Essays on Economic Growth and Imperfect Markets

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6 INEQUALITY, LABOUR MARKET INSTITUTIONS AND TECHNICAL CHANGE

6.1 Introduction

In the United States the income distribution has become more uneven in the last 10 to 15 years. This has initiated a debate on the causes of rising income inequality. This debate mainly focuses on the position of low-skilled relative to high-skilled workers, and on the role of international trade as opposed to biased technical change - biased at the expense of low-skilled workers and in favour of high-skilled workers. In the debate technical change is often seen as the main culprit. Quantitative research indicates that international trade is unlikely to be solely responsible for rising inequality, or, at least, that other explanations than trade are equally legitimate and deserve serious attention (see for example Leamer 1994). Besides, some research suggests that technical changes in the past years have altered the composition of demand for labour. Krueger (1993), for example, derives that the introduction of the computer has benefited high-skilled workers. Furthermore, several studies of plant-level data report that a higher share of skilled workers is associated with technology indicators (see, for example, Doms, Dunne and Troske, 1997)

So the story goes that technical changes are to blame for the rising inequality in the United States and perhaps also in the United Kingdom, and - in combination with rigid labour markets - for relatively high unemployment of low-skilled workers in continental Europe. However, experiences of some countries do not easily fit into the story. Japan has a low unemployment rate, a relatively even income distribution and has seen hardly rising income differences. Besides, some OECD countries are thought to have successfully reformed labour market institutions. These countries, among which the Netherlands, unemployment has fallen, but income inequality has not shown a spectacular rise as in the United States or the United Kingdom.

It might be that technical change is biased in the United States, but not in Japan or the Netherlands. This is difficult to establish, since the process of technical change and its effect on wage inequalities is a black box. Difficult is to explain why it is biased at the expense of low-skilled workers, let alone why it is different in different countries.[43] The role of technical change is often derived from a rising skill premium and - as a logical, theoretical consequence - rising demand for high-skilled workers relative to low-skilled workers. Biased technical change then merely describes, rather than explains, rising inequality.

[43] In the literature some interesting attempts to explain biased technical change have appeared. See for example Acemoglu (1999).

The story of biased technical change only focuses on low-skilled and high-skilled workers. This focus is however too narrow. Davis (1992) also reports that in many developed countries income equality has risen during the seventies and eighties. But, not only income differences between low-skilled and high-skilled workers have increased in this period, but also differences between young and old and even among similar workers - workers of the same age and with identical (formal) education - have become more pronounced. A theory that accounts for only between-group inequality, is not sufficient. Instead a theory of within-group inequality must complement it. See for a simple model Aghion, Caroli and Garcia-Peñalosa (1999).

Also, the causality may run the other way: from income distribution to economic growth and technical change. Cross-section analysis of the link between growth and income distribution, initiated by Persson and Tabelini (1992, 1994), consistently reveals a negative relation between these two. A country with a relatively equal income distribution grows faster ceteris paribus. This result is often explained by growth-depressing income or capital taxes that redistribute income. Here the (primary) income distribution is a determinant of growth rather than the other way around.

This chapter develops the idea that technical change is the same everywhere but that the response -- in terms of more or less inequality -- is different in different countries. Technical change is conceived as innovations destroying old products and creating new and better products, in a similar vein as Grossman and Helpman (1991) and Aghion and Howitt (1992). In fact, the model is similar to the one that has been developed by Grossman and Helpman (1991). At the heart of it is R&D that aims to improve - and destruct - existing products. The reason for a different response to a similar, technological shock is found on the labour market. Competition on this market is assumed to be imperfect. The description of the labour market has much in common with the model of Acemoglu and Newman (1997).

A firm cannot perfectly monitor workers. To alleviate this problem a firm pays different wages to identical workers. To provide the right incentives to workers, a firm rewards some workers. In a sense, workers can pursue a career with one firm. Some workers are successful, others are not. Innovations bring new products but also destroy existing products, firms and thus careers. Technical changes in the form of innovations hamper a firm because a successful career then becomes a less efficient instrument for this firm to motivate workers. A firm can respond to a higher innovation rate by increasing or by decreasing wage differences between careerwise successful and unsuccessful workers. This choice crucially depends among other factors on labour market institutions. Progressive income taxes, firing costs and also trade unions make it more likely that a firm responds to more uncertainty by reducing wage differences. Potentially, these institutions can explain the differences between continental Europe and the United States. At least, for a small sample of countries the data support the predicted relation among innovations, trade unions and earnings inequality.

Section 2 characterizes wage setting by firms, and the consequences of innovations on the wage distribution. Section 3 goes into labour market institutions, in particular progressive income taxes, firing costs and trade unions, that affect the wage distribution. Section 4 endogenizes technical change, showing that the outcome of the labour market not only depends on the innovation rate, but also determines it. In other words, higher growth could lead to more income inequality, but the direction in this relation can also run from inequality to growth. In section 5 the analysis becomes empirical and considers a cross-section of countries. The analysis is not very extensive, but nevertheless shows that both trade unions and innovations are important determinants of wage inequality. Section 6 concludes.

6.2 Wage distribution and innovations

In this section a model of wage determination is set out. It shares one element with other efficiency-wage models, namely that firms threaten to dismiss low-productive, shirking workers. A new element is that firms promise to reward (some) high-productive workers. To discipline workers firms rely not only on the stick but also on the carrot. Furthermore, it resembles a model developed by Acemoglu and Newman (1998). Whereas they focus on differences in monitoring technology between Europe and the United States, here the attention is given to (differences in) tax progression, firing costs and the position of trade unions.

Workers have to invest to acquire firm-specific skills in order to be productive. A firm cannot perfectly observe skills and productivity. Of some workers it observes productivity, of other workers it does not. The wage of a worker depends on whether or not the firm observes the worker's productivity. A firm tries to stimulate investment in firm-specific skills by announcing that when it learns productivity of a group of workers, it will reward productive workers in this group by paying them a high wage and will punish unproductive workers in this group by dismissing them. The firm pays the rest of the workers a low wage. The outcome is that workers earn a different wage even though they are ex-ante identical.

To convince workers to invest in firm-specific skills, the firm thus uses both a carrot and a stick. The carrot is of course that productive workers may receive a high rather than a low wage, and the stick is that unproductive workers are dismissed. The trouble is after a worker has invested in firm-specific skills these skills may prove to be worthless. Competition may force a firm to leave business and a firm cannot therefore keep its promise to pay a high wage to some productive workers. Current R&D threatens the future position of the firm, since it seeks to overtake today's monopoly position tomorrow. Innovations thus undermine the promise to pay a high wage and erode the role of the carrot in stimulating investment in firm-specific skills. The model explores this channel along which innovations affect wage inequality. The exact relation between innovations on the one hand and wage inequality on the other hand is uncovered in the rest of this section. It depends among other things on (risk) preferences, monitoring technology and labour market institutions.

In this section we characterize wage-setting by a representative firm and in particular the effect of the (exogenous) innovation rate on wages and wage inequality. In section 4, the model is extended to determine the allocation of labour across two sectors and the innovation rate.

Rather than developing a full-fledged dynamic analysis of the relation between firm and workers a short cut is taken. A dynamic analysis essentially results, but is largely simplified. Even though production, consumption and investment take place simultaneously, a sequence on the decisions by both parties is imposed.[44]

1 The firm offers a wage scheme to its workers.

2 The workers choose to invest or not.

3a The firm learns whether it will survive or not. In the presence of a (future) competitor the firm reneges on the announced scheme; it does not pay the high wage, but pays every worker the low wage. In the absence of such a competitor the firm sticks to this scheme (see 3b).

3b The firm learns their productivity of some workers (a fraction q of all workers). These workers are paid a high wage, whereas the others receive a low wage. (Unproductive workers are fired.)

4 The workers that have invested, but are not rewarded extra, decide wether to stay or to leave.

Two remarks have to be added. First, step 2 already assumes that the workers want to take the job. The condition that workers indeed want this, is always satisfied in the context of this model. This will be explained later. Second, step 3a does not say that a firm is driven out of business, but says that it will be competed away. It still exists, but approaches closure. A firm that is about to be closed, can no longer offer a career (credibly) and does not pay a high wage. This assumption is *crucial* for the outcome of the wage-setting process.

[44]An analysis in which decisions are separated by real time, has to consider precautionary savings in face of the uncertainty about labour income and risk-averse preferences of workers. Precautionary savings complicate such an analysis greatly.

Workers

The offer of the firm to workers must obey two constraints. The first condition that an employer must consider, is that workers must be willing to invest as to acquire firm-specific skills and to become productive. A complication is that a firm can only observe productivity of a worker with probability q. Incomplete information on the part of the firm gives a worker an opportunity to choose: the worker either invests or does not. If a workers invests, he has a probability of being rewarded; if a workers does not invest, he saves the effort but has a probability q of being fired.

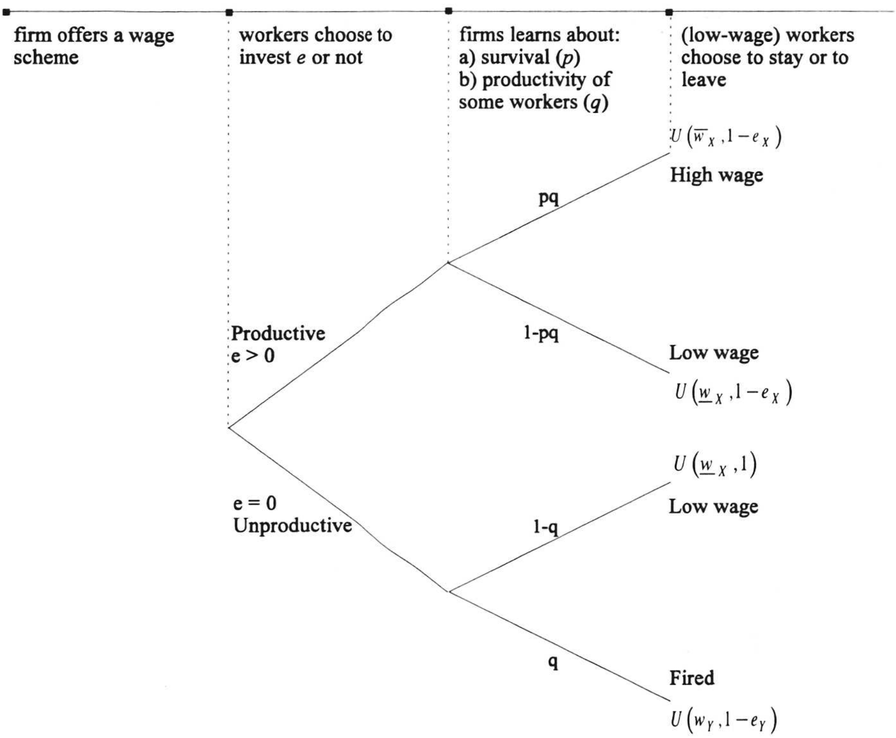
Figure 6.1 schematically shows the consequences of either alternative.

- If a worker chooses to acquire skills, the probability of a high wage $(\overline{w})$ is pq and the probability of a low wage $(\underline{w})$ is $1\text{-}pq$. The probability of being rewarded is the product of the probability that a firm survives (p) and the probability that a firm observes the productivity (q).
- If a worker decides to ignore the carrot and to shirk, the probability to be forced to leave the firm is q and the probability to stay with the firm is $1\text{-}q$. A worker who is fired, has to look for a job outside this sector, denoted X, in a different (low-wage) sector, denoted Y.[45]

A worker weighs both alternatives - to invest or not - by comparing expected utility. Utility in a given situation is derived from consumption out of wage income (w), but is negatively affected by the exogenous, fixed effort necessary to acquire skills (e, $0 \leq e < 1$). Both the X-sector and the Y-sector require workers to invest in skills, with effort e_X and e_Y respectively. An important difference between the two sectors is monitoring. In the Y-sector monitoring is perfect whereas in the X-sector shirking is a problem. The tree in Figure 6.1 summarizes the two alternatives for a worker in the X-sector: investing or not (given that each worker prefers a job in X-sector over one in the Y-sector).

[45] An alternative assumption is a worker can look for a job in either of the two sectors. Both assumptions yield similar results. The assumption in the main text is simply more convenient than this alternative assumption.

Figure 6.1 *Consequences of different investment decisions*



In the subsequent analysis a specific utility function will be used. In particular, the relative rate of risk aversion is constant (σ) and the elasticity of substitution between consumption of goods and 'leisure' $(1-e)$ is unity,

$$\begin{aligned}\sigma \geq 0 : \quad U(w,1-e) &= \frac{[w(1-e)]^{1-\sigma}}{1-\sigma}, \\ \sigma = 1 : \quad U(w,1-e) &= \ln[w(1-e)] .\end{aligned} \tag{6.1}$$

These assumptions imply that the (marginal) value of investment effort (e) is proportional to the wage income (w), and exclude the tendency to - if possible - change the investment effort in response to growing wages. A consequence is that the results of the model can be couched in terms of relative wage differences only. Note that workers are risk-neutral when $\sigma = 0$ and otherwise risk-avers.

A worker is willing to invest if $U_X^e|_{e>0} \geq U_X^e|_{e=0}$ or, more specifically, if

$$pq\frac{1}{1-\sigma}\left[\overline{w}_X(1-e_X)\right]^{1-\sigma} + (1-pq)\frac{1}{1-\sigma}\left[\underline{w}_X(1-e_X)\right]^{1-\sigma} \geq (1-q)\frac{1}{1-\sigma}\left[\underline{w}_X\right]^{1-\sigma} + q\frac{1}{1-\sigma}\left[w_Y(1-e_Y)\right]^{1-\sigma} . \tag{6.2}$$

This (in)equality can be reordered,

$$pq\left(\frac{1}{1-\sigma}\left[\overline{w}_X(1-e_X)\right]^{1-\sigma} - \frac{1}{1-\sigma}\left[\underline{w}_X(1-e_X)\right]^{1-\sigma}\right) + q\left(\frac{1}{1-\sigma}\left[\underline{w}_X\right]^{1-\sigma} - \frac{1}{1-\sigma}\left[w_Y(1-e_Y)\right]^{1-\sigma}\right) \geq \frac{1}{1-\sigma}\left[\underline{w}_X\right]^{1-\sigma} - \frac{1}{1-\sigma}\left[\underline{w}_X(1-e_X)\right]^{1-\sigma} . \tag{6.2'}$$

The right-hand side of the last (in)equality represents the cost of investment, whereas the left-hand side is the benefit of investing in skills and productivity. The benefit encompasses two terms. The first term between brackets on the left-hand side is the reward of investing e – a high rather than a low wage –, and the second term between brackets is the penalty – a job in Y rather than in X. This (in)equality will be labelled *investment condition* or, alternatively, the incentive compatibility condition.

The investment condition is always binding. If the benefit of investing is lower than the cost, workers do not invest in skills and they are unproductive. Firms have to raise the wages to instate the incentive to invest. However, if the benefit of investing is higher than the cost, workers are productive but firms can economize by lowering the (high and low) wages such that the incentive to invest remains in tact.

The costs of investing in productive skills, e_X and e_Y, are exogenous. Throughout this chapter they are set equal to each other, $e_X = e_Y = e$. The two sectors would pay the same wage if monitoring in the X-sector was perfect.

The second condition that a firm must consider, is that after monitoring a worker must stay to work for a low wage and will not take a job in the other sector. By assumption a worker must invest to be productive in the Y-sector as well, even if he already had to invest to be productive in the X-sector.

The reason is that skills in the X-sector are partly firm-specific, and are not as productive in the Y-sector as they are in the X-sector. A new job in this sector thus requires extra investment. He will not try to find work elsewhere after the outcome of the monitoring process is established if,

$$\underline{w}_X \geq w_Y(1-c) \ , \quad 0 \leq c < e \ , \tag{6.3}$$

where c is a measure for the *extra* investment. This measure indicates the degree to which skills in the X-sector are firm-specific and are substitutes for skills in the Y-sector.[46] This inequality will be referred to as the (ex-post) *competition condition*.[47]

Firms

If besides the investment condition, the competition condition is binding, a firm does not have the ability to set (one of the) wages freely. Instead, the two conditions determine the two wages, $\overline{w}_X$ and $\underline{w}_X$. More specifically, from the competition condition follows the low wage and from the investment condition, given the low wage and the wage in the traditional sector, follows the high wage. In this case, (ex-post) competition from the other, traditional sector constricts the firm from decreasing the low wage further.

Not always the firm wants to decrease the low wage as much as possible. Conceivably, it may sometimes want to set the low wage higher the competitive wage, i.e., the wage that the firm at least has to offer so as to induce productive workers to stay. To understand this, consider optimal wage-setting from the perspective of the firm.

A firm minimizes the expected wage cost per worker, w_X^e,

$$\min_{\overline{w},\underline{w}} \ w_X^e = pq\overline{w}_X + (1-pq)\underline{w}_X \ , \tag{6.4}$$

[46] If a worker went from the X-sector to the Y-sector total investment would be $(1-c)(1-e_X) - 1$ in terms of effort, where e_X is investment for a job in the X-sector and c the extra investment for a job in the Y-sector.

[47] A job in the innovative sector is ex ante more attractive than one in the traditional sector. Substitution of (6.3) into (6.2) shows that the expected utility in the X-sector is higher than in the Y-sector if $c \leq e$. In this configuration, every worker would like to work in the X-sector ex-ante, but not every worker can. Firms can choose, but select workers - they are identical - randomly. Moreover, dismissal is indeed a penalty. The threat of losing a job when caught is not empty.
In the opposite configuration, if $c \geq e$, the condition that (expected) utility of a job in each sector is the same, would have to determine the low wage. Acemoglu and Newman (1997) use this condition. If this condition holds, ex-ante competition among firms sets a lower bound for the low wage, and if condition (6.3) holds, ex-post competition does.

subject to the investment condition. The two first-order conditions can be reduced to one optimality condition, which will also be referred to as the *distribution condition*,

$$(1-pq)\left[-(\overline{w}_X)^{-\sigma} + (\underline{w}_X)^{-\sigma}\right](1-e)^{1-\sigma} - (1-q)(\underline{w}_X)^{-\sigma} \leq 0 \; . \tag{6.5}$$

One way to understand this optimality condition is to imagine that the firm sets wages such that a small decrease of the high wage and a small increase of the low wage, leaving the expected wage unaffected, does not change the incentive to invest for workers positively or negatively.

If productivity is perfectly observable and q=1, wages do not differ. If not, the firm rewards workers differently. This inequality then shows the familiar trade-off between optimal risk-sharing and optimal incentives.[48] The first term arises from uncertainty in combination with risk aversion. The firm takes into account that uncertainty about the wage -- high or low ? -- discourages investment in skills. It is the main reason that the firm does not always want to set the low wage as low as possible. More uncertainty implies that the job becomes less attractive and that the penalty -- the utility difference between this job and a job elsewhere -- is less a reason to invest. To restore the penalty, the firm has to raise both wages and it sees the wage costs rise. The second term is the result of less than perfect monitoring. The firm realises that a higher low wage means a higher incentive to shirk. A worker may try to save the effort of investing in skills, where the probability of not being caught shirking is 1-q. In other words, a higher low wage raises the cost of investment -- the utility difference between investing and not investing.

There are two cases to consider. In the one case, the low wage is set in order to avoid that workers do not search for a job elsewhere: the competition condition (6.3) is binding. In the other case, the low wage follows from the trade-off between optimal risk-sharing and optimal incentives: the distribution condition (6.5) is binding. So, either the competition condition (6.3) or the distribution condition (6.5) is operative. In either case, the wage scheme must induce investment by workers and make the plans of the firm and the workers compatible. The investment condition (6.2) always holds.

Both cases, in which either the competition or the distribution condition is binding, will be discussed subsequently. Attention mainly goes out to the impact of the survival probability p on the relative wage difference within the X-sector and between the X-sector and the Y-sector, $\overline{w}_X/\underline{w}_X$ and w_X^e/w_Y. This will demonstrate that a similar technological shock -- more or less innovations -- may have

[48] A firms and a worker run the risk that the firm does not observe productivity of the worker. Because the firm is risk-neutral and the worker is not, optimal risk-sharing would imply that the firm carries this risk.

a different effect on wage inequality, depending on which case prevails. After this, the next step (in section 6.3) is to demonstrate that the two different cases agree with the different situations in continental Europe one the one hand and the Anglo-Saxon countries on the other hand.

6.2.1 *Wage-setting: the case of competition*

The low wage is not necessarily an instrument to a firm to provide the optimal incentive to invest in firm-specific skills. In the case under discussion the firm reduces the low wage until workers start to leave the firm. The workers have the option of applying for a job elsewhere. The outside option of workers constrains the firm when setting the low wage. Even though further decreasing the low wage would improve the incentive to invest in firm-specific skills, the firm is kept from further decreasing the low wage by competition on the labour market among firms. The competition condition is binding and the optimality condition is not.

Substituting the ex-post competition condition into the investment condition, (6.3) and (6.5) yields an explicit expression for the relative difference between the high and the low wage,

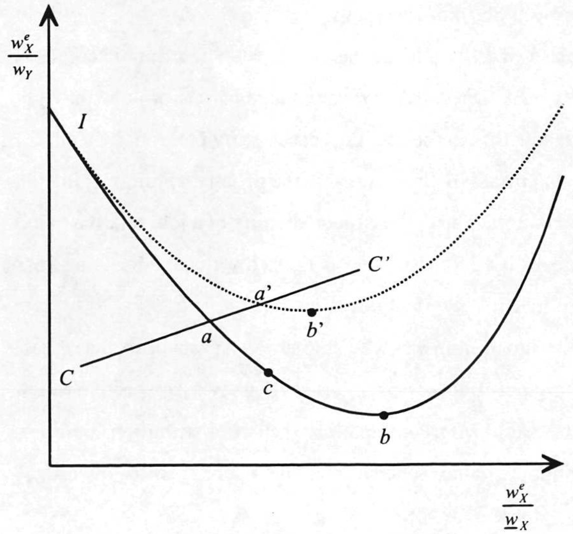
$$pq\left[\left(\overline{w}_X/\underline{w}_X\right)^{1-\sigma} - 1\right] = \left[(1/1-e)^{1-\sigma} - 1\right] - q\left[(1/1-e)^{1-\sigma} - (1/1-c)^{1-\sigma}\right], \tag{6.6}$$

where it is good to recall that the costs of investment in both sectors, X and Y, are assumed to be the same, $e_X = e_Y = e$. In the case of competition the relative wage difference depends on (four) factors that determine the penalty, the reward and the incentive not to invest. The most interesting factor is the impact of the probability that the firm survives, p. When this probability decreases, the reward tends to fall. The promise of a high wage becomes for workers a less compelling argument to invest. In other words, a career or a steep wage profile becomes less efficient instrument to motivate workers when a firm is more likely to fail and also to break its promise to pay a high wage. When the odds get worse, a firm responds by raising the stakes. A decrease of p implies an increase of $\overline{w}_X/\underline{w}_X$, such that the expected reward does not change. Equation (6.6) also makes clear that less efficient monitoring (q decreases), higher investment cost (e increases) and a worse outside option for workers (c increases) will bring about more wage inequality within a firm ($\overline{w}_X/\underline{w}_X$ increases).[49]

[49] One other factor is ignored here: expectations. Nowadays many workers seem to feel less secure about their job than they used to do. In the model both firms and workers form expectations about the survival probability. The p featuring in the investment condition is the survival probability as perceived by workers, whereas the p in the expression for the wage cost is the survival probability expected by firms. In the model the increased sense of insecurity among workers corresponds to a decreased survival

Leave the discussion about wages within the X-sector and turn to the wage difference between X-sector and Y-sector. Typically, the expected wage cost in the X-sector exceeds those in the Y-sector, $w_X^e > w_Y$, and increases when p falls. Figure 6.2 illustrates the effect of the survival probability on wage inequalities in the case of competition. It shows along the Y-axis the relative wage difference between the two sectors and along the X-axis the wage difference within the X-sector. The definitions are such that an increase in either measure corresponds to an increase in wage inequality. The II'-curve represents combinations of w_X^e/w_Y and $w_X^e/\underline{w}_X$ for which the investment condition holds. This curve can be derived by substituting the wage cost equation (6.4) into the investment condition. For lower than optimal values of $w_X^e/\underline{w}_X$, to the left of point b in Figure 6.2, the curve slopes downward. When $w_X^e/\underline{w}_X$ is below its optimum value but comes closer to it, the utility of a job elsewhere can increase and w_X^e/w_Y can decrease while maintaining the incentive to invest. The CC'-line, along which the competition condition holds, intersects with the negatively sloped part of the II'-curve. Point a gives the equilibrium combination of $w_X^e/\underline{w}_X$ and w_X^e/w_Y, when the competition condition is binding.

Figure 6.2 *Wage inequalities and the effect of the survival probability*



probability. If workers fear that a firm is more likely to fail and expected p decreases, and the reward becomes a less efficient instrument, this firm must respond by increasing wage differences.

When the survival probability p falls, the II'-curve shifts upward. Point a' characterizes the new equilibrium in which both $w_X^e/\underline{w}_X$ and w_X^e/w_Y are higher. If the survival probability falls the high wage must increase at an increasing rate as to maintain the expected value of the reward, and the expected wage cost in the X-sector increase. This is precisely the reason that rewarding only some workers and creating wage differences is not always an efficient instrument to encourage investment in firm-specific skills.

6.2.2 *Wage-setting: the case of optimal inequality*

In the case under review a firm trades off optimal incentives against optimal risk-sharing and pays more than is necessary to keep workers with the firm. The distribution condition is binding and relates the relative difference between the high and the low wage to three factors,

$$\left(\frac{\overline{w}_X}{\underline{w}_X}\right)^{-\sigma} = 1 - \frac{(1-q)(1-e)^{\sigma-1}}{1-pq} . \tag{6.7}$$

Again, less efficient monitoring and lower q induces a higher relative wage difference. However, more investment and higher e does not necessarily imply more inequality. When the cost of investment increases, the wage difference, $\overline{w}_X/\underline{w}_X$ increases if $\sigma < 1$ but decreases if $\sigma > 1$. The main difference is however the impact of the survival probability, p. A firm does not rely on the reward to provide the right incentive in this case of optimal inequality as much as in the previous case of competition. Instead, the penalty for a low-productive worker is more important. A firm increases the penalty by diminishing the wage difference. Because workers are risk-averse, this raises the expected utility of a job, relative to job in the other sector. When the survival probability decreases and p falls, the reward becomes less important and the penalty more important, so that $\overline{w}_X/\underline{w}_X$ declines.

Whereas the wage difference in the X-sector diminishes when the survival probability decreases, the sectoral wage difference increases. The marginal effect of p on w_X^e/w_Y is negative, irrespective which condition is binding. Point b in Figure 6.2 is the equilibrium combination when the distribution condition is binding. In this point w_X^e/w_Y attains its minimum value. When p falls, the II'-curve shifts upward, b' characterizes the new equilibrium and w_X^e/w_Y increases.

The closing remark, to underscore the difference between competition case and the optimal-inequality case, concerns the introduction of a legal minimum wage. In the case of optimal inequality a legal minimum wage does not necessarily have a large effect on wage costs and (sectoral) employment, whereas in the case of competition the minimum wage is clearly distortionary. A quick look at Figure 6.2 shows this. Assume that $\underline{w}_X < w_Y$ and that the introduction of a minimum wage pushes the low wage in the X-sector up and $w_X^e/\underline{w}_X$ down. In other words, a minimum wage is equivalent to an upper bound on $w_X^e/\underline{w}_X$ and should feature in Figure 6.2 as a vertical line. $w_X^e/\underline{w}_X$ falls below its equilibrium value, i.e. point a in the competition case and point b in the optimal-inequality case. In both cases the expected wage costs in the X-sector tend to rise. A consequence is as well that the high wage decreases and the wage difference within the X-sector decreases. Thus, a minimum wage decreases wage differences, not only at the bottom end of the wage distribution (between $\underline{w}_X$ and w_Y) but also at the top end (between w_Y and $\overline{w}_X$).

In the optimal-inequality case the impact on expected wage cost is however small, and the marginal effect in point b is even negligible. This suggests that the distortionary impact on the sectoral allocation of labour is also small. The conclusion is thus that in the optimal-inequality case a minimum wage does not seem to be a very inefficient instrument for income policy. However, in the competition case the effect on wage costs is positive, since in point a the II'-curve slopes downward, so that the welfare loss in this case is not inconsequential.

6.3 Labour market institutions and wage inequality

Industrialised countries have very different income distributions, and also have seen different changes therein. Broadly speaking, in the Anglo-Saxon countries income inequality has risen sharply, whereas in continental Europe changes in equality have been contained, at the cost of high unemployment. To add to the confusion, some countries, Japan for example, have always had a low unemployment rate, and some countries, the Netherlands for example, have lowered the unemployment rate significantly, but have not seen the income distribution becoming more uneven. This wide variety of experiences indicates that the relation between technical change, labour market institutions and the income or wage distribution is not straightforward and must be studied carefully.

The analysis of wage setting in section 2 is here extended to include various policy instruments affecting the performance of labour markets as well as the wage distribution. This section will deal with firing cost and a system of progressive income taxes. Higher firing cost and more progressive income taxes further the configuration in which the distribution condition is binding and more technical change does not lead to more wage inequality. Also a monopoly trade union is introduced into the analysis. A union brings about a more equal wage distribution. The union's response to more uncertainty as a result of more technical change is theoretically ambiguous. Simulations suggest that in response to more uncertainty a union is more likely to choose for more risk-sharing than a firm.

Clearly, in continental Europe income taxes are more progressive, firing costs are higher and trade unions are more important than in the United States. The findings thus lead to the conclusion that the optimal-inequality case is likely to apply to continental Europe and the competition case to the Anglo-Saxon countries.

6.3.1 Progressive income taxes

In the optimal-inequality case a system of progressive income taxes induces a firm in the X-sector to diminish the wage difference. For a firm paying a high wage becomes less appealing the more the marginal tax rate for a high income exceeds the rate for a low income. The marginal rates alter the distribution condition,

$$\frac{1-\bar{\tau}}{1-\underline{\tau}}\left(\frac{\bar{w}_X}{\underline{w}_X}\right)^{-\sigma} = 1 - \frac{(1-q)(1-e)^{\sigma-1}}{1-pq}, \; \bar{\tau} > \underline{\tau}, \tag{6.8}$$

where τ is the marginal tax rate. This clearly shows the impact of the marginal rates on the wage difference.

In Figure 6.2 point *a* and *b* represent equilibria in which the marginal tax rates are the same. In point *a* the competition condition holds and in point *b* the distribution condition is binding. If the marginal rates become different and the average rates remain the same, the competition condition is unaffected, whereas the distribution condition is. In the last case the equilibrium point moves upward and to the left along the II'-curve, and becomes for example point *c* rather than point *b*. This shows that the optimal-inequality case, in which the distribution condition is binding, is more likely in the presence of progressive income taxes.[50]

[50] Average tax rates do not matter a great deal. The model determines relative after-tax wage differences. Changes in the average tax rates lead to adjustment of before-tax wages, but do not bring about changes in the after-tax wages. This stems from the assumption about utility functions. The substitution elasticity between goods and 'leisure' is unity.

6.3.2 *Firing cost*

In the wage scheme discussed in section 2 a firm threatens to dismiss a low-productive worker. If a firm learns that a worker has not acquired firm-specific skills, this worker has to look for a job in the Y-sector. Firing cost may change this. For a firm it may become economic to employ the worker, rather than dismiss him or her. This destroys the credibility of the threat to dismiss a low-productive worker.

The wage scheme now allows the possibility of renegotiations between a firm and a low-productive worker. Suppose this worker has productivity $\tilde{A}$, $0 < \tilde{A} < 1$ and the firing cost are denoted F. If the low-productive worker remains employed with the firm, the surplus is $p_X\tilde{A} + F$. If the worker finds employment in the Y-sector, the surplus, accruing to this workers, is $w_Y(1-e)$. If the net surplus is positive, w_X^e, the firm and the worker (equally) divide the spoils and two will not separate.

If the net surplus is positive and partly accrues to the worker, increased firing cost shifts the II'-curve in Figure 6.2 upward. Firing cost thus makes the configuration, in which the distribution condition holds, more likely to prevail.

6.3.3 *Trade unions*

While the analysis can easily allow for progressive income taxes and firing cost, introducing trade unions requires more drastic changes. In particular the first-order condition for the relative wage difference will change. Suppose a monopoly union, rather than a firm, sets the wages. The trade union takes into account a labour demand function. Demand (L) is a negative function of the expected wage cost, $L = (w_X^e)^{-\epsilon}$ where ϵ is the constant wage elasticity of demand. Here only a partial equilibrium analysis is pursued. The trade union faces the familiar trade-off: the expected utility of a job in the X-sector $\left(U_X^e\right)$ can be increased only at the expense of those workers that are forced to find a job in the Y sector. Those workers lose because the utility of job in the Y-sector $\left(U_Y\right)$ is lower than the expected utility of a job in the X-sector.

The union maximizes expected utility

$$\max_{\underline{w}_X,\, \overline{w}_X} \quad \frac{L}{N}\left(U_X^e - U_Y\right) + U_Y,$$

where N denotes membership and L / N is the probability of finding a well-paid job with the firm in the X-sector. The union seeks an optimal solution subject to the investment condition (6.2), the competition condition (6.3), and the labour demand function. The expected wage cost are defined by equation (6.4), and the utility functions are the same as before.

If the competition condition holds, wage-setting by the firm or by the trade union does not make any difference. The two wages, $\overline{w}_X$ and $\underline{w}_X$ follow from the two conditions: the competition condition and the investment condition. The first-order condition for an optimal relative wage difference however changes. The derivation of this condition is given in the Appendix. It becomes

$$(1-pq)\left[-(\overline{w}_X)^{-\sigma} + (\underline{w}_X)^{-\sigma}\right](1-e)^{1-\sigma} - (1-q)(\underline{w}_X)^{-\sigma} = -\lambda(1-q)\underline{w}_X^{\;-\sigma}, \tag{6.9}$$

where λ tells for which combination of income and employment the union settles when facing the trade-off between the two,

$$\lambda = \frac{(\overline{w}_X)^{-\sigma}(1-e)^{1-\sigma}}{\varepsilon\left[U_X^e - U_Y\right]} . \tag{6.10}$$

In a sense it is a measure for the union's power. For example, if the wage elasticity of employment (ε) increases, λ decreases and the trade union has to allow more wage inequality among the workers. The decision by the union converges then towards that by the firm in absence of the union. However, whereas firm set the left-hand side of the equality to zero (see equation 6.4), the trade union does not as long as λ is positive. The trade union thus chooses less wage differences and more equality. It sets the low wage higher than the firm and designs a less efficient wage scheme. The reward becomes a lesser incentive to invest and the penalty becomes more important; the expected wage must rise to satisfy the investment condition. The rising wage is bought with lower employment.

If reinterpreted, Figure 6.2 can also demonstrate wage setting by a trade union. Assume that the CC'-line represents the first-order condition for a trade union rather than the competition condition. If w_X^e/w_Y increases, the utility difference between a job in the X-sector and the Y-sector becomes higher, and the union values the loss of employment more. It will thus allow inequality and increase $w_X^e/\underline{w}_X$. Hence, the first-order condition is an upward-sloping line or curve in Figure 6.2.

Principally, the impact of the survival probability on the choice of the union is ambiguous. A lower survival probability and a higher innovation rate shifts the first-order condition upwards and to the left in the reinterpreted Figure 6.2. The reason is the following. A lower survival probability has an immediate, negative effect on the position of workers in the X-sector. It thus reduces the utility difference between jobs in the X-sector and in the Y-sector. The union's first-order condition can then only hold if the utility difference is restored to its original value: the wage in the Y-sector must fall (w_X^e/w_Y up) or the low wage in the X-sector must rise ($w_X^e/\underline{w}_X$ down). However, also the investment condition is affected, irrespective of wage-setting by a firm or by a union. The II'-curve shifts upward and to the right. For providing the right incentive to invest, the reward becomes less important, so that the relative wage difference within the X-sector can become smaller and $w_X^e/\underline{w}_X$ can rise, given w_X^e/w_Y. An alternative point of view is that the penalty becomes more important, so that the utility difference between jobs in the X-sector and in the Y-sector must increase and w_X^e/w_Y must rise, given $w_X^e/\underline{w}_X$. The net effect on the wage difference in the X-sector is ambiguous. The leftward shift of the first-order condition implies less wage inequality within the X-sector but the rightward shift of the investment condition more inequality.

Table 6.1 wraps up the discussion about wage setting and the consequences of a higher innovation rate for the wage inequalities. It distinguishes three cases. In the first case the competition condition holds (see equations 6.3 or 6.6). In the second case the firm's distribution condition is relevant (see equation 6.5 or 6.7). This case is labelled optimal inequality in the table. In the third and last case the trade union sets wages and the union's first-order condition is binding (see equation 6.9). Numbers are printed in italics if the firm's first-order condition or if the union's first-order condition dominates the competition condition.

Table 6.1 *Wages and the survival probability; simulation results for three cases*

		$p = 1$	$p = 0.85$	$p = 0.70$	$p = 0.55$	$p = 0.40$	$p = 0.25$
$\sigma = 0.75$							
competition	$\overline{w}_H/\underline{w}_L$	1.521	1.630	1.797	2.080	2.653	4.324
	$w_X^e/\underline{w}_X$	1.312	1.322	1.335	1.356	1.397	1.499
	w_X^e/w_Y	1.214	1.222	1.235	1.255	1.292	1.386
optimal inequality	$\overline{w}_H/\underline{w}_L$	-	33.094	7.697	4.537	3.371	*2.773*
	$w_X^e/\underline{w}_X$	-	17.368	3.813	2.167	1.569	*1.266*
	w_X^e/w_Y	-	0.897	1.066	1.189	1.285	*1.362*
trade unions	$\overline{w}_H/\underline{w}_L$	-	1.680	*1.761*	*1.834*	*1.876*	*1.871*
	$w_X^e/\underline{w}_X$	-	1.347	*1.319*	*1.275*	*1.210*	*1.131*
	w_X^e/w_Y	-	1.211	*1.241*	*1.279*	*1.327*	*1.379*
$\sigma = 1.5$							
competition	$\overline{w}_H/\underline{w}_L$	1.519	1.651	1.873	2.315	3.577	16.525
	$w_X^e/\underline{w}_X$	1.311	1.332	1.367	1.434	1.619	3.329
	w_X^e/w_Y	1.213	1.232	1.264	1.326	1.497	3.079
optimal inequality	$\overline{w}_H/\underline{w}_L$	2.700	1.948	*1.664*	*1.513*	*1.418*	*1.353*
	$w_X^e/\underline{w}_X$	2.020	1.484	*1.279*	*1.169*	*1.100*	*1.053*
	w_X^e/w_Y	1.163	1.227	*1.261*	*1.283*	*1.298*	*1.310*
trade unions	$\overline{w}_H/\underline{w}_L$	*1.367*	*1.327*	*1.287*	*1.252*	*1.223*	*1.199*
	$w_X^e/\underline{w}_X$	*1.220*	*1.167*	*1.121*	*1.083*	*1.054*	*1.030*
	w_X^e/w_Y	*1.234*	*1.257*	*1.276*	*1.291*	*1.303*	*1.312*

$w_X^e = 1$, $c = 0.075$, $e = 0.40$, $q = 0.60$, $\varepsilon = 8$

Table 6.1 clearly shows that a trade union will choose less wage inequality within the X-sector than the firm does, unless the competition condition is valid for both the trade union and the firm. It also demonstrates that in the case of trade unions the impact of the survival probability is ambiguous. If $\sigma = 1.5$, the effect of a lower probability is less wage inequality within the X-sector. However, if $\sigma = 0.75$, the effect is exactly the opposite for relatively high values of the survival probability. It becomes weaker when the probability falls and eventually changes sign when it falls even further. In general, the impression is that a union is more likely than a firm to choose for more inequality in response to a lower survival probability. In the other two cases ambiguities do not arise. In the competition case a lower probability implies more inequality whereas in the optimal-inequality case a lower probability leads to less inequality. The three cases have however in common that indisputably less certainty about the future of firms in the X-sector implies a higher (relative) wage in this sector, to offset the negative effect of uncertainty for workers in this sector.

6.3.4 Assessing the role of labour market institutions

The discussion of progressive income taxes, firing cost and trade unions clearly shows that they have a significant impact on the wage distribution and changes therein in response to more technical change. They diminish the relative wage difference within the X-sector. Not only do they affect the distribution, but they can also alter the relation between technical and the wage distribution quite drastically. The optimal-inequality case is more likely to prevail than the competition case, if the tax system is progressive and firing workers is costly to a firm. The power of trade union may also be a reason is why more technical change and a higher innovation rate lead to a more equal distribution (within the X-sector). These institutions thus potentially explain the difference between the American and the European situation. The analysis underpins the story that in the United States more rapid technical change leads to more inequality, whereas in continental Europe labour market institutions prevent this from happening. These institutions may at the same time cause relatively high unemployment. The analysis shows that progressive income taxes, firing cost and unions raise the expected wage cost of the X-sector. This may distort the sectoral allocation of resources. However, a more realistic interpretation of the analysis is that they raise the difference between the actual wage and the market-clearing wage and increase unemployment. In this interpretation the outside option for workers is not working in a different sector, but not working at all. The analysis can thus very well explain the dichotomy between the American and the European economies: in the United States the competition case prevails, so that more rapid technical change leads to more inequality; in Europe labour market institutions let risk-sharing prevail, so that inequality is less, and does not increase in response to more rapid technical change, but unemployment is relatively high.

6.4 R&D and innovations: endogenous technical change

This section concentrates on the pace at which innovation occur. Technical change is conceived as innovations destroying old products and creating new and better products, in a similar vein as Grossman and Helpman (1991) and Aghion and Howitt (1992). In fact, the model closely resembles the one that has been developed by Grossman and Helpman. At the heart is R&D that aims to improve - and destruct - old products.

This section links the analysis to existing literature about endogenous economic growth and provides a context for the discussion in the previous sections. More important, it looks from a different angle to relation between technical change and wages. It shows that technical change not only is a determinant of the wage distribution, but is also a result of the labour market process. Th implication is that the same institutions that explain lower inequality in continental Europe, relative to the United States, may also explain a slower pace of (technical) change.

The model distinguishes only one productive factor, labour, and two sectors, X and Y, in which labour is employed. The first sector is characterized by monopolistic competition. Each firm supplies a unique product of superior quality. It sets the price such that any potential competitor, supplying a product of a slightly inferior quality, does not want to enter the market. The monopoly is however temporary. Current research for a product of an even better quality threatens the future position of a firm in the X-sector. This research is carried out in the perfectly competitive Y-sector.

The model describes a small open economy. This economy produces one tradeable, final good. This good is produced by using intermediate goods from the X-sector. The economy produces two non-tradeable goods, products from the X-sector and blueprints for better products from the Y-sector. Capital is fully mobile, so that the real interest rate is given. This assumption cuts the link between investment and consumption. We only need to consider wages, employment and investment.

Economic growth

The final goods sector is perfectly competitive. Final goods (Z) are produced with intermediate products from the X-sector according to

$$Z = \exp\left(\int_0^1 \ln\left[k(i)x(i)\right] di \right) = K \exp\left(\int_0^1 \ln\left[x(i)\right] di \right) , \tag{6.11}$$

where $x(i)$ denotes variety indexed i, $k(i)$ is the quality that corresponds to variety i and K is an aggregate measure for technology. Productivity in the final goods sector is augmented if better products are introduced. The quality of the new varieties exceeds that the quality of similar, already existing varieties with a exogenous factor λ, $\lambda>1$. Each period the quality of p products remains the same, whereas the quality of 1-p products increases. The growth of final goods production is then each period $g_Z = g_K = \lambda^{1-p}$. So, innovations are the engine of growth.

Economic growth arises from the introduction of better products. Research for and development of better intermediate goods raises the productivity of these goods in the production of final goods. However, more economic growth does not necessarily imply a higher innovation rate and a lower expected life-span of firms. Growth depends not only on the sheer number of intermediate goods that are upgraded (p), but also on the improvement in quality of these goods (λ).

Price-setting and profits in the X-sector

All firms in the X-sector are identical. They employ the same amount of labour and charge the same price. The price of a typical variety is set such that a product of a slightly inferior quality is demanded nor supplied. The production cost of a potential entrant, rather than the cost of the incumbent, determines the price of an available variety.

Not only the production technology of potential (inferior) entrant matters, but also the monitoring technology. The process of wage-setting assumes that the incumbent does not pay a high wage when the incumbent is about to lose its monopoly. A logical extension of this assumption is that a potential entrant does not pay a high wage either, and does not pay a high wage ever. An entering firm will not earn positive profits, and has thus nothing to loose and everything to win, by letting workers believe that it will stick to an announced wage scheme. If workers would believe an entering firm, this firm would reap the gain - by paying all workers a low wage rather than to some workers a high wage. Therefore, it cannot differentiate wages credibly.

The potential entrant has to resort to a less productive technology than the incumbent, that does not require firm-specific skills and is not troubled by imperfect monitoring. The productivity of a potential entrant $\left(\underline{A}\right)$ is lower than the productivity of the incumbent firm $\left(\overline{A}\right)$.[51] The entrant has to pay

[51] Alternatively, the incumbent firm and the entering firms use the same technology and both face the problem to provide workers with the right incentive to invest. Still, because the entrant cannot differentiate wages, this firm has higher wage cost than the incumbent firm. The results do not change if this alternative route would be chosen.

workers w_Y and the production cost of an entrant are $w_Y/\underline{A}$.[52] These costs are higher than the cost of the incumbent: $w_Y/\underline{A} > w_X^e/\overline{A}$. Limit pricing involves that the price set by the monopolist is factor λ higher than the production cost of the potential competitor. Profits per worker are

$$\alpha\lambda w_Y - w_X^e > 0 \ ,$$

where $\alpha = \overline{A}/\underline{A}$. A monopoly confers a benefit, additional to the profits derived from the exclusive ability to supply a product of a superior quality. A monopolistic, enduring position helps to build a long-term relationship between workers and firm, that partly overcomes the problem of underinvestment in firm-specific skills.

The innovation rate

Profits in the X-sector are the precise reason for R&D in the Y-sector. Producing a blueprint and creating a new monopoly yields a stream of profits. The value of a firm in the X-sector (V) equals the present, discounted sum of future profits and determines the price of a blueprint,

$$V = \frac{\left(\alpha\lambda w_Y - w_X^e\right)L_X}{r + 1 - p} \tag{6.12}$$

where L_X denotes employment (per firm) in the X-sector and r the exogenous real interest rate. The production cost in the Y-sector are Bw_Y, where is B is the labour requirement for producing a blueprint. Competition ensures that the price of a blueprint equals the cost of producing one. Using this equality and substituting the full-employment condition $L = L_X + L_Y = L_X + B(1-p)$ gives an (implicit) expression for the innovation rate 1-p,

$$Bw_Y = \frac{\left(\alpha\lambda w_Y - w_X^e\right)\left[L - B(1-p)\right]}{r + 1 - p} \tag{6.13}$$

The right-hand side of the equality decreases when the innovation rate increases. To produce more blueprints labour is drawn from the X-sector and profits in this sector decline. This and the increase in the discount rate depress the value of a firm in the X-sector. If the interest rate r falls or if the labour

[52] Again this assumes that the effort to acquire skills is for every job the same.

requirement in the Y-sector B falls, the innovation rate $1-p$ goes up and the survival probability p decreases.

The process of wage-setting is also relevant for investment in R&D. When the relative wage cost in the X sector rise and w_X^e/w_Y increases, profits in this sector decline, the return on investing in R&D becomes less, and the innovation rate declines. The previous sections have extensively discussed the opposite relation. There has been shown that a falling innovation rate and an increased survival probability leads to lower wage cost in the X-sector and to a lower wage ratio w_X^e/w_Y. Thus, a strong interaction exist between R&D on the one hand and inter- and intra-sectoral wage distribution on the other hand. The causality does not run one way, from growth to income distribution or from income distribution to growth.

The labour market institution discussed in section 3 (progressive income taxes, firing costs and trade unions) are a reason behind less wage inequality in Europe, relative to the United States. More equality and less efficient wage schemes however raise the wage cost in the X-sector. This depresses profits and lowers the innovation rate. These institutions are also a potential reason for different technical change in Europe and the United States, with the latter being more 'dynamic' than the former.

6.5 A brief empirical analysis

In this section the analysis becomes empirical. Data for various OECD countries allow to explore the link among measures for inequality, uncertainty and labour market institutions. The empirical analysis in this section does not put the theoretical ideas in earlier section to a proper test. The sample is simply too small and the level of aggregation is probably too high. Its aim is more modest. The analysis is only intended to uncover whether labour market institutions have an impact on earnings inequality and/or the survival probability and to have a first, tentative look at the relation between earnings inequality and the survival probability. It shows that trade unions effectively contain earnings differences but it fails to show an effect of job protection measures on earnings inequality (directly or indirectly, through the survival probability). The survival probability however is found to have a significant, negative effect on earnings inequality, so that less uncertainty seems to imply less inequality. In turn, this probability depends strongly on a measure for innovative activity.

The data comprise two measures for earnings inequality. The first is based on income deciles, provided in OECD (1997). It is equal to the ratio of the upper limit of the ninth decile to that of the fifth. The second is the Gini-coefficient, taken from Deininger and Squire (1993). Also, for the survival probability direct observations are available. The OECD (1997) presents the outcome of a survey, asking the probability that a worker stays with a firm if he or she performs well. Besides, job tenure, the average number of years that workers stay in the same job, is an indirect measure for the survival probability. Statistics on job tenure are often put forward to rebut the claim that technical change has accelerated, thereby increasing the turnover on the labour market and contributing uncertainty among workers. In recent years job tenure has remained more or less constant and does not point at a higher turnover.

The analysis considers several explanatory variables. One variable gauges the influence of trade unions. It is defined as the ratio of union membership to total employment. Another variable measures firing costs. It is an aggregate measure, constructed by the OECD (1999), for the difficulties firms encounter when trying to dismiss workers. A third candidate to explain earnings inequality is progression in the national systems of income taxes, but that variable is further ignored here. The reason is that the two measures for inequality are based for some countries on before-tax earnings and for other countries on after-tax earnings. Consequently, (unreported) regression results are rather poor. Regressions have been run with several measures for tax progression. Each does not have a statistically consistent relation with the measures for inequality.

Also, the unemployment rate is invoked to explain the survival probability. The theoretical analysis has disregarded cyclical factors behind the survival probability and has only considered structural explanations -- technical change, innovations and so on. However, the state of the business cycle is likely to affect the perceived position of workers as well. Introducing the unemployment rate into the analysis does raise the question of causality. The causality may run from the survival probability to the unemployment rate or vice versa. The problem of causality may also arise when the so-called inventiveness coefficient, i.e. resident patent application per 10000 habitants, is introduced to explain the survival probability. This problem will not be addressed as the empirical analysis is limited in scope.

Table 6.2 *Turnover on the labour market and income inequality in the OECD* regression results

	independent variables							
	unemployment rate	inventiveness coefficient	union density	job protection	survival probability	job tenure	number of observations	R^2
survival probability	-2.274***	-1.210***	1.925				17	0.643
	(0.515)	(0.358)	(1.508)					
	-2.198***	-1.290***		0.074			19	0.579
	(0.509)	(0.375)		(0.079)				
job tenure	0.031	0.017		0.728**			18	0.396
	(0.065)	(0.088)		(0.283)				
			0.011	0.771***			16	0.403
			(0.014)	(0.271)				
earnings inequality (1)	-1.471	-0.375					16	0.023
	(2.644)	(1.245)						
				1.661			16	0.011
				(4.272)				
					-1.449***		16	0.439
					(0.438)			
						-0.644	15	0.002
						(4.049)		
			-0.435**		-1.361***		16	0.594
			(0.195)		(0.388)			
			-0.470*			1.060	16	0.181
			(0.290)			(3.959)		

Table 6.2 continued

earnings	-0.039	0.112					19	0.022
inequality (2)	(0.348)	(0.237)						
				-0.375			19	0.011
				(0.858)				
					-0.293***		19	0.318
					(0.101)			
						-0.797	18	0.064
						(0.763)		
			-0.141***		-0.094		17	0.595
			(0.037)		(0.071)			
			-0.145***			-0.470	16	0.554
			(0.038)			(0.562)		

The regression equations include a constant. These are not shown in the table. *, **, and *** denote statistical significance at the 10%, the 5% and the 1% level respectively.

survival probability	probability that a worker stays if he performs well in 1992; survey question OECD (1997), Table 5.3
job tenure	average number of years that a worker has the same job in 1992; OECD (1997) Table 5.5
earnings inequality (1)	ratio of upper limit of the ninth decile to that of the fifth decile in 1993; OECD (1996) Table 3.1
earnings inequality (2)	Gini-coefficient in early nineties (from 1987 onwards); Deininger and Squire (1996)
unemployment rate	unemployment in the first half of the nineties, % of labour force (standardized); CPB WildCat
inventiveness coefficient	resident patent applications per 10000 inhabitants; OECD (1999)
union density	union membership in 1994, % of employment; OECD (1997)
job protection	difficulty of dismissal in late eighties; OECD (1999) Table 2.2 column 3

Table 6.2 gives the regression results. The first two rows show that the survival probability, the unemployment rate and the measure for innovative activity -- the inventiveness coefficient -- are closely correlated.[53] The evidence for an additional, independent effect of trade unions or job protection on the survival probability is not strong. Similar regressions with different results have been run with job tenure rather than the survival probability at the left-hand side (the 5th and 6th rows). Job tenure appears to be unrelated with the unemployment rate and the inventiveness coefficient. Higher firing costs however bring about more tenure.

[53] A different measure for innovative activity is R&D expenditure by firms as a fraction of gross domestic product. This measure gives produce more or less similar results as the inventiveness coefficient.

Regressions with the two measures for earnings inequality underline that the survival probability and job tenure are not equivalent, interchangeable indicators for job uncertainty. Either measure for inequality is negatively affected by the survival probability but does not depend on job tenure. This does not change when union density is introduced into the regression equations. Both union density and the survival probability affect earnings inequality, although in the case of the second measure for inequality, the Gini-coefficients, the effect of the survival probability is no longer statistically significant once union density is introduced into the equation. Table 6.2 shows further that the unemployment rate, the inventiveness coefficient and job protection do not have direct effect on inequality.

The conclusion is that trade unions use their influence to contain earnings differences. The survival probability is also an influential factor. Typically, a higher probability and thus less uncertainty implies less inequality. The empirical analysis also gives a hint about the factors that determine the survival probability. The unemployment rate and the innovative activity, measured by the inventiveness coefficient, are found to have clearly negative effect on this probability. Two other candidates, trade unions and job protection measures, fail to have a statistically significant impact.

6.6 Conclusions

Central in this chapter is the interaction between wage inequality and technical change. Technical change is conceived as innovations destroying current products and monopolies and creating new ones. The survival probability of a firm in the technology race matters for the wage distribution. Owing to incomplete information firms pay different wages to identical workers. Some workers are rewarded, others not. This wage scheme becomes a less efficient instrument to stimulate investment in firm-specific skills when the innovation rate increases and the survival probability (of a firm or job) falls.

The interaction between wage inequality and technical change is elusive. An unequivocal relation between the two does not emerge for two reasons. First, a firm can respond to faster technical change and more uncertainty in two ways. It can respond by higher rewards for some workers and more inequality. However, to maintain the incentive to invest a firm may also opt for a higher average wage (relative to the outside option) and more equality. Second, causality in the relation between the wage distribution and technical change may run in either direction. The uncertainty that technical change creates, affects the wage distribution. However, the wage distribution and the factors that determine this distribution may in turn affect the pace of technical change. Institutions matter not only for labour market performance but also for the process of technical change and growth. For example, unions may demand more equal but less efficient wage schemes. This implies higher wage costs in the innovative sector leading to less employment in this sector and to a lower overall innovation rate. This chapter not only considers the role of trade unions but also the effect of firings cost and progressive income taxes on the wage distribution.

The empirical analysis at the end of the chapter is modest in its aims. At least, it underlines that trade unions use their influence to contain wage in equality. Besides, it indicates that drawing conclusions from job tenure and changes therein are premature. The claim that technical change attributes to job uncertainty is often downplayed. The reason is that in recent years job tenure has remained more or less constant and does not point at a higher turnover as a result of faster or different technical change. However, from the empirical analysis a negative relation between a direct measure for the survival probability and wage inequality emerges, whereas job tenure and inequality appear to be uncorrelated.

Appendix A First-order conditions for trade unions

Maximize

$$l\left(U_X^e - U_Y\right) + U_Y,$$

subject to

$$\lambda l\left[U_X^e - (1-q)U^c - qU_Y\right]$$

where

$$U_X^e = pq\frac{1}{1-\sigma}\left[\overline{w}_X(1-e_X)\right]^{1-\sigma} + (1-pq)\frac{1}{1-\sigma}\left[\underline{w}_X(1-e_X)\right]^{1-\sigma},$$

$$U^c = \frac{1}{1-\sigma}\left[\underline{w}_X\right]^{1-\sigma} \text{ and } U_Y = \frac{1}{1-\sigma}\left[w_Y(1-e_Y)\right]^{1-\sigma}.$$

Employment is a negative function of the expected wage, w_X^e. The expected wage depends on the low and the high wage as well as the probability to survive,

$$w_X^e = pq\overline{w}_X + (1-pq)\underline{w}_X.$$

The first-order conditions are

$$w_X^e:\ \frac{\partial l}{\partial w_X^e}\left(U_X^e - U_Y\right) + (1+\lambda)l\frac{\partial U_X^e}{\partial w_X^e} = 0\ ,$$

$$\underline{w}_X:\ (1+\lambda)\frac{\partial U_X^e}{\partial \underline{w}_X} + \lambda(1-q)\frac{\partial U^c}{\partial \underline{w}_X} = 0\ .$$

Using the expressions for the various utility levels, the expression for the incentive compatibility constraint and $e_X = e_Y = e$ gives

$$w_X^e:\ -\varepsilon\left(U_X^e - U_Y\right) + (1+\lambda)\overline{w}_X^{\,-\sigma} w_X^e(1-e)^{1-\sigma} = 0\ ,$$

$$\underline{w}_X:\ (1+\lambda)(1-pq)\left[-(\overline{w}_X)^{-\sigma} + (\underline{w}_X)^{-\sigma}\right](1-e)^{1-\sigma} - \lambda(1-q)(\underline{w}_X)^{-\sigma} = 0\ .$$

Factoring out the term $1+\lambda$ gives equation (6.9).