers a more skilled worker to a less skilled one. This contrasts with the situation in the perfectly competitive labour market where profits from skilled and unskilled workers were equal, i.e. $\Delta(\tau) = 0$ for all τ , and so the firm was indifferent regarding the skill level of its employee. In the non-competitive labour market outlined in Fig. 2, the firm may therefore want to invest in the skills of its employees so as to increase its profits.

To see this more clearly, suppose that workers themselves cannot invest in training at all. Then, our analysis of Fig. 2 shows that the firm will provide and pay for training up to $\tau^f > 0$, given by $c'(\tau^f) = f'(\tau^f) - w'(\tau^f)$. In other words, the firm would choose the level of training by setting the marginal change in the second period profit equal to the marginal cost of training.

It is important to emphasise that, due to labour market imperfections and monopsony power, workers are not being paid their full marginal product even though the skills are general. So general skills are being rewarded as if they were (partly) specific. Labour market imperfections therefore turn general skills into *de facto* specific skills.

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 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.

The discussion so far has established that firms may have an incentive to invest in the general skills of their employees. However, we used an arbitrary wage function, did not specify the sources of the imperfections, and assumed that workers themselves are not able to contribute to training expenses. In the rest of the section, we discuss these issues, and argue that under plausible assumptions, wages will be below marginal product, the equilibrium wage structure will be compressed, and firms will bear some of the cost of training, even when workers can also invest in skills.

2.3. *Sources of Wage Compression and Labour Market Rents*

The first reason for rents and a compressed wage structure is the presence of transaction costs in the labour market, for example matching and search frictions. In practice, it is difficult for workers to quit their existing jobs and find new suitable employers. Similarly, it is costly for firms to replace their employees. The presence of search costs in the labour market therefore creates a bilateral monopoly situation in wage determination. There is a match-specific surplus (rent), created by the costs of finding new partners, and this surplus will have to be shared by bargaining.² This typically implies that firms obtain a fraction of the productivity of the worker as profits. For example, the wage of the worker may be equal to $\beta f(\tau)$, while the firm obtains $(1 - \beta)f(\tau)$ as profits. Bargaining (induced by market frictions or otherwise) therefore compresses the wage structure and creates incentives for firm-sponsored training.³ This story is proposed and developed in detail in Acemoglu (1997).

A second source of wage compression and labour market rents is the presence of asymmetric information between the current employer of the worker and other firms in the economy. There are two types of information that outside employers may not have. The first concerns the amount of training and human capital that the worker has acquired. Our discussion above, which emphasised that training practices are difficult to contract on and imperfectly observed by outsiders, implies that potential employers will be unable to judge the exact

² See Mortensen (1982), Diamond (1982) and Pissarides (1990) for analyses of the standard search and matching model. See Peters (1991), Moen (1997) and Acemoglu and Shimer (1997) for models with search frictions but no bargaining.

³ Notice that for this source of wage compression to work, it is not necessary for skilled workers to have less bargaining power than unskilled workers. In fact, they may have more. Wage compression arises naturally because the surplus brought to the employment relation is larger when the worker is more skilled, and the firm obtains a share of this larger pie.

quantity and content of the training the worker has received. They may therefore be unwilling to compensate workers for these uncredentialed skills, enabling the initial employer to keep its trained workers for a relatively low wage. Since in this situation all the increase in productivity does not get translated into wages, the equilibrium wage structure will be compressed. This explanation for the presence of firm-sponsored training programmes was first suggested by Katz and Ziderman (1990), and is formalised by Chang and Wang (1996). Although this explanation is plausible when applied to company training in the United States, it may be less relevant for the German apprenticeship system where the content of apprenticeship programmes is regulated by the government and follows a well-specified curriculum.⁴

An alternative explanation based on asymmetric information is developed in Acemoglu and Pischke (1998*a*). In that paper, we argue that the important asymmetry of information between current and potential employers concerns the ability of young workers. The early years of a worker's career reveal valuable information about whether he is suited to the occupation he has chosen. We show that when ability and training are complements, so that high ability workers benefit more from training, this type of asymmetric information leads to a compressed wage structure and encourages firms to sponsor training. Intuitively, workers who are laid off have, on average, lower ability, thus the value of training is relatively low for them. Since a high ability trained worker cannot quit and signal his ability, the employer can keep him while paying less than the full value of his skills. This source of wage compression encourages the employer to invest in skills. In Section 5 below, we develop a simplified version of this story to illustrate a number of differences between German and US labour markets.

Su (1997), Autor (1998) and Malcomson *et al.* (1997) build on and extend the simple adverse selection model of training discussed above. Su and Malcomson *et al.* model in more detail the possibility that firms may renege on their training promise in the presence of the asymmetric information problem between the current employer and other firms. More significantly, Malcomson *et al.* show how such a model determines the length of an apprenticeship, which is assumed exogenous in Acemoglu and Pischke (1998*a*). Autor (1998) considers a model in which workers know their ability, and firms learn their employees' ability during training. High ability workers self-select into jobs offering training, which also have lower wages initially and steeper wage profiles.⁵ Autor also looks at the impact of competition among firms on training and finds that more competition may increase the amount of firm-sponsored training and the slope of the wage profiles.

A third reason for wage compression is asymmetric information between the worker and the employer regarding the exact level of effort and diligence

⁴ Naturally, for this and the next source of wage compression to be important, it is necessary that new employers learn about the value of the worker's previous training (or ability) slowly. Otherwise, a short initial screening period would solve the problem.

⁵ The use of training to induce self-selection among heterogeneous workers is also analysed in Statt (1998).

exerted by the employee. This implies that the remuneration of the worker has to be a function of his performance and other indicators related to his effort in order to ensure that he chooses the appropriate amount of effort. In other words, wages need to satisfy the worker's incentive compatibility constraint. The resulting wage structure is often compressed. In Acemoglu and Pischke (1998*b*), we show that the presence of moral hazard and limited liability constraints, which imply that the worker cannot receive a negative payment, will typically compress the structure of wages, and thus encourage firms to invest in the skills of their employees. Intuitively, in order to induce effort, employers have to make a certain minimum payment to a worker, even if he is not very productive. So when the productivity of a worker is below this level, it can be increased without having to increase wages. Hence, for workers receiving the minimum payment necessary to induce effort, the structure of wages is highly distorted, and the firm would receive most of the increase in productivity due to training. Of course, for the firm to be profitable in this case, some other mechanism, such as mobility costs for workers, needs to create rents. This situation depicted in Fig. 3, where the dashed line draws the wage structure in the absence of moral hazard. Δ denotes rents captured by the employer due to other imperfections. Since $w(\tau) = f(\tau) - \Delta$, without moral hazard there is no training. Moral hazard requires employers to pay a minimum wage of w^* to induce effort, leading to a compressed wage structure. If the firm has to pay $\max\{f(\tau) - \Delta, w^*\}$, then it is willing to invest in training up to the level τ^f as denoted in the figure. Loewenstein and Spletzer (1998), in a related contribution, show that efficiency wages, paid to reduce turnover, can also lead to firm-sponsored training. Essentially, the reason is again a compression in the wage structure.

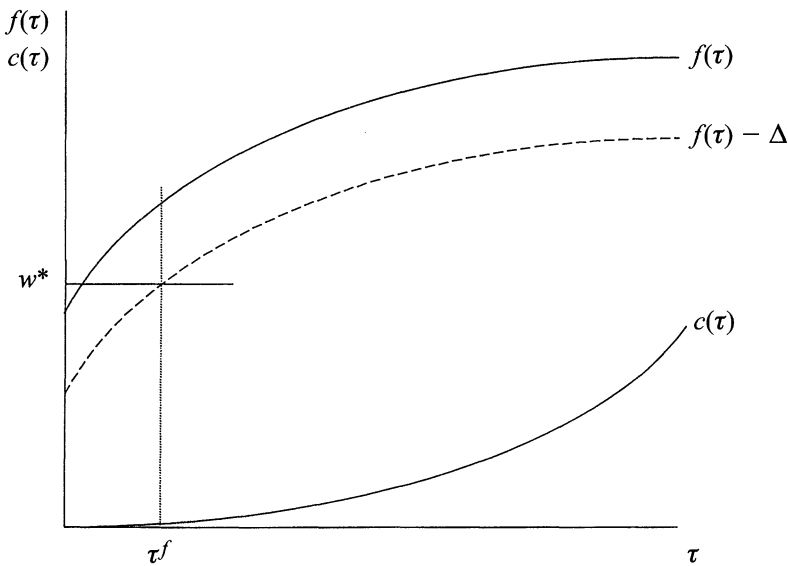


Fig. 3. *Training with a Minimum Wage Payment*

Another source of firm-sponsored training is the interaction of specific and general skills. Our discussion around Figs. 1-3 assumed in that all skills were general. This of course was a simplification. Training and experience in a firm usually lead to the accumulation of both general and firm-specific skills. We know from Becker's contribution that firms may share the costs of firm-specific investments. Can firm-specific skills encourage firms to also share the costs of general training investments? The answer depends on whether the presence of firm-specific skills leads to a compression in the wage structure. If firm-specific skills are present but do not interact with general skills, they do not lead to firm-sponsored general training. This can be seen most easily in Fig. 1 where the wage function is $w(\tau) = f(\tau) - \Delta$. Firm-specific skills create a rent Δ for the current employer and when the worker changes jobs, his productivity declines because he has lost his firm-specific human capital. However, the rent from firm-specific skills is independent of additional general skills. So, there is no wage compression, and firms do not invest in workers' general skills.

Firm-specific skills, however, most often influence how productive general skills are. For example, the knowledge how to use a particular software is much more valuable when an employee knows the exact goals of his division. This implies that general and specific skills are complements. When the amount of general skills a worker possesses increases, the value of the specific skills will also go up. This means that the marginal product and wage schedules look like $f(\tau)$ and $w(\tau)$ in Fig. 2, and the structure of wages is once again compressed. This wage compression encourages firms to invest in the general skills of the worker (as well as specific skills). This story is suggested and developed in Acemoglu and Pischke (1998*b*).

A number of other authors have emphasised similar reasons for firm-sponsored general training. Bishop (1996) points out that although skills may be general, each worker has a particular mix of skills, and this mix may be more suited to the current employer than to other employers. This would encourage employers to invest in the skills mix that they require, which is specific, although each skill component is general. Stevens (1994) develops a similar argument by pointing out that in practice skills are neither completely general nor purely specific. This mixture, she argues, makes the outside market for workers non-competitive. She models this imperfect competition as Cournot and shows that firms may invest in the skills of their employees which are in part general. Finally, Franz and Soskice (1995) point out that it may be the accumulation of general and specific skills which is complementary. Teaching firm-specific skills may reduce the cost of also teaching general skills to employees, and *vice versa*. This implies that firms may invest in general skills indirectly when teaching firm-specific skills.

There are also labour market institutions which compress the structure of wages directly, and therefore would serve to encourage firms to invest in general skills. For example, minimum wages increase the pay of less skilled workers, while leaving the wages of skilled workers largely unaffected. In Acemoglu and Pischke (1998*c*), we show how minimum wages can increase training. In particular, as in the case of efficiency wages discussed above, if a

firm provides training to a worker whose productivity is below the minimum wage, it does not have to increase his wage. So around the minimum wage, the structure of wages is highly compressed and the firm is the *de facto* residual claimant of increases in productivity, encouraging firm-sponsored training. Fig. 3 also illustrates how minimum wages compress the wage structure and encourage training, with w^* interpreted as the minimum wage. Once again, some other source of labour market rents, to generate $\Delta > 0$, is necessary for this story to work, otherwise, the minimum wage would force the firm out of business.

Most economists also believe that unions compress the structure of wages by forcing employers to pay higher wages to less skilled workers (Freeman and Medoff, 1984). In Acemoglu and Pischke (1998*b*), we show how union wage setting can also lead to firm-sponsored training. Unemployment benefits in most countries are progressive as they have higher replacement ratios for lower paid workers. This can once again create the necessary wage compression for firm-sponsored training. Jansen (1998) shows that firing costs can also lead to similar results.

2.4. *Sharing the Costs of General Training*

Our discussion so far has established that when the structure of wages is compressed, firms prefer to employ more skilled (trained) workers, and as a result, they may want to invest in the skills of their employees. Nevertheless, because workers also benefit from training (as long as $w'(\tau) > 0$), it is not immediate whether employers will invest in general skills when workers can do so. In this subsection, we investigate how the costs of general training will be shared, if at all. Throughout, we will assume that the wage structure is compressed, so that firm-sponsored training is feasible. Our discussion follows the more detailed analysis in Acemoglu and Pischke (1998*b*) by distinguishing two cases.

We refer to the first case as the non-cooperative regime. Here, workers are unconstrained in the amount of investment they make towards their skills, but this investment is decided after the employment relation starts, and independently of the firm's contribution to training expenses. More explicitly, at time 0, once they are together, the firm and the worker independently decide how much to contribute towards training investments. The worker's contribution could be in terms of a pay concession, while the firm may contribute towards the monetary expenses. In Acemoglu and Pischke (1998*b*), we establish that in this case all the costs will be borne by one of the parties. Denote the level of training which maximises workers' utility, assuming no investment by the firm, by τ^w , which satisfies $w'(\tau^w) = c'(\tau^w)$. If τ^w is greater than τ^f , then the worker will bear all the cost of general training as in Becker's model. In contrast, if the worker's preferred level of training, τ^w , falls short of the firm's, all costs will be borne by the firm, even though training is general and the worker is not liquidity constrained. This is the case drawn in Fig. 2 where the function $w(\tau)$ is less steep than $\Delta(\tau)$, so τ^f is higher than τ^w . The intuition for the result is

simple. When the firm already chooses a level of training greater than the worker's preferred choice without any investments from the worker, he would have no incentive to invest further in skills. An important implication of this result is that as the structure of wages becomes more compressed, the firm's preferred level of training increases and that of the worker declines, so it becomes more likely that firms will invest in general skills.

An alternative scenario is the full-competition regime. The previous analysis did not allow the firm to offer an employment package consisting of a wage and a training level to the worker before their employment relationship starts. In the non-cooperative case, there is an externality from the firm's training investment because the worker benefits from this training. The possibility to write contracts over both the training level and the wage lets the firm internalise this external effect, and leads to more training. In Acemoglu and Pischke (1998*b*), we show that in the full-competition regime, the cost of training will be shared between the worker and the firm. Although some of the comparative statics are different in this case (see the discussion in the Section 4), a more compressed wage structure continues to lead to more firm-sponsored training.

Overall, in a variety of circumstances, a compressed structure of wages will encourage firms to bear some, or perhaps all, training costs. Furthermore, when wages are more compressed, firms will tend to pay for a larger fraction of training costs, and are more likely to pay for all the costs. As emphasised above, these results rely on non-competitive labour markets, because wages need to be less than the worker's productivity and must increase less steeply than productivity when workers become more skilled.

3. Market Failures in Training?

In this section, we discuss the policy implications of the non-competitive theories of training outlined so far. Although our state of knowledge is not advanced enough to make precise policy recommendations, a brief discussion of whether the amount of training achieved by the market economy is likely to be efficient is useful.

A number of other authors have emphasised market failures in training, see, for example, Ritzen and Stern (1991). The focus, however, has typically been on credit market problems and the poaching externalities emphasised by Pigou (1912). Credit market problems were also pointed out by Becker, and are well understood. Although poaching externalities are important, they cannot be analysed fully in competitive labour markets where workers always receive their full marginal products (i.e. there is always complete 'poaching' in some sense). Therefore, in the rest of this section we focus on market failures in training explicitly caused by labour market frictions.

Recall that in the standard theory of human capital, training investments are efficient if workers are not liquidity constrained. In this theory, government intervention is often unnecessary, and should be mostly limited to improving loan markets. In fact, subsidies to training would be counterproductive when

the degree of liquidity constraints varies across workers, because with subsidies, workers who are not liquidity constrained will invest more than the efficient amount due to the lower marginal cost of investment.

The theory we have outlined in the previous section leads to two different conclusions. First, even when workers are severely liquidity constrained, the amount of training may not be as low as predicted by Becker's theory, because firms would undertake some of the general training investments. Second, and more important, even when workers are unconstrained, the amount of training is likely to fall well short of the first-best level of investment. In the rest of this section, we discuss the reasons for this underinvestment.

The first source of underinvestment arises when training investments are decided after the employment relation starts. Our analysis above discussed how in the non-cooperative regime, the amount of training is equal to the firm's or to the worker's preferred level. With a compressed wage structure, both the firm and the worker share the proceeds from training, but neither is the full residual claimant. When training decisions are made individually, as in the non-cooperative regime, neither party will take the effect of investment on the other into account and training is suboptimally low.

This inefficiency can be overcome if the worker and the firm can write employment contracts which specify both the wage and the training level in advance, as in the full-competition regime discussed above. Nevertheless, there is another externality which remains operative even in this case. This externality arises because general training in non-competitive labour markets often benefits future employers. In contrast to competitive labour markets where future employers pay the full marginal product of workers, in labour markets with a compressed wage structure, a new employer would also make higher profits from employing a more skilled worker. This argument is developed in Acemoglu (1997), who establishes that even when workers have access to perfect loan markets and there are no contractual problems, the amount of training in imperfect labour market will be suboptimally low. If the source of market failure in training is the positive externalities on future employers, the policy remedies of the standard theory would be of no benefit.

Since the amount of training in a non-competitive labour market is likely to be suboptimal, it is instructive to discuss possible policy solutions briefly. The most common remedy is subsidies. In most of the simple models we have discussed, training subsidies would be beneficial. One potential problem, however, is that when monitoring workplace training is difficult, due to reasons discussed above, subsidies may be relatively ineffective. For example, if the amount or quality of training the firm provides is completely non-contractible, then with or without subsidies, the firm will choose the same amount of training, and subsidies are simply a windfall gain to the firm. An alternative to subsidies would be the direct provision of training by the government, but government training programmes fail to exploit the complementarity between training and production, and their curricula may lag behind the needs of businesses and trainees. The US experience with subsidies and government

run training programmes is rather mixed, suggesting that only expensive government programmes are successful, see e.g. Lalonde (1995).

This suggests that it may be necessary to supplement subsidies with regulation.⁶ Most regulation, as in the case of the German apprenticeship system, monitors the quality of training programmes and certifies skills. One effect of regulation would be that it makes it easier for firms and workers to contract on the amount of training, allowing them to eliminate the externality that arises when training is decided non-cooperatively (see e.g. Acemoglu and Pischke (1998*a*)). Hence, regulation would allow workers to contribute to the amount of training they receive, so it would be most useful when workers have some ability to pay for training. With a similar argument, regulation would also complement the use of subsidies by enabling the government to monitor whether a firm receiving subsidies is actually training. But regulation could also be counterproductive. For example, if other firms' uncertainty about the value of skills acquired in a training program encourages initial employers to provide training, as in the model of Katz and Ziderman (1990) discussed above, certification of the skills may reduce firm-sponsored training.

Overall, labour market imperfections lead to inefficiencies in training by creating wage compression in the current and future employment relations. Since the source of the problem is not in the credit market, subsidies or regulation may be necessary to redress it, though in non-competitive labour markets, there may be complementarities between these policies, or some of them may be counter-productive. So a more case-by-case analysis is necessary. Although we currently lack the type of detailed empirical information necessary to make precise policy recommendations, the results here are useful, as they suggest the opposite conclusions to those developed by Becker and accepted by many labour economists.

4. Evidence on Patterns of Wages and Training

In this section, we summarise some evidence related to the key predictions of the non-competitive theories of training discussed in Section 2. The first subsection surveys evidence suggesting that general training leads to a path of wage growth which falls short of productivity growth, enabling employers to recoup the costs of training. The second part discusses whether more compressed wage structures lead to more training.

4.1. Productivity and Wage Growth After Training

According to Becker's theory, when training is general, wages after training grow at the same rate as productivity. There are a number of studies which find this not to be the case. Loewenstein and Spletzer (1998) show that training in off-site vocational courses, which are typically very general, increase wages with

⁶ See Malcomson *et al.* (1997) for a model where both regulation and subsidies are necessary to reach first-best training.

the current employer much less than wages with future employers. The fact that employers and workers are willing to take part in the training programmes suggest that there are productivity gains from training. So it appears that the employers are able to recoup the cost of training due to the slower growth of wages than productivity. Pischke (1996) also finds zero or small returns for further training of men in Germany. Most of this training is quite general, as many workers report receiving a written certificates at the end, which they would use when getting a new job.

Barron *et al.* (1997) and Bishop (1991) find in data from the Employment Opportunity Pilot Project (EOPP) and Small Business Administration (SBA) that employers claim training is valuable with other firms, but their measures of productivity growth associated with training exceed wage growth by a factor of ten. The measures of productivity in these studies are subjective—not in dollar units—, so this evidence has to be interpreted with some care. Nevertheless, the findings are consistent with the stories developed in Section 2. Using the same data, Bishop (1987) also finds that wages across workers doing the same job in the same firm differ much less than productivity measures, which again means the structure of wages is compressed. Similar evidence is reported by Akerlof (1982) and Frank (1984).⁷

4.2. *Do Compressed Wage Structures Encourage Training?*

In Becker's theory, the degree of wage compression has no impact on firm-sponsored training, as firms do not pay for training in any case. Also, since workers undertake all investments in general training, wage compression reduces returns to training, and discourages investments in skills. In contrast, models based on non-competitive labour markets suggest that wage compression may encourage firms to pay for training. The theories outlined in Section 2 predict that a more compressed wage structure should lead to more firm-sponsored training, and in fact, it may increase the overall amount of investment in general skills. In particular, when only firms invest in training, wage compression always increases training investments. In the non-cooperative regime, where both firms and workers may contribute to training investments, wage compression increases the firm-sponsored component of training, and may increase or decrease total investments in skills. Finally, in the full-competition regime, wage compression again increases the share of the costs of general training borne by the firm, though in the simplest cases, it reduces total investments (see Acemoglu and Pischke (1998*b*)). It is important to

⁷ This evidence on wage compression across workers is suggestive, but recall that what is necessary for firm sponsored training is that the wage structure is compressed in the sense that the worker does not get fully compensated for increases in his productivity due to training. If workers are heterogeneous, there may not be a link between wage compression across workers and compression of the returns to training for an individual worker. This is the analogue to the ability bias in estimating the returns to schooling from data on schooling and earnings across individuals. See e.g. Griliches (1977) or Card (1999).

emphasise, overall, that non-competitive theories do not predict that wage compression should necessarily increase training, but that this is a possibility.

Studying the relationship between the structure of wages and investments in training can therefore potentially distinguish between competitive and non-competitive theories of training. This task, however, is difficult because wage returns to training are endogenous, so are likely to be high when training is more useful. Hence, we have to find exogenous variation in the structure of wages to trace its impact on training investments. In this section, we discuss the relation between training and wage compression induced by minimum wages and unions. Minimum wages, in particular, have a detrimental effect on training in the standard competitive model, because they prevent workers from taking wage cuts to finance investments in general training. But they also compress wages by making unskilled labour relatively more expensive. Therefore, they provide a useful contrast between competitive and non-competitive approaches.

Part of the literature investigating the impact of minimum wages on training in the United States focused on whether minimum wage laws lead to slower observed wage growth in micro data. Both Leighton and Mincer (1981) and Hashimoto (1982) have found this to be the case and concluded that minimum wage laws lead to less training. This evidence on wage growth does not necessarily imply that less training takes place, however. Since minimum wages cut the lower tail of the wage distribution, and typically create a spike at the minimum, they would appear to reduce the slope of age-earnings profiles even when they have no effect on training. In fact, in the minimum wage model discussed above, even though minimum wages increase training, they unambiguously reduce the slope of age-earnings profiles. Grossberg and Sicilian (1997), for example, find no effect of minimum wages on training, but still find lower wage growth for minimum wage workers. Furthermore, Card and Krueger (1995) compared cross sectional wage profiles in California before and after the 1988 minimum wage increase with a number of control states. They also found flatter profiles in California after the minimum wage increase. However, they point out that the Californian profile also shifts up and does not cross the previous age-wage profile, which is inconsistent with the competitive theory, and accords well with the predictions of non-competitive theories.

Given the difficulty of interpreting changes in the slope of wage profiles, it is more compelling to look at the impact of minimum wages on training directly. Leighton and Mincer (1981) use worker reported data on the receipt of training from the Panel Study of Income Dynamic (PSID) and the National Longitudinal Survey. They find that workers in states with more binding minimum wages receive significantly less training. Cross state comparisons may be confounded by the presence of other state effects, however. For example, industrial and occupational composition of employment varies substantially across states, and different industries and occupations have different skill requirements. These considerations suggest that across state comparisons are hard to interpret. Schiller (1994) reports a similar finding using later data

from the National Longitudinal Survey of Youth (NLSY) by comparing the training incidence of minimum wage workers with those earning higher wages. The evidence from this study is even harder to interpret because worker traits which lead to higher pay are typically also associated with more training. Grossberg and Sicilian (1997) use the EOPP data and compare minimum wage workers both to workers earning slightly less and slightly more, ameliorating the problem of worker heterogeneity somewhat. They find insignificant negative effects on training for male minimum wage workers and insignificant positive effects for women.

Some of these problems are overcome by Neumark and Wascher (1998), who use Current Population Survey (CPS) supplements to compare the impact of minimum wages on training within states using comparisons of young workers in 1991 with older workers (who are unlikely to be affected by the minimum wage) and with young workers in 1983. These comparisons assume that state differences in training levels over long periods are the same for younger and older workers or over long time periods, which is a stringent requirement. They find negative effects of minimum wages on training, which seem to be too large, especially since not all young workers are affected by the minimum wage.⁸ This suggests that the fixed effects assumptions is suspect.

In Acemoglu and Pischke (1998*c*), we analyse the effect of minimum wage increases on worker training using the NLSY for the period 1987 to 1992. This period encompasses a number of state minimum wage increases as well as two hikes in the federal minimum wage in 1990 and 1991. The federal increases had very different impacts on low skilled workers in high and low wage states (Card, 1992). Thus, our analysis uses within state variation in minimum wages for a homogeneous group of workers. In fact, since we have a panel of individuals, we can even control for individual specific effects. We find no evidence of a reduction in training in response to minimum wages. Zero or small positive effects of minimum wages on training investments for workers near the minimum wage are inconsistent with the standard theory of human capital, while they are what non-competitive theories predict.

The evidence on the impact of unions on training is mixed. The studies we are aware of look directly at the impact of unions on training. Duncan and Stafford (1980) and Mincer (1983) use the PSID, Lillard and Tan (1992) use the CPS, and Barron *et al.* (1987) use the EOPP and find negative effects of union status on training. Barron *et al.* (1997), on the other hand, report insignificant union effects using the EOPP data and find positive effects for

⁸ Their estimates imply that training among workers aged 20–24 in California (a high minimum wage state) was 3.2 percentage points lower than in states at the federal minimum. However, even most young workers earn substantially above the minimum, so the sample includes many workers not affected by the minimum wage, making the estimates implausibly large. For example, assuming, quite generously, that minimum wages affect all workers earning less than 160% of the minimum (which comprise 30% of workers aged 20–24), this estimate implies that among affected workers, training is lower by over 10 percentage points (i.e. 3.2 percentage points divided by 0.30). The average incidence of training among workers aged 20–24 earning 160% of the minimum or less in low minimum wage states is 2.7%, so this estimate implies that California's minimum wage would have wiped out all training *four times* among affected workers in these states!

formal training in the SBA data. Lynch (1992) also finds positive effects for formal training in the NLSY. For the United Kingdom, Booth (1991) reports more training for union workers, and Green (1993) finds more training for unionised workers in small establishments but not in large establishments. Overall, this evidence does not give strong support either to competitive or non-competitive theories.

It is also useful to look at the relation between returns to skill and training across countries which have different wage structures. In the mid 1980s, the log difference of ninetieth and tenth percentile wages was 1.73 in the United States and 1.11 in the United Kingdom as opposed to 0.83 in Germany, 0.67 in Sweden, 1.22 in France and 1.01 in Japan (OECD, 1993). These differences in wage structures suggest that returns to training are also likely to be compressed in Germany, France, Sweden and Japan as compared to the United States and the United Kingdom (though recall the caveat in footnote 7). In line with the predictions of the non-competitive theories, the incidence of company provided *formal* training appears to be higher in Europe and Japan than in the United States: OECD (1994, Table 4.7) reports that 23.6% of young workers in France, 71.5% of those in Germany and 67.1% of new hires in Japan receive formal training. By way of comparison, only 10.2% of US workers receive any formal training during their first seven years of labour market experience. However, comparisons of training levels across countries are difficult because the data are collected using different methods, and the measured training levels are not easily comparable.⁹ Perhaps more important than the level of training in different countries is the observation that firms seem to be more likely to bear the costs of general training in Europe than in the United States. In Germany, vocational skills are typically learned in apprenticeships and we saw in Table 1 that large firms have sizable net costs for this type of training. Comparable skills are more often learned in community colleges and vocational schools in the United States, and paid for by the trainees themselves. This pattern is in line with the predictions of the non-competitive theories.

5. Training Systems, Inequality and Institutions

In this section, we discuss the implications of different training systems for other economic issues. In particular, we argue that the different training systems of the United States and Germany are mutually reinforcing with their patterns of labour mobility and regulation regimes. We also suggest that different training practices may have been an important factor in the different paths that inequality took in these two countries. Although there are many reasons for why training practices in Germany and the United States are different, we motivate our discussion using a simplified version of the model in Acemoglu and Pischke (1998*a*) which is based on asymmetric information

⁹ Nevertheless, Lynch (1994, Table 4) reports numbers on training incidence across countries which show a similar pattern of more training in most Continental European countries than in the United States, Canada, and United Kingdom.

about worker ability between the current employer and the outside labour market. This model exhibits a multiplicity of equilibria with different amounts of training, labour mobility and matching.

In the model economy, training takes only two values, $\tau \in \{0, 1\}$, where $C > 0$ is the cost of training $\tau = 1$. Output produced by a worker at time 1 is $\alpha(\tau)\eta$ where η is ability. There is no production at time 0. The worker's ability is unknown at the beginning of time 0, and the employer discovers it at the end of this period. Ability takes two values: with probability p , $\eta = 0$ and with probability $1 - p$, $\eta = 1$. The productivity gain from training is $\alpha(0) = 1$ and $\alpha(1) = \alpha > 1$. Finally, we assume that in the second period, workers receive a shock, θ , which increases their productivity in a number of jobs other than the one they are currently holding. This shock therefore captures in a simple way the process of learning by young workers about their comparative advantage. The distribution of θ is uniform over $[0, 1]$. We assume that θ is publicly observed, so if a worker quits and takes a job for which he is more suited, his wage will be $v = v_0 + \theta$. The common component of the outside wage, v_0 , is determined by competition among outside firms at time 1. So it is equal to the expected productivity of a worker who has been laid off or has quit, since these outside firms do not observe workers' ability nor whether they have quit or have been laid off. The training firm makes a single wage offer w to all retained workers. Workers therefore quit if w falls short of their outside wage $v_0 + \theta$. Finally, we assume that only firms invest in training, and training takes place at the beginning of time 0, before the worker's ability is known.

Suppose a firm decides to train. Then, profits with training $\tau = 1$ are given by

$$\pi(\tau = 1) = (1 - p)(w - v_0)(\alpha - w) - C. \quad (1)$$

In words, all workers with $\eta = 0$ are laid off, so the firm retains a fraction $(1 - p)$ of workers. Of those, only a fraction $(w - v_0)$ stays with the initial employer. The others leave because their productivity shock in other firms, θ , was too favourable. $(\alpha - w)$ is the profit from a trained and high ability worker in the second period. The optimal wage offer of the firm maximises profits, (1), and is equal to $w = (\alpha + v_0)/2$. Using the quit rule above and Bayes' rule, we obtain that the common component of wages for quitters and laid off workers is:

$$v_0 = \frac{(1 - p)(1 - w + v_0)\alpha}{p + (1 - p)(1 - w + v_0)}. \quad (2)$$

Workers in the second-hand labour market are either low productivity and laid off (fraction p), or high productivity who have quit because of the match-specific shock (fraction $(1 - p)(1 - w + v_0)$).

The important feature of this setup is that v_0 (and v) will be high when workers are expected to quit their jobs with a high probability, because many of the workers looking for a job at time 1 will be of high ability. This high wage will encourage other, relatively high ability workers, also to quit, so the quit probability will indeed be high. And conversely, when the outside wages are

low, workers will often prefer not to quit even when they are poorly matched to their current firm, i.e. $(1 - w + v_0)$ will be low. This mutually self-reinforcing behaviour can lead to a multiplicity of equilibria. Since the firm's payoff from training is related to the probability that workers quit, there will be more training in the low wage-low quit equilibrium, and less in the high wage-high turnover case.

To illustrate this multiplicity of equilibria, consider the parameter values $p = 0.25$, $\alpha = 2.2$ and $C = 0.3$, and denote the probability of voluntary quits as a function of training by $q(\tau)$. Then, there will be two equilibria:

1. No-training equilibrium: $E(v) = 1.27$, $v_0 = 0.72$, $w = 0.86$, $q(0) = 0.86$, $\tau = 0$.
2. Training equilibrium: $E(v) = 0.88$, $v_0 = 0.31$, $w = 1.25$, $q(1) = 0.05$, $\tau = 1$.

where $E(v)$ is the average wage of workers changing jobs. Notice the contrast between these two equilibria. The first one has no training, a high level of labour mobility due to relatively high outside wages, and as a result, better matching between workers and firms. The second one has higher training, lower labour mobility due to the larger wage losses of workers changing jobs, and therefore, a worse pattern of matching.

With this model in the background, we now discuss different patterns of labour mobility between the United States and Germany. A striking difference between the United States and German labour markets is the degree of worker turnover. Topel and Ward (1992) calculate that the median number of jobs held by a male worker during the first ten years of his labour market experience is six in the United States, whereas in Germany is one or two (see Acemoglu and Pischke (1998a)). In terms of the simple model above, we can think of Germany as in the low mobility-high training equilibrium, while United States is in the low training-high mobility allocation.¹⁰ This suggests that an economy with low mobility is more likely to have low wage gains for workers changing jobs, but tends to invest more in training, and this pattern reinforces low-mobility. So the correspondence between mobility and training is not surprising (see also Blinder and Krueger (1997)). The observation that low labour mobility goes hand in hand with low returns to switching jobs is also consistent with the empirical evidence: there are substantial wage gains associated with switching jobs in the United States (Topel and Ward, 1992; McCue, 1996), but small or even negative effects in Germany (Zimmermann, 1996).

An interesting question is whether a low mobility-high training equilibrium is likely to yield higher output and productivity. This question cannot be

¹⁰ Of course, differences in mobility and training across countries can also arise from differences in parameters rather than the possibility that these countries are in different equilibria. For example, the distribution of θ may differ between Germany and the United States and this will have a first-order effect on v_0 and on the form of the equilibrium. Technology as well as the system of schooling may be an important determinant of the distribution of θ . The schooling system also determines the degree of uncertainty about young workers' ability, which is a key factor in this model.

answered unambiguously. The training equilibrium achieves a higher level of profits for firms, but some workers prefer the training equilibrium and others the no-training equilibrium, with the no-training equilibrium resulting in higher average wages in the economy. With the parameter values we have chosen, total surplus (the sum of the average wage and profit per worker) is higher in the training equilibrium. This result is easily reversed, however, and the no-training equilibrium generates greater surplus, if training were more costly, say $C = 0.6$.

The fact that wages do not reflect marginal products makes it harder to use easily observable data to assess relative productivities across countries when labour markets are not competitive. For example, Harhoff and Kane (1997) compare age-earning profiles between Germany and the United States, and find that the profiles in both countries have the same slope. They interpret this as evidence that the lack of training in the United States does not cause inefficient human capital formation. Looked at through the lenses of the model we just described, however, the slope of the wage profile alone is rather uninformative about productivity growth. The slope of the age-earning profile in the United States results from the fact that workers accumulate human capital via matching. In Germany, where workers receive more firm-sponsored training, firms are paying for training expenses, so increases in productivity due to training do not entirely get reflected in wages. In contrast, in the more competitive US labour market, one would expect increases in productivity due to better matches to be more readily reflected in wages. This stylised characterisation therefore suggests that the age-earnings profiles in the United States may be a good measure of the rate of human capital accumulation, whereas the age-earning profiles in Germany understate the rate at which the productivity of German workers grow, so in this calculation, higher productivity due to better matching in the United States appears not to compensate for the lack of training investments by firms.

Another major difference between the German and American labour markets is the regulation regime. In the United States, employment is essentially at will and the importance of unions in most industries is limited. In contrast, in Germany, as in other Continental European labour markets, there are high firing costs and unions play an important role in wage determination, and regulate hiring and firing practices. Immediately after an apprenticeship, however, firms are free to let apprentices go, without incurring any firing costs. A number of economists have suggested that firing costs in Europe are very harmful as they reduce the flexibility of employment relations and create wage push, and via these channels, they are one of the primary causes of unemployment. This leads to the policy recommendation that firing costs in Europe should be reduced (see, for example, OECD (1994)). Others, for example Abraham and Houseman (1993), have pointed out that job security provisions as in Germany may have a number of benefits, and that it might be useful for the United States labour market to increase the costs faced by employers in laying off workers.

Here, we want to point out that different training systems may make differ-

ent labour market regulation regimes optimal. In particular, in Germany, firms may learn sufficiently about their employees at the apprenticeship stage that they have much less incentive to fire them later in their career. In addition, to the extent that apprenticeship programmes provide industry specific skills, it may be socially beneficial for firms to keep workers even when demand is low. So, firing costs may not be as harmful as they first appear, given the German training system. Moreover, labour market deregulation, by reducing wage compression and removing the role of unions, may endanger the German training system. Labour market reform may therefore be counter-productive in this country.

In contrast, employers in the United States are more willing to lay off workers when demand is low because the workers have fewer skills specific to this industry. Introducing firing costs is therefore likely to affect efficiency adversely in the United States by reducing the flexibility of firms, and by locking workers into jobs for which they have accumulated only few skills. Overall, therefore, the theories discussed in this paper suggest that there are complementarities between training systems and regulation regimes, and radical changes in labour market institutions may have unforeseen, counter-productive consequences, both in Germany and the United States.

A final issue we would like to discuss is the interaction between training systems and patterns of wage inequality. Wage inequality has increased considerably in the United States over the past twenty years. In contrast, most measures point to a more compressed wage structure in Germany in the 1980s, and more strikingly, there have not been major changes in the structure of wages in this country. Table 2 gives various measures of wage inequality in Germany and in the United States over this period. Although differences in labour market institutions could partly account for the differences in the overall degree of wage compression (see for example, Blau and Kahn (1997), for a discussion), it is much harder to explain why wage inequality did not increase in Germany while rising sharply in the United States. A first story may be that new technologies adopted in the United States, which were important in raising inequality, were not adopted in Germany. This story, however, is not very convincing since, at least in manufacturing, Germany and the United States are at a very similar level of development, and are likely to use and adopt similar technologies at the same time. For example, Card *et al.* (1996) and DiNardo and Pischke (1997) show that computers were adopted only at a slightly slower pace in Canada, France, and Germany than in the United States.

A second explanation for the different patterns of wage inequality in Germany and the United States may be that the labour market institutions which compressed wages in the 1960s and 1970s did not allow new technologies to widen the gap between skilled and unskilled workers in Germany. This story, however, predicts an increase in unskilled unemployment in Germany relative to skilled unemployment. In particular, if labour market institutions push unskilled wages above their labour market clearing level, firms would increasingly substitute skilled workers for the unskilled. The unemployment figures for Germany given in Table 3 do not support this story. Relative

Table 2
Changes in the Wage Distribution in Germany and in the United States

	1979	1985	1991
90–10 Differentials of log hourly wages			
Germany (QaC)	1.05	1.07	1.07
Germany (SOEP)	–	1.07	1.00
US (CPS)	1.26	1.39	1.39
Returns to schooling			
Germany (QaC)	0.078	0.067	0.076
Germany (SOEP)	–	0.074	0.070
US (CPS)	0.066	0.086	0.094
90–10 Differentials of wage residuals			
Germany (QaC)	0.81	0.83	0.84
Germany (SOEP)	–	0.79	0.77
US (CPS)	0.96	1.07	1.07

Notes: The data are from the 'Qualification and Career Survey' (QaC), the 'Socio Economic Panel' (SOEP), and the Outgoing Rotation Group files of the 'Current Population Survey' (CPS). The top panel shows the differences between the 90th and the 10th percentiles of the log hourly wage distribution. The middle panel shows the coefficients from a regression of log hourly wages on years of schooling, controlling for a quartic in experience, dummies for female, married, their interaction, metropolitan residence, and (US only) for blacks and other non-whites. The bottom panel shows the difference between the 90th and the 10th percentiles of the residuals from these distributions.

Table 3
Unemployment in Germany and in the United States

Germany			
	1975–82	1983–90	1991–2
Less qualified	6.4	13.0	10.7
Highly qualified	1.7	3.1	2.2
Ratio	3.8	4.2	4.9
All workers	3.1	5.6	4.1
United States			
	1971–82	1983–90	1991–3
Less qualified	7.8	11.3	11.0
Highly qualified	2.0	2.4	3.0
Ratio	3.9	4.7	3.7
All workers	4.9	6.2	6.0

Source: Nickell and Bell (1996).

Notes: Standardised unemployment rates. Less qualified have no High School degree in the United States and no vocational qualification in Germany; highly qualified have a university degree (see Nickell and Bell (1996) for details).

unemployment rates in the two countries are in tandem, and in fact, the unemployment rates for all groups appear to have increased both in Germany and the United States. It is therefore an unresolved puzzle why wage inequality did not increase in Germany (see also Nickell and Bell (1996) and Krueger and Pischke (1997)).

A possible explanation which follows from our analysis so far is that part of the reason may be that firms in Germany have a greater incentive to train unskilled and low education workers, enabling them to also benefit from the introduction of new technologies. In contrast, unskilled workers receive less training in the United States. So unskilled workers in the United States may have been hurt by skill-biased technical change more than in Germany, simply because their average skill level is lower.

To develop this argument further in the context of the models discussed in Section 2, suppose that there are two types of workers, high education and low education. High education workers are more productive, and both types can be trained, increasing their productivity. In Germany, both types of workers receive firm-sponsored training. In contrast, in the more competitive United States labour market, there is little wage compression and the level of (firm-sponsored) training is lower than in Germany. One might then expect especially little training for less educated workers in the United States: the utility cost of taking a wage cut would be much higher for the less educated because of their already low initial wages and possible credit constraints, so they are unlikely to finance investments in general training themselves.

Now consider the arrival of new technologies, increasing the productivity of more educated workers relative to less educated workers. Suppose also that these technological changes increase the value of training for both types. In Germany, where wages are regulated by unions and generally compressed, firms will be encouraged to undertake more training for both types of workers, so wage inequality remains basically the same. In contrast, in the United States, training of less skilled workers is unlikely to increase. In fact, if changes in technology reduce the productivity of less educated workers, their wages may fall, making it even harder for them to finance their own training. This leads to a reduction in training for these workers. Meanwhile, since the return to training for high education workers has increased, they are more likely to invest in their own training. This divergence in the training patterns therefore exacerbates the already increasing wage gap between more and less educated workers.

This stylised model accords well with the changes in the training patterns in the two countries. Table 4 reports the incidence of training for high and low education workers in the United States and Germany. These numbers are not directly comparable across countries, because the survey questions refer to different concepts.¹¹ However, they are comparable over time within a country. The table shows that training has increased slightly for both types of workers in Germany over the 1980s. In contrast, the likelihood of training for a low education worker has declined in the United States, but high education workers now receive more training. This pattern fits the stylised model we just

¹¹ The numbers for Germany exclude apprenticeship training. Including apprenticeships, overall company training is much higher in Germany than the United States.

Table 4
Training Incidence in Germany and in the United States

	United States		Germany	
	1983	1991	1979	1991
Formal company training				
Less qualified	4.20 (0.26)	3.84 (0.26)	3.60 (0.32)	4.60 (0.43)
Highly qualified	13.64 (0.19)	14.45 (0.42)	10.62 (0.24)	14.09 (0.30)
Company training including informal training				
Less qualified	15.35 (0.47)	10.70 (0.42)	–	–
Highly qualified	26.90 (0.25)	23.98 (0.22)	–	–

Notes: Standard errors are in parentheses. The numbers for the United States are from the Training Supplements to the January CPS. The numbers for Germany are from the QaC Data. Samples include men and women age 20 to 59, working in the private sector. Less qualified have less than 12 years of schooling in the United States and no vocational qualification in Germany. The questions about company training differ between the two surveys so that the incidence of training should not be directly compared between the two countries.

described but is hard to reconcile with the standard model of training based on competitive markets.¹²

6. Concluding Remarks

We have surveyed some recent research on patterns of training practices and theories in which firms are willing to contribute to the costs of general training investments. We have suggested that labour market imperfections have to be an ingredient of any model attempting to understand why firms pay for general training. This opens the way for a discussion of the importance of labour market institutions, their impact on the structure of wages, and how they influence human capital investments. We have shown that non-competitive labour markets often compress the structure of wages, and this encourages firms to invest in general training. In fact, wage compression may increase human capital investments, a prediction which stands in stark contrast to the standard theory. Although the empirical predictions of the non-competitive models are not as clear-cut as those of the standard theory, a simple reading of cross-country evidence is much more in line with the non-competitive models.

¹² This observation does not imply that further subsidies to training programmes in the United States is a useful remedy for the increase in wage inequality. Recall that low education US workers are likely to possess fewer skills to begin with, so this gap must be made up first. Furthermore, adapting to new technologies may require prior training in a basic skills (e.g. the type of training best done at the apprenticeship stage). So for most low-pay workers, it may be less effective. Finally, as pointed out by Heckman (1993), a training programme for unskilled workers large enough to overcome these obstacles would be exceedingly costly.

Moreover, a variety of micro evidence, though not completely unambiguous, also support the non-competitive models.

We would like to conclude by pointing out a number of areas where empirical research would be very valuable. First, further tests to distinguish competitive and non-competitive theories are necessary. We believe that the most promising approach is to find policy-induced differences in wage compression across markets, and analyse their impact on training. Second, there is need for more work in measuring the return to training. Although there is a large literature estimating wage gains to workers after training, non-competitive models emphasise that productivity growth should exceed wage growth. Measurement of the overall return to training therefore requires direct measures of productivity. Detailed analysis of particular firms and industries may be necessary to achieve such measurement. Also because future employers may also benefit from a worker's training, the measurement of total return is even more difficult.

Another issue which requires research is the optimal mix of schooling and training. First, in non-competitive theories, there are important links between schooling and equilibrium training, especially because the breadth of skills provided by schools and the amount of uncertainty about young workers' ability are major determinants of firms' incentives to provide training. Second and more important, schooling provides general-purpose knowledge by teaching conceptual tools and information, useful in a variety of occupations and industries. General purpose education both facilitates the acquisition of more specific skills and provides workers with the flexibility necessary to realise their comparative advantage. The best way to increase productivity in a given profession, however, is likely to be via on-the-job training. Measurement of overall returns to training and how they interact with the amount of schooling may enable us to make more informed statements about the optimal mix of schooling and training. Such information would be useful, for example, in determining the relative costs and benefits of the United States and German systems, where the relative weights of general-purpose education and industry specific training are quite different.

MIT and NBER

References

- Abraham, Katherine and Houseman, Susan (1993). *Job Security in America. Lessons from Germany*. Washington, D.C.: The Brookings Institution.
- Acemoglu, Daron (1997). 'Training and innovation in an imperfect labor market,' *Review of Economic Studies*, vol. 64, pp. 445–64.
- Acemoglu, Daron and Pischke, Jörn-Steffen (1998*a*). 'Why do firms train? Theory and evidence,' *Quarterly Journal of Economics*, vol. 113, pp. 79–119.
- Acemoglu, Daron and Pischke, Jörn-Steffen (1998*b*). 'The structure of wages and investment in general training,' NBER Working Paper no. 6357. Forthcoming *Journal of Political Economy*, June 1999.
- Acemoglu, Daron and Pischke, Jörn-Steffen (1998*c*). 'Minimum wages and on-the-job training,' mimeo. MIT.
- Acemoglu, Daron and Shimer, Robert (1997). 'Efficient unemployment insurance,' mimeo. MIT and Princeton University.
- Akerlof, George (1982). 'Labor contracts as partial gift exchange,' *Quarterly Journal of Economics*, vol. 97, pp. 543–69.

- Autor, David (1998). 'Why do temporary help firms provide free general skills training? Theory and evidence' mimeo. Harvard University.
- von Bardeleben, Richard, Beicht, Ursula and Fehér, Kálmán (1995). *Betriebliche Kosten und Nutzen der Ausbildung. Repräsentative Ergebnisse aus Industrie, Handel und Handwerk*, Berichte zur beruflichen Bildung Heft 187. Bielefeld: Bertelsmann.
- Barron, John M., Berger, Mark C. and Black, Dan A. (1997). *On-the-job Training*. Kalamazoo: W. E. Upjohn Institute for Employment Research.
- Barron, John M., Fuess, Scott M. and Loewenstein, Mark A. (1987). 'Further analysis of the effect of unions on training,' *Journal of Political Economy*, vol. 95, pp. 632–40.
- Becker, Gary (1964). *Human Capital*. Chicago: The University of Chicago Press.
- Bishop, John H. (1987). 'The recognition and reward of employee performance,' *Journal of Labor Economics*, vol. 5, pp. S36–56.
- Bishop, John H. (1991). 'On-the-job training of new hires,' in (David Stern and Joseph M. M. Ritzen, eds.) *Market Failure in Training? New Economic Analysis and Evidence on Training of Adult Employees*. Berlin: Springer Verlag, pp. 61–98.
- Bishop, John H. (1996). 'What we know about employer-provided training: a review of the literature,' Cornell University, Center for Advanced Human Resources Studies Working Paper 96-09.
- Blau, Francine and Kahn, Lawrence, M. (1997). 'International differences in male wage inequality: institutions versus market forces,' *Journal of Political Economy*, vol. 4, pp. 791–837.
- Blinder, Alan S. and Krueger, Alan B. (1996). 'Labor turnover in the USA and Japan: A tale of two countries,' *Pacific Economic Review*, vol. 1, pp. 27–57.
- Booth, Allison (1991). 'Job-related formal training: who receives it and what is it worth?' *Oxford Bulletin of Economics and Statistics*, vol. 53, pp. 281–94.
- Card, David (1992). 'Using regional variation in wages to measure the effect of the federal minimum wage,' *Industrial and Labor Relations Review*, vol. 46, pp. 22–37.
- Card, David (1999). 'The causal effect of education on earnings,' in (Orley Ashenfelter and David Card, eds) *The Handbook of Labor Economics*. Volume III, Amsterdam: North Holland.
- Card, David, Kramarz, Francis and Lemieux, Thomas (1996). 'Changes in the relative structure of wages and employment: a comparison of the United States, Canada, and France,' NBER Working Paper no. 5487.
- Card, David and Krueger, Alan B. (1995). *Myth and Measurement. The New Economics of the Minimum Wage*. Princeton: Princeton University Press.
- Chang, Chun and Wang, Yijiang (1996). 'Human capital investment under asymmetric information: the Pigovian conjecture revisited,' *Journal of Labor Economics*, vol. 14, pp. 505–19.
- Diamond, Peter (1982). 'Wage determination and efficiency in search equilibrium,' *Review of Economics Studies*, vol. 49, pp. 217–27.
- DiNardo, John E. and Pischke, Jörn-Steffen (1997). 'The returns to computer use revisited: have pencils changed the wage structure too?' *Quarterly Journal of Economics*, vol. 112, pp. 291–303.
- Duncan, Greg J. and Stafford, Frank P. (1980). 'Do union members receive compensating wage differentials?' *American Economic Review*, vol. 70, pp. 355–71.
- Frank, Robert (1984). 'Are workers paid their marginal products?' *American Economic Review*, vol. 74, pp. 549–71.
- Franz, Wolfgang and Soskice, David (1995). 'The German apprenticeship system,' in (Friedrich Buttlar et al., eds.) *Institutional Frameworks and Labor Market Performance. Comparative Views on the German and U.S. Economies*. London and New York: Routledge, pp. 208–34.
- Freeman, Richard B. and Medoff, James L. (1984). *What Do Unions Do?* New York: Basic Books.
- Green, Francis (1993). 'The impact of trade union membership on training in Britain,' *Applied Economics*, vol. 25, pp. 1033–43.
- Griliches, Zvi (1977). 'Estimating the returns to schooling: some econometric problems,' *Econometrica*, vol. 45, pp. 1–22.
- Grossberg, Adam J. and Sicilian, Paul (1997). 'Minimum wages, on-the-job-training, and wage growth,' mimeo. Trinity College and Grand Valley State University.
- Hamilton, Gillian (1996). 'The market for Montreal apprentices: contract length and information,' *Explorations in Economic History*, vol. 33, pp. 496–523.
- Harhoff, Dietmar and Kane, Thomas (1997). 'Is the German apprenticeship system a panacea for the U.S. labor market?' *Journal of Population Economics*, vol. 10, pp. 171–96.
- Hashimoto, Masanori (1982). 'Minimum wage effects on training on the job,' *American Economic Review*, vol. 72, pp. 1070–87.
- Heckman, James (1993). 'Assessing Clinton's program on job training, workfare, and education in the workplace,' NBER Working Paper no. 4428.
- Jansen, Marion (1998). 'Tenure, training, and unemployment: may firing costs increase productivity?' mimeo, Universitat Pompeu Fabra, Barcelona.
- Jones, Ian S. (1986). 'Apprentice training costs in British manufacturing establishments: some new

- evidence,' *British Journal of Industrial Relations*, vol. 24, pp. 333–62.
- Katz, Eliakim and Ziderman, Adrian (1990). 'Investment in general training: the role of information and labour mobility,' *ECONOMIC JOURNAL*, vol. 100, pp. 1147–58.
- Krueger, Alan B. (1993). 'How computers have changed the wage structure: evidence from microdata, 1984–1989,' *Quarterly Journal of Economics*, vol. 108, pp. 33–60.
- Krueger, Alan B. and Pischke, Jörn-Steffen (1997). 'Observations and conjectures on the U.S. employment miracle,' NBER Working Paper no. 6146.
- Lalonde, Robert J. (1995). 'The promise of public sector-sponsored training programs,' *Journal of Economic Perspectives*, vol. 9, pp. 149–68.
- Leighton, Linda and Mincer, Jacob (1981). 'The effects of the minimum wage on human capital formation,' in (Simon Rottenberg, ed.) *The Economics of Legal Minimum Wages*. Washington: American Enterprise Institute for Public Policy Research, pp. 155–73.
- Lillard, Lee A. and Tan, Hong W. (1992). 'Private sector training: who gets it and what are its effects?' *Research in Labor Economics*, vol. 13, pp. 1–62.
- Loewenstein, Mark A. and Spletzer, James R. (1998). 'Dividing the costs and returns to general training,' *Journal of Labor Economics*, vol. 16, pp. 142–71.
- Lynch, Lisa M. (1992). 'Private sector training and the earnings of young workers,' *American Economic Review*, vol. 82, pp. 299–312.
- Lynch, Lisa M. (1994). 'Introduction,' in (Lisa M. Lynch, ed.), *Training and the Private Sector. International Comparisons*. NBER Series in Comparative Labor Markets, Chicago: University of Chicago Press, pp. 1–24.
- Malcomson, James M., Maw, James W. and McCormick, Barry (1997). 'General training by firms, contract enforceability, and public policy,' mimeo. University of Southampton and University of Swansea.
- McCue, Kristin (1996). 'Promotions and wage growth,' *Journal of Labor Economics*, vol. 14, pp. 175–209.
- Mincer, Jacob (1983). 'Union effects: wages, turnover, and job training,' in (Joseph Reid, ed.) *New Approaches to Labor Unions*. Greenwich: JAI Press, pp. 217–52.
- Moen, Espen (1997). 'Competitive search equilibrium,' *Journal of Political Economy*, vol. 102, pp. 385–411.
- Mortenson, Dale (1982). 'Property rights and efficiency in mating, racing and related games,' *American Economic Review*, vol. 72, pp. 968–79.
- Neumark, David and Wascher, William (1998). 'Minimum wages and training revisited,' NBER Working Paper no. 6651.
- Nickell, Stephen and Bell, Brian (1996). 'Changes in the distribution of wages and unemployment in OECD countries,' *American Economic Review Papers and Proceedings*, vol. 82, pp. 302–8.
- OECD (1993). *Employment Outlook 1993*. Paris: OECD.
- OECD (1994). *Employment Outlook 1994*. Paris: OECD.
- Peters, Michael (1991). 'Ex ante price offers in matching games: non-steady states,' *Econometrica*, vol. 59, pp. 1425–54.
- Pissarides, Christopher (1990). *Equilibrium Unemployment Theory*. Oxford: Blackwell.
- Pischke, Jörn-Steffen (1996). 'Continuous training in Germany,' NBER Working Paper no. 5829.
- Pigou, A. C. (1912). *Wealth and Welfare*. London: Macmillan.
- Ritzen, Joseph M. M., and Stern, David (1991). 'Introduction and overview,' in: (David Stern and Joseph M. M. Ritzen, eds.) *Market Failure in Training? New Economic Analysis and Evidence on Training of Adult Employees*. Berlin: Springer Verlag, pp. 1–14.
- Rosen, Sherwin (1972). 'Learning and experience in the labor market,' *Journal of Human Resources*, vol. 7, pp. 326–42.
- Rosenstein-Rodan, Paul (1943). 'Problems of industrialisation of eastern and southern-eastern Europe,' *ECONOMIC JOURNAL*, vol. 53, pp. 202–11.
- Ryan, Paul (1980). 'The cost of job training for a transferable skill,' *British Journal of Industrial Relations*, vol. 8, pp. 334–52.
- Soskice, David (1994). 'Reconciling markets and institutions: the German apprenticeship system,' in (Lisa M. Lynch, ed.) *Training and the Private Sector. International comparisons*. NBER Series in Comparative Labor Markets, Chicago: University of Chicago Press, pp. 25–60.
- Steedman, Hilary (1993). 'The economics of youth training in Germany,' *ECONOMIC JOURNAL*, vol. 103, pp. 1279–91.
- Statt, Anne-Louise (1998). 'Great prospects: employer provided training as a credible screening device,' mimeo. University of Stirling.
- Stevens, Margaret (1994). 'A theoretical model of on-the-job training with imperfect competition,' *Oxford Economic Papers*, vol. 46, pp. 537–62.
- Su, Li-Ju Tessie (1997). 'General training in a labor market with adverse selection,' mimeo. UCLA.
- Topel, Robert H. and Ward, Michael P. (1992). 'Job mobility and the careers of young men,' *Quarterly Journal of Economics*, vol. 107, pp. 439–80.
- Zimmermann, Klaus F. (1996). 'German job mobility and wages,' *Münchener Wirtschaftswissenschaftliche Beiträge* no. 96–12.