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Technology, Trade and Inequality

Abstract:
In recent decades new technology has led to increasing demand for well-educated labour at the expense of labour with lower education levels. Moreover, increased imports from low-cost countries have squeezed out many Norwegian manufacturing firms employing a sizeable share of workers with low education. In this article a large macroeconomic model for Norway (MODAG) is used to quantify the importance that technological developments and competition from low-cost countries have had for the economy and for low- and high-educated labour. The results show that above all technological developments, but also increased trade with low-cost countries, have reduced demand for low-educated labour relative to well-educated labour. Wage formation factors have however meant a) that technological developments have also benefited those with low education who still hold a job, and b) that a relative fall in prices on goods from poor parts of the world has kept down wage differentials.

Keywords: Skill-bias technological change, international trade, centralized wage setting, inequality, labour demand, macroeconometric model.

JEL classification: E24, E27, F16, O33

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1. Introduction

Recent decades have seen substantial changes in the composition of the labour force in Norway. The share with higher education has risen. This is not specific to Norway but a feature common to all western countries. The characteristic distinctive to the Norwegian development is that the trend has not been accompanied by a substantial rise in unemployment among those with the lowest education levels or by major changes in wage differentials. The explanation is probably that the educational upgrading of the labour force has largely kept pace with changes in demand.

The economic literature often highlights two trends that dampen demand for low-educated labour and increase demand for those with relatively high education levels. First, technological advances, not least in the IT field, favor well-educated labour at the expense of those with low education. Jobs previously done by a large number of unskilled workers are now automated. Moreover, a high level of qualifications is needed to develop and oversee management systems. This type of technological change has made itself pervasive throughout the manufacturing sector via mass production and international trade, which explains the increasing share of well-educated labour throughout this sector.

Second, a number of sectors that make intensive use of low-educated labour have become increasingly exposed to competition from recently industrialized low-cost countries. This has led to the gradual demise of this type of enterprise in the western world, with consequences above all for workers with a relatively low level of education. Relocation of textile and furniture manufacturing to low-cost countries are examples of this process.

Many studies find a strong link between educational upgrading of the labour force and computer use and investments in research and development, cf. Berman et al. (1994) and Autor et al. (1998). Berman et al. (1998) present international documentation from many countries; see also Salvanes and Førre (2003) for a study of Norway. Hence a frequent conclusion is that technological developments are behind the observed trends in labour demand. Wood (1994) is possibly the foremost spokesman for the notion that increased international trade – above all with recently industrialized countries with low labour costs – has altered product prices and profitability in manufacturing sectors in the wealthy part of the world. The empirical surveys referred to above find less support for this view, however.

To what degree has the spread of new technologies and trade with low-cost countries contributed to employment changes in recent decades? And what are the consequences for wages and unemployment for the respective educational groups? A fruitful approach to these issues is to deal with manufacturing activity in a disaggregated manner, independently of whether developments are technology-driven or whether increased international trade explains the changes of recent decades. Our approach employs a new version of a large-scale macroeconomic model called MODAG[1] in which the labour force is split into five education categories. Integrating a relatively heterogeneous labour market in a large macroeconomic model, which also describes the rest of the Norwegian economy, not only permits the study of the significance of education-specific labour markets in other areas of the economy, but also enables account to be taken of the second-round effects back to the labour market. For example, technological change that favors well-educated labour will enhance the competitiveness of sectors featuring a large proportion of well-educated labour and raise the wages of such labour. Higher incomes will raise consumption, which not only further improves the labour market for the well educated but also raises wage levels for low-educated labour. At the same time higher average productivity will raise wage levels for those with the lowest education. Higher profitability in some sectors will also change the structure of industry and influence corporate investment. In the next instance such factors will have further consequences for the labour market. MODAG can capture many such complex relations in the Norwegian economy where parts are highly inter-dependent.

Calculations show that the education-favoured demand can essentially be traced back to skilled bias technological changes rather than to increased trade with low-cost countries. This conclusion supports much of the international literature and analyses for other countries referred to above. We also show that the interplay between the labour market and the rest of the economy along with aspects of Norwegian wage formation have enabled technological developments and lower import prices on a number of commodities to secure a relatively good wage trend for low-educated workers who hold a job despite the problems it has created for such workers on the labour market. The reason for this is twofold. First, since average productivity enters all wage-equations, technical innovations benefit all workers. Second, a lower growth in consumer prices decreases wage-differentials because price growth has a stronger effect on wages to high-educated workers than to the workers with less education.

Section 2 presents the development in employment, unemployment and wages for the various educational groups in Norway in recent decades. Section 3 examines the macroeconomic model, MODAG, used in the calculations. This section also examines what enlargements of the model were necessary to describe the education-specific submarkets in the economy. Sections 4 and 5 present the results from two alternative scenarios, i.e. the significance of the technological changes in section 4

[1] MODAG was developed by Statistics Norway and is used by, among others, the Ministry of Finance in preparing the National Budget. The model is described in greater detail in section 3. See Cappelen (1992) for a documentation of the model.

and of the development in import prices in section 5. Section 6 contains a summary and concluding remarks.

2. The development in relative unemployment rates and in relative wages

Formal educational attainment is generally used as an indicator of workers' qualifications and abilities since it is relatively simple to measure (see for example Manacorda and Petrongolo, 1999). This is of course not without its problems, for one thing because formal education has to some extent replaced job experience without this being accompanied by an increase in qualifications. Alternative indicators are not easy to come by; for example, jobs are not always easy to classify and surveys and tests are often unreliable.

Our data on employment and wages by educational status are closely integrated into the Norwegian national accounts system and cover the period 1972 to 1997.[2] To simplify one can think of our data simply as a disaggregation of the traditional labour market module of the national accounts. This secures consistency with other information about the input structure of each production sector of the economy. The employment data is to a large extent based on the Labour Force Survey. Employment (both hours worked and persons) and hourly wages by sector are disaggregated into five educational groups with the number of years of education in parentheses

- Primary education (less than 11 year)
- Secondary education (11-12 years)
- Vocational education (11-12 years)
- Low university education (13-16 years)
- High university education (17 years or more)

Figure 1 shows the development in the employment shares of education categories at the national level in the period 1972-2000[3]. The figure shows that employment in Norway has shifted away from workers with primary education to workers with higher education, in particular vocational training and a short university education. The explanation is probably twofold. First, formal education has replaced job experience without raising workers' qualifications. Previously the norm was to go straight from primary school to vocational training within a company. Now it is more usual to undergo vocational

[2] Our data consist of both provisional figures provided by the Unit for National Accounts at Statistics Norway as well as own imputations in the cases where data are not available yet.

[3] Since employment figures broken down by education are unavailable for the years 1998-2000, model-generated figures are used.

training within the formal education system. Second, the labour force's level of education has undergone a genuine upgrading with increasing numbers seeking a longer education.

Figure 1. Employment shares of education categories in Norway in the period 1972-2000. Percent

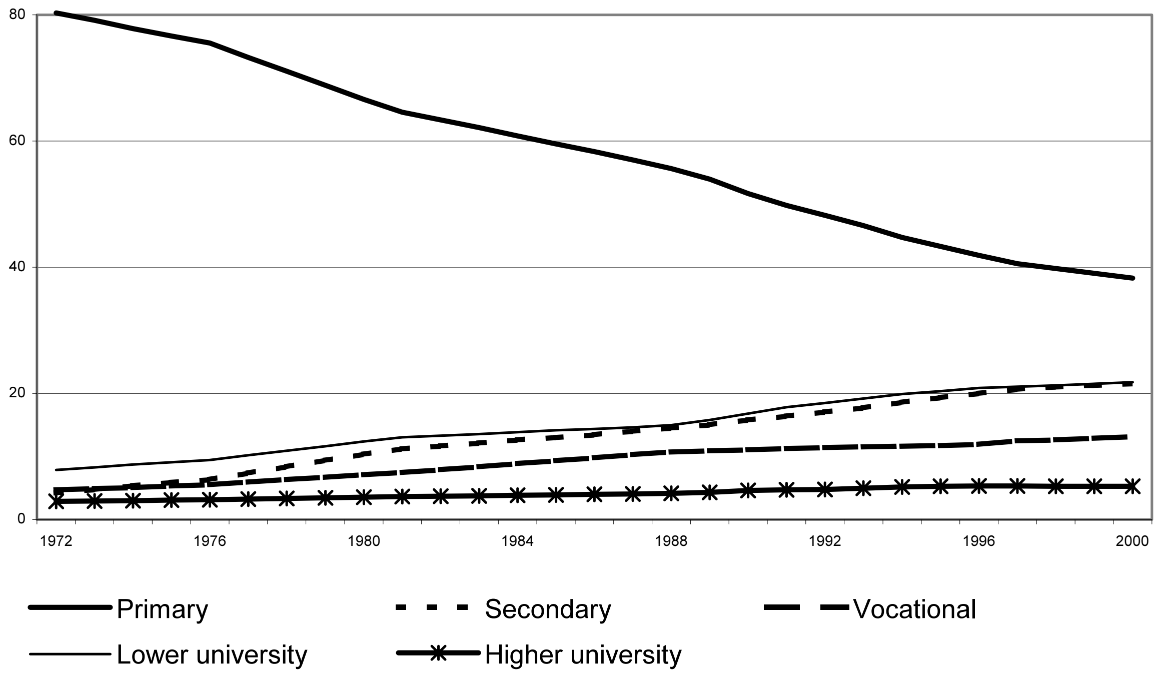
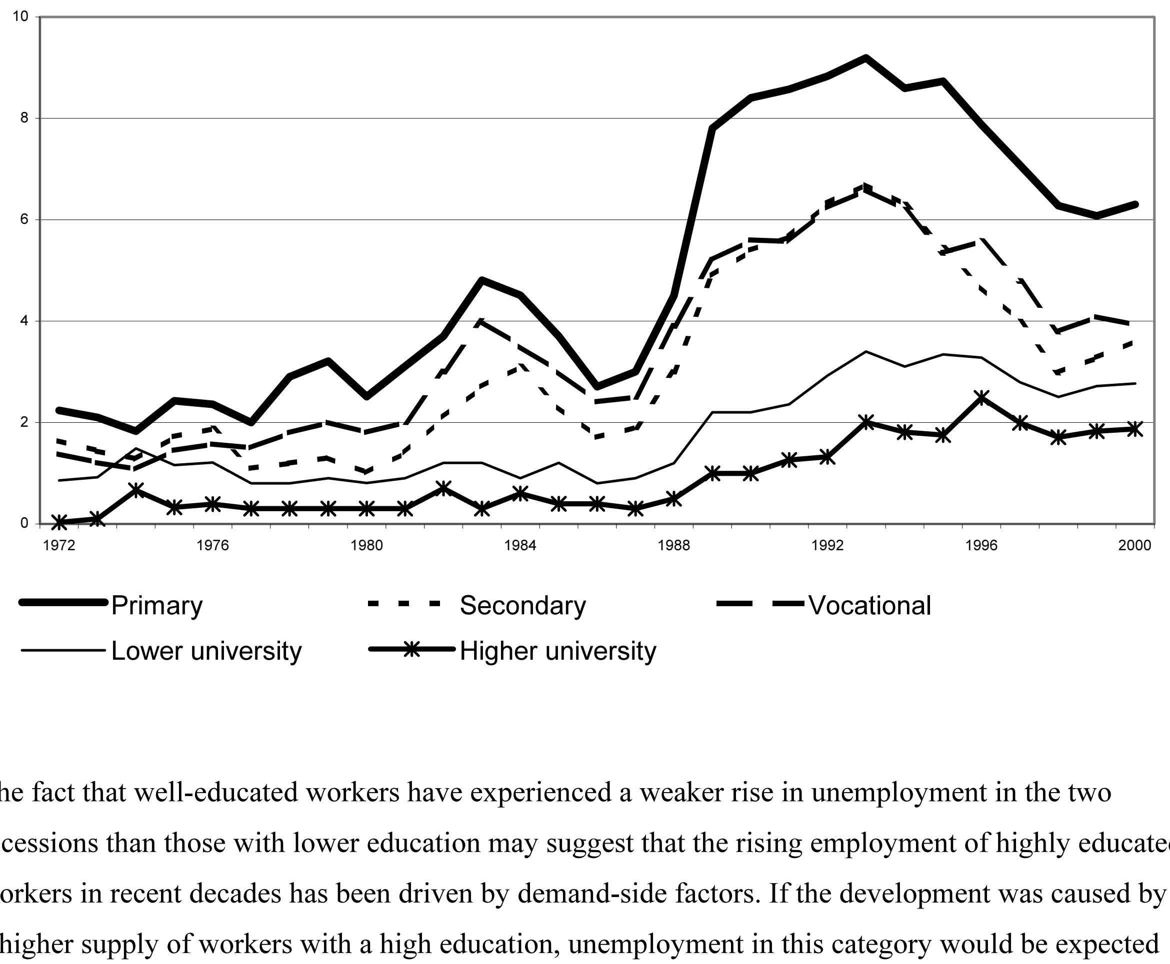


Figure 2 shows the development in unemployment in percent of the labour force according to Statistics Norway's Labour Force Survey (LFS) for the above five education categories in the period 1972-2000. There are large differences in levels throughout the period, with the highest unemployment among those with the lowest education. The unemployment figures show two substantial downturns in the Norwegian economy during the period. The years 1981-1983 saw a rise in unemployment among workers with primary and upper-secondary schooling, while unemployment among university-trained workers remained low. In the years 1988-1993, on the other hand, unemployment rose in all categories. To the extent that demand-side factors underlie the economic fluctuations, the drop in demand in the latter recession was broad-based. Hence the recession weakened the labour market for all education categories. The recession at the start of the 1980s, on the other hand, was probably initiated by factors affecting different categories in different ways, as in the case of skill biased technological changes and increased competition from low-cost countries.

However, unemployment is affected by factors on both the demand side and the supply side, although it is often assumed that the real supply of labour, i.e. the number of potential labour market participants, changes more slowly than demand. This said, the labour supply, as measured by LFS, turns out to be highly cyclically dependent such that the labour force moves in the opposite direction to unemployment – a phenomenon usually referred to as *the discouraged worker effect*.

Although unemployment among those with low education in times of recession has risen by a far greater margin than among the well-educated, the differences may in fact be even greater than shown by Figure 2. Table 1 shows the degree of co-variation between the participation rates, i.e. the share included in the labour force, and the unemployment rate for the five education categories. Above all those with primary education are more prone to exit the labour force when unemployment rises. Hence it can be assumed that the problems facing these groups in the labour market are greater than the unemployment figures alone suggest.

Figure 2. Unemployment in percent by level of education



The fact that well-educated workers have experienced a weaker rise in unemployment in the two recessions than those with lower education may suggest that the rising employment of highly educated workers in recent decades has been driven by demand-side factors. If the development was caused by a higher supply of workers with a high education, unemployment in this category would be expected to rise more than among those with lower education. However, scholars disagree on this. Acemoglu (1998) points out that persons with higher education who fail to get work matching their qualifications take the jobs of those with lower education since they often work more effectively for the same pay.

Hence workers with the lowest education are more likely to become unemployed, even though, relatively speaking, this type of labour is in shortest supply.

Table 1. Correlation coefficients* between unemployment rates and participation rates by worker's level of education

Primary	Secondary	Vocational	Low university	High university
-0.96	-0.26	0.06	-0.12	-0.47

* A correlation coefficient is a measure of the degree of linear co-variation between two variables. It is designed to lie between -1 and 1. 1 shows that the variables have a perfect positive linear relation and -1 that they have a perfect negative linear relation.

Source: Labour Force Survey, Statistics Norway.

Figure 3. Hourly wage in relation to workers with primary education

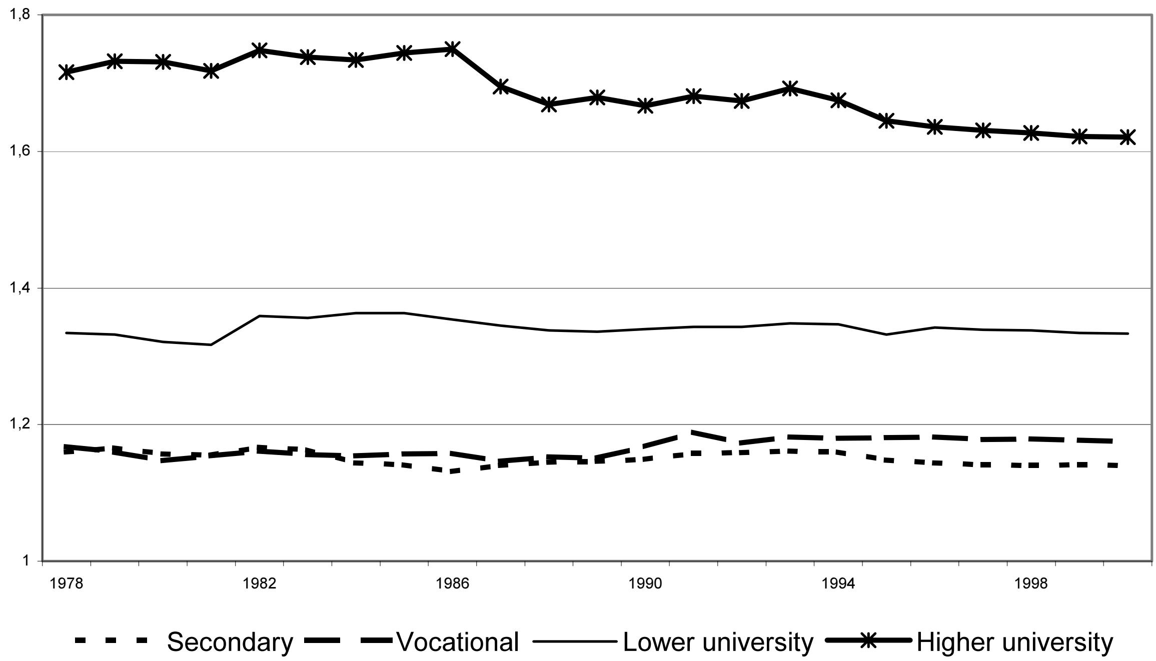


Figure 3 shows the development in relative hourly wage rates for the four education categories with the highest education measured in terms of the hourly wage rate for those with just primary education in the period 1978-2000. Relative wages for those with a high university education fell through the period; otherwise the main impression is that relative wages remained fairly stable in this period. The relative fall in wages for those with a high university education was particularly marked at the end of the 1980s and in the first half of the 1990s. Whereas the first period can be ascribed to a relatively weak wage trend for those with a high university education working in manufacturing, in the latter period it was persons with a high university education in sectors sheltered from international competition, above all the public sector, that made the largest contribution to the fall. Several reasons are likely: there are indications that well-educated labour in the public sector achieved lower wage growth in this period due to the adoption of a more centralized wage formation regime after the passage of wage legislation in 1988 and 1989. Another reason may be an increase in the female share of well-educated labour in the public sector in the period. To the extent that women's wage level remains below that of men with a similarly high level of education, this has served to push down the average wage.

Figure 4. Hourly wage in the sheltered sector relative to manufacturing industry

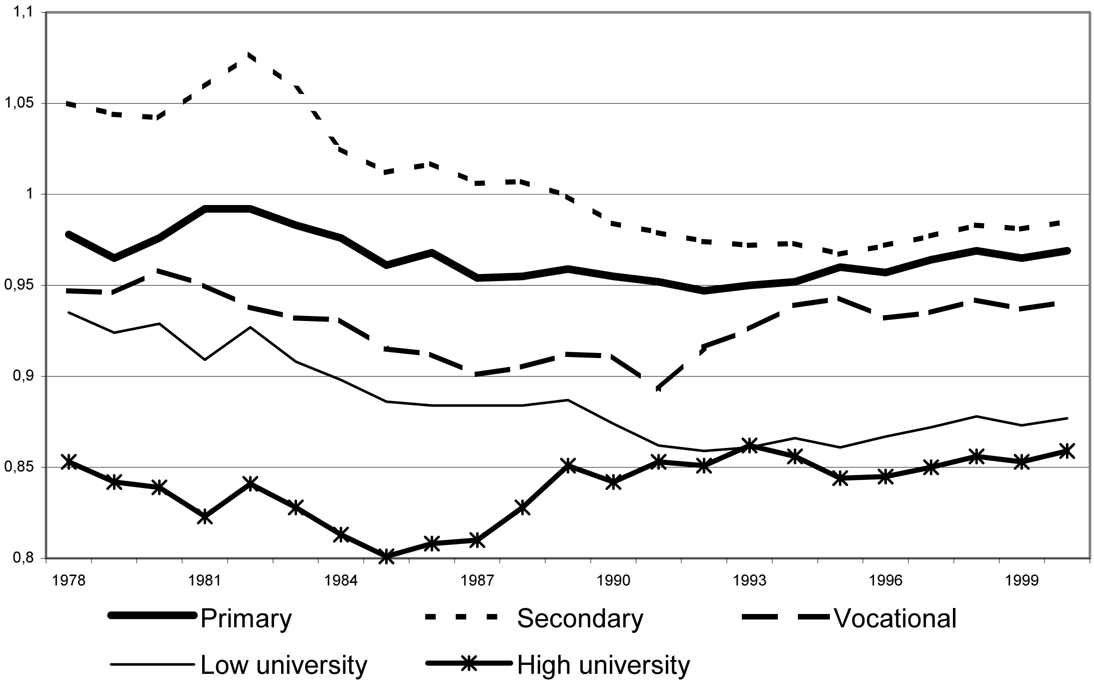


Figure 4 shows the development in the hourly wage in the sheltered sectors in relation to manufacturing industry for persons with the same education background over the period 1978-2000. In this context sheltered sectors means the public sector and private services sector. At the start of the 1980s relative hourly wages fell for all education categories in the sheltered sectors in relation to manufacturing industry. Disregarding those with secondary education, the declined continued to the start of the 1990s. Since that time relative wages in the sheltered sectors have strengthened somewhat, although, compared with manufacturing industry, wage levels in the sheltered sectors were still lower in 2000 than at the start of the 1980s. Even so, all categories have lower wage levels than workers with education of the same duration in the manufacturing industry. Viewed in this context, those with a high university education are the furthest to the rear in wage terms. This reflects the low level of wages in the public sector where 55 percent of this labour is employed.

Scrutiny of the labour market situation for the various education categories in Norway shows that the demand for as well as supply of labour has shifted towards labour with longer education in recent decades. However, the shift has only widened the unemployment differentials among the education categories for brief periods. In keeping with this, and possibly to an even greater extent, wage differentials in the same period are unusually stable. The exception is among those with a long university training who show a weaker wage trend than all other categories since the end of the 1980s. Wage differentials between low-educated labour in manufacturing industry and low-educated labour in the sheltered sectors are generally negligible. Wage levels among those with a university education in the sheltered sectors, on the other hand, are 10-15 percent below the level in manufacturing industry.

2.1. MODAG – a model for the Norwegian economy

The macroeconomic model used in the calculations is called MODAG. While the economic mechanisms do not differ significantly from those found in other Norwegian and foreign macroeconomic models, the model is highly disaggregated by international standards (38 commodities and 28 domestic production sectors). We will here give a brief presentation of the main mechanisms in the model. The model is documented in more detail in Cappelen (1992).

Norwegian firms are assumed to possess a certain market power, i.e. they face demand that depends both on their own and competitors' prices. Prices in export and domestic markets are largely decided by the firms' own variable costs, foreign prices and the level of capacity utilisation. Production for the export and the domestic markets (apart from resource-based industries where production is exogenous) is thereafter determined by the relationship between Norwegian and foreign prices and indicators of total foreign and domestic demand respectively. Also imports of the various products are determined as part of this process. Firms' demand for variable factor inputs is determined by production in the sector, relative prices on the variable factor inputs and the stock of real capital.

Domestic demand can be divided into household consumption and housing investment, business sector investment and public sector demand. The model does not explain public sector demand and investments in a number of energy-related activities, whereas most of the other components are established in empirically quantified behavioral relationships. Real income, real wealth and real after-tax interest rates are the main items determining household consumption. Housing investment is a function of approximately the same variables, along with the price of existing and new homes. Production sectors' real investments in four different types of capital are determined primarily by the sectors' output, but also to some extent by profitability.

The manufacturing sector is the wage leader in MODAG, and nominal wages are determined by unemployment, productivity and producer prices in manufacturing industry, consumer prices and a number of tax parameters. The link between wage level and unemployment is such that a given change in unemployment has larger consequences for the wage level the lower unemployment is at the outset. Unemployment is the difference between supply of and demand for labour where supply is determined primarily by demographic variables and by the level of unemployment, whereas the real after-tax wage level plays only a modest role. Real disposable social security benefits are however important for the oldest workers' labour supply. Wage relations by education that are employed in the version of the model used in this article are described in detail below and in Appendix C.

The economic relationships in an economic model such as MODAG are estimated on the basis of historical data series. There is considerable disagreement on whether and to what degree such models lend themselves to analyses of the type we have carried out here. In his critique Lucas (1976) says that when the agents in an economy choose their actions, they do so based on optimizing behavior and rational expectations of the future. Hence these agents will change their behavior if expectations change. When the economy changes as a result of political decisions for example, the linkage between economic variables will also change. If relations in economic models are determined such that they are invariant to policy changes, the models can be used for policy analyses. If not, policy change will change the actual model, in which case the model is not suited to studying structural changes. Ericsson and Irons (1995) examine the now extensive volume of literature on the Lucas critique with special emphasis on tests of the critique's empirical relevance. The authors' conclusion is that the Lucas critique is relevant in theory, but has limited relevance in practice. Only a few empirical studies find support for the critique. Moreover, experience shows that MODAG functions surprisingly well even in the event of major social changes. While the Lucas critique represents a qualitatively important objection to the use of empirically specified models, experience suggests that the critique hits isolated aspects of the models hardest and that it is not important in purely quantitative terms.

2.2. Education-specific submarkets in MODAG

Labour is treated as a homogeneous factor input in the standard version of MODAG. The national accounts now provide data on hours worked and hourly wage rates for various production sectors by five education categories for the period 1972-1997. Time series for labour supply by education category were constructed using education-specific unemployment rates from Statistics Norway's labour force survey (LFS). The data are used to construct a version of MODAG with education-specific sub-markets within the labour market. In the following we describe the modeling of labour supply, labour demand and wage formation in this version of the model.

2.2.1. Modeling labour supply by education category

The total supply of labour is determined in the same way as in the standard version of MODAG. Participation rates are modeled in terms of age and gender as a function of, inter alia, real wage and unemployment; a discouraged worker effect causes the labour supply to diminish when unemployment rises and vice versa. In the scenarios presented below, however, it is assumed that the distribution of the supply of labour on the various education categories is not affected. The labour supply for all education categories therefore follows the development in the overall labour supply. For example, a relative change in unemployment between different categories will not alter the relationship between the labour supply in the same categories. If average unemployment remains unchanged, the labour supply will show no change whatsoever. This is a somewhat unsatisfactory supposition and the quantitative effects in the counterfactual simulations should be interpreted in light of this simplifying assumption. Qualitatively, however, it is not obvious that this assumption will affect the results. It would be unreasonable to expect a change in the composition of employment to trigger an even larger change in the distribution of the labour supply, such that unemployment develops in the same direction as employment. Moreover, the education-specific labour supply turns out to develop very slowly and in line with a trend. Many youth seems to choose longer education as compared to earlier regardless of remuneration and the labour market situation.

2.2.2. Modeling factor demand with various types of labour present

The version of MODAG used here distinguishes between nine factor inputs, including five different types of labour, classified by education background. The other four factor inputs are real capital, electricity, other energy and material inputs. In all industries a distinction is drawn between workers with high and low education respectively. MODAG comprises just fewer than thirty industries. The advantage of such a disaggregated production structure is that account can be taken of the considerable differences between production processes. Some are labour-intensive while others employ relatively little labour. Labour force composition also differs from industry to industry. Typically, firms' demand for various types of labour will vary across industries. For example, a production increase in a given industry could have different effects on demand for various types of labour than an equally large production increase in another industry. Hence changes in industry composition may have a substantial effect on relative demand for labour.

In eleven sectors a behavioral adjustment of various types of labour has been carried out by modeling employers' assessment of high-educated versus low-educated labour. The eleven comprise seven manufacturing sectors, three private service sectors and the agriculture sector. For seven of these sectors persons with a vocational training are regarded as low-educated labour, while for the other four they are regarded as high-educated labour. Assessment of high versus low-educated workers depends on relative wages, stock of machine capital and production volume along with a trend, which in the absence of observable variables, is assumed to represent the technological level (but possibly also other factors) that is relevant to the relationship between the two types of labour. A technical and more complete description of the demand of variable inputs in a situation with heterogenous labour is outlined in Appendix A.

Describing how technological change leads to changes in demand for various types of labour is a relatively complex matter. Technical progress takes place in many different ways, and the best that can be hoped for is to obtain information for variables that are more or less good indicators of what is to be measured. A number of microeconomic studies have had access to information on the use made of IT in manufacturing, cf. for example Autor et al. (1988) who examines whether relatively IT-intensive firms have a larger share of well-educated labour than firms making little use of IT.

Access to this type of information has, at any rate up to the present, not been available when quantifying employers' assessment of various types of labour using aggregated data, and the technological level is usually represented by a linear time trend. This is done for example by Falk and Koebel (2002) whose aim were to comment on the effect of outsourcing and importing of inputs on demand for various types of labour in the German manufacturing industry. There is reason to believe that within a given sector different firms put technical innovations to use at different times; moreover, learning processes are under way in each and every firm to prepare for the installation of new technology. Hence aggregation over firms may cause technical development within an industry to appear smoother than is the case for a particular firm.

Quantification of behavioural relations shows an effect of the trend variable that is commensurate with technical change having occurred in favor of high-educated labour and in disfavor of low-educated labour. The annual relative change in the relationship between hours worked and high and low education labour respectively that can be traced to the trend effect is between 1 and 10 percent, depending on the industry in question. Economic literature has also focused on technological change brought about by improvements in the quality of real capital (above all machine capital). This entails that recently acquired capital is more productive than capital acquired earlier. Recent real capital may displace labour with low education and require the employment of well-educated labour in order to be used efficiently. Hence an improvement in the quality of real capital could favor well-educated labour.

National accounts data provide the basis for the MODAG macro model. However, quality enhancements are not taken into account when constructing the figures for real capital. Hence it is not surprising that the effect of an increase in machine capital differs somewhat from one manufacturing sector to the next. In the food industry, wood processing industry, engineering industry and retail trade an increase in the stock of machine capital leads to a relative increase in hours worked by the well-educated. For the other sectors the effect is either zero or in the opposite direction. A fixed-factors assumption has been incorporated for high and low education. This means, for example, that a 1 percent increase in the number of hours worked by those with a high education translates into a 1 percent increase in the number of hours worked by all those that are in this aggregate. Thus there is no effect of changes in relative wages between these workers.

The effect of a production increase also differs somewhat from industry to industry. For three of the industries an increase in production volume produces a bias towards those with a high education. This is the case for the food industry, the wood processing industry and the industrial chemicals industry. Thus a change in production level resulting from domestic and foreign demand impulses will, in production sectors where the effect of a change in production differs from zero, have a direct impact on employers' assessment of high-educated versus low-educated labour.

2.2.3. Modeling wage formation for various education categories

Appendix B gives a more thoroughly description of the education specific wage-equations than is given here. The results of the econometric analysis are also given in the appendix. Modeling of wage formation is based on theories of bargaining between worker and employer organizations. Account has also been taken of the specific institutional features of the Norwegian wage formation process. These include the central role of the Norwegian wage formation process in preserving Norwegian manufacturing industry's international competitiveness throughout the post-war period. This is highly important in a small, open economy such as Norway's. Aukrust (1977) and Lindbeck (1979) formalized these mechanisms at an early stage in a theory, which subsequently received the appellation *the main course theory*. The theory states that in the long run wages in a small, open economy will follow the path set by the trend in productivity in the competitively exposed sector and the development in world market prices. However, the mechanisms that secured this wage trend are not explained by the theory. In bargaining theories wages are fixed in negotiations between (representatives of) the employer and worker sides[4]. Trade union members are assumed to desire the highest possible purchasing power and lowest possible unemployment (among their members), while the employers are assumed to maximize profit. Hence wages in these models depend both on "inside factors" such as prices and productivity and on "outside factors" such as unemployment and alternative wage. Where trade unions and the employers are coordinated and wage formation is

[4] See Nickell and Andrews (1983), Nickell (1984), Hoel and Nymoen (1988) and Nickell and Wadhwani (1990).

centralized, the bargaining theory provides a theoretical justification for the main course theory in which both manufacturing industry's competitiveness and unemployment emerge as "inside factors".

As in the case of the standard version of MODAG, and in keeping with the institutional aspects of Norwegian wage formation, we distinguish between three main sectors when modeling wage formation: manufacturing industry, private services and the public sector. The relative wage change for the various branches within each of these main groups is assumed to be identical. However, there is room for flexibility in Norwegian wage formation since about half of the total wage growth takes place outside the collective bargaining arena[5]. By estimating wage relations for each of the five education categories in each of the three main sectors, an explicit measure of wage-formation flexibility can be obtained. Most analyses find a connection between wage level and pressure in the labour market concerned as measured by, for example, the level of unemployment (see Blanchflower and Oswald, 1994). This is commensurate with wage formation taking place in bargaining between trade unions and employers. However, where wage bargaining largely takes place at a centralized level and/or is coordinated between several sectors, the focus shifts from local labour markets to macroeconomic variables. This can be tested. If wages are highly sensitive to changes in education-specific unemployment rates, this suggests that that wage differentials will increase in periods of rising unemployment differentials.

Both total and education-specific unemployment prove to be of significance to wage differentials in Norway. An increase in general unemployment strongly moderates wages to workers in the three categories of lowest education while those with the highest education levels do not appear to give much emphasis to this. On the other hand, those with a high university education attach more importance to the development in unemployment among their own numbers. This entails that an increase in general unemployment will help to increase wage differentials via slower wage growth for those with the lowest education. If, in addition, the increase in unemployment particularly affects those with low education, wage differentials will increase further. However, an increase in unemployment among those with a high university education will reduce wage differentials vis-à-vis other groups. The results also indicate that public sector workers are somewhat more preoccupied by the development in unemployment, specifically in education-specific unemployment, than workers elsewhere in the economy.

For manufacturing industry we find support for the notion that wage costs follow the trend in labour productivity and product prices in the long term, given that no changes occur either in the total or

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[5] See Holden (1989) and Rødseth og Holden (1990). Holden (1989) finds that the contractual increment at the centralized negotiations has a strong effect on wages, and that this effect is not offset by wage drift.

education-specific rate of unemployment. Alongside variables that are of significance in the long run, changes in consumer prices and governmental interventions also play a part in annual wage growth. The two categories with highest education are compensated for increases in consumer prices to a higher degree than those with lowest education. In the main sectors of private and public services the results show that remuneration depends on the so-called alternative wage alongside the total and education-specific unemployment rate. The alternative wage in private services is a weighted average of hourly wages in manufacturing industry and the public sector, while the alternative wage in the public sector is a weighted average of hourly wages in manufacturing industry and private services. Hence for a given unemployment rates the total long-term effect will be that the wage trend for each education category in the two service sectors follows the wage trend for the same education category in manufacturing industry. If the composition of labour develops identically in the three sectors, the average wage level in each sector will also develop identically in the long run.

All in all we find strong support for the notion that manufacturing industry is the wage leader for the service sectors for all education categories, but that changes in education-specific and aggregate unemployment may contribute to changed wage differentials between sectors in both the short and long run. In the same way changes in unemployment could also change wage differentials between workers with differing education in the same sector. This indicates that despite the centralized and coordinated nature of Norwegian wage formation, there is a considerable degree of educational and sectoral flexibility. The relations we have found in the wage formation process are very stable, indicating that no structural changes of significance have taken place in the estimating period. The Norwegian wage-bargaining system, with its focus on manufacturing industry's competitiveness and small wage differentials, has proven robust to changes in the labour market in this period. Despite the fact that an ever smaller share of workers are employed in manufacturing industry and that more and more workers are highly educated, the role of relatively low-educated manufacturing workers as wage-leaders for those with higher education and for those in service trades does not appear to have diminished.

3. Significance of technological progress

According to our analyses, much of the increased demand for well-educated labour over the past 30 years follows a trend. This is interpreted as the effect of the fact that the implementation of new technology in this period has largely favored labour with high education. Using the new technology requires well-qualified labour. The demand for such labour therefore rises in step with the evolution of technology. The new technology has also largely replaced labour with lower education, thereby weakening the labour market for those with lower qualifications.

In order to calculate the significance of this technology-driven bias in labour demand, we have altered the education-specific trend effect in the demand for labour from 1980 up to 2000. This may be regarded as an alternative scenario for the Norwegian economy where the assumption is that technological progress has not favored the well-educated to the extent that is actually the case. We have reduced the trend bias in labour demand towards more skilled labour by 10 percent annually. Hence in this scenario it is still the case that technological change favors the well-educated, but by a somewhat smaller margin (10 percent) than the historical path indicated by the estimated results.

Assuming smaller bias in labour demand than that actually witnessed has substantial significance for the economy and for educational submarkets in the labour market. Changes in total and education-specific unemployment have a large bearing on wage formation and explain much of the effect on the economy in this scenario. Relative changes in unemployment – among education categories – could conceivably have consequences for the labour supply, but, as mentioned in section 3.1.1, we have not modeled the labour supply for each education category. Hence we retain the relative supply of labour unchanged. The quantitative effect of this scenario should be viewed in light of this modeling assumption.

There is a smaller bias in demand towards well-educated labour in this scenario than that actually witnessed. This increases employment among low-educated labour and reduces employment among well-educated labour in relation to the actual path. In our calculation 25,000 more low-educated persons are employed in 2000 than was actually the case. In comparison, employment among the well-educated is reduced by 10,000 persons. Table 2 shows the development in unemployment in this scenario. Up to 2000 the unemployment rate among those with primary education is reduced by 1.9 percentage points. Those with upper-secondary general studies show 2.5 percentage points lower unemployment. Among workers with upper-secondary vocational training and with university training, unemployment in 2000 is between 1.6 and 2.1 percentage points higher in this alternative scenario than was actually the case in 2000.

Table 2. Effect on unemployment of weaker education-favoring technological growth. Deviation from actual unemployment in percentage points

Educational group	1985	1990	1995	2000
Total	0	-0.1	-0.1	-0.2
Primary	-0.3	-0.6	-1.2	-1.9
Secondary	-0.4	-0.8	-1.7	-2.5
Vocational	0.6	0.9	1.3	1.6
Low university	0.7	1.1	1.5	2.1
High university	0.6	1	1.4	1.9

Reduced unemployment among those with low education and increased unemployment among the well-educated contributes to reduced wage differentials in all sectors of the economy, cf. Table 3. In manufacturing industry, however, all categories experience a reduction in wages compared with the actual path. In 2000 only those with a secondary education are employed in the service segment of the private and public sector, which has a higher wage level in this alternative scenario, i.e. 1.6 and 3.2 percent higher respectively. However, since prices on consumer goods also fall somewhat, real wages to those with the lowest education rise somewhat. The increase in real wages to those with the lowest education is minimal despite the fact that unemployment among those with the lowest education shows a marked fall. The reason for this is that when employment shifts in the direction of labour with lower education, average productivity also falls. A relatively centralized wage formation regime distributes wealth creation fairly evenly across the various categories regardless of their individual productivity. Hence in wage terms low-educated labour has shared in the gains produced by technological changes over the past 20 years that have favored those with high education.

In addition to the fact that lower average productivity reduces the wage to the high educated, higher unemployment among the latter means that their wage level is far lower than the actual path. In manufacturing industry the wage reduction for those with a short university education is modest, while those with a long university education earn almost 9 percent less in 2000 than shown by the actual path that year. In other words, the wage to those with long university training weakens by about 8 percentage points even though unemployment rises more for those with a short university training. The reason is that the increase in education-specific unemployment among the well-educated has a stronger wage-moderating effect among those with a long university training than among those with a short university training. Due to the strong link between wage growth in manufacturing industry and in the sector sheltered from international competition, those with long university training in the sheltered sector also experience a corresponding decline in their wages compared with the wages of those with a short university education. In addition, the rise in unemployment among all persons with a high education has a stronger wage-moderating effect in the sheltered sector, entailing a far poorer out-turn here for those with a long university training here. For those with short university training in the sheltered sector, wages are 8-9 percent lower in 2000 than was actually the case that year. In comparison, wages to those with long university training are 15 percent lower. In 2000 both those with a short and a long university training in the sheltered sector earned an almost 15 percent lower wage than their respective colleagues in manufacturing industry. In other words an increase in unemployment of the order indicated in this scenario widens these wage differentials by a further 6 percentage points.

Table 3. Effect on disbursed hourly wage of weaker education-favoring technological change. Deviation from actual wage in percent

Main sector	1985	1990	1995	2000
Industry				
Primary education	-0.2	-0.6	-0.8	-0.2
Secondary education	-0.2	-0.6	-0.8	-0.2
Vocational education	-0.2	-0.6	-0.8	-0.2
Low university education	-0.7	-1	-1.1	-0.8
High university education	-2.9	-6.5	-8.9	-8.7
Private services				
Primary education	-0.3	-1.2	-1.5	-0.3
Secondary education	-0.2	-0.8	-0.9	1.6
Vocational education	-0.5	-1.8	-2.2	-1.5
Low university education	-2.9	-5.8	-7	-7.5
High university education	-5.8	-11.5	-14.1	-15.1
Public services				
Primary education	-0.2	-1.1	-1.3	-0.2
Secondary education	0	-0.3	-0.2	3.2
Vocational education	-0.8	-2.3	-2.6	-2.5
Low university education	-2.8	-6.2	-7.3	-8.1
High university education	-5.5	-12	-14.5	-15.8

The consequences of this scenario for a number of key macroeconomic variables are shown in Table 4. Domestic demand falls. Household consumption is the main factor pushing down overall domestic demand, although housing investments also fall. The reason for this is that lower wages have reduced households' real disposable income. In 2000 private consumption is about 1.2 percent lower than under the actual path. At the same point housing investments are about 1.9 percent lower, after having been more than 6 percent lower at the beginning of the 1990s. Housing capital has thus adjusted to a lower income level. Working in the opposite direction, lower wages help to improve competitiveness and raise employment levels, which takes exports in 2000 0.2 percent higher in the alternative scenario than in the actual path. Lower demand serves to reduce GDP despite the fact that more people are in employment. In 2000 GDP for Mainland (non-oil) Norway is 0.3 percent lower than in the actual development path.

Table 4. Effect of a weaker education-favoring technological change on key macroeconomic variables. Percentage change from actual level unless otherwise specified

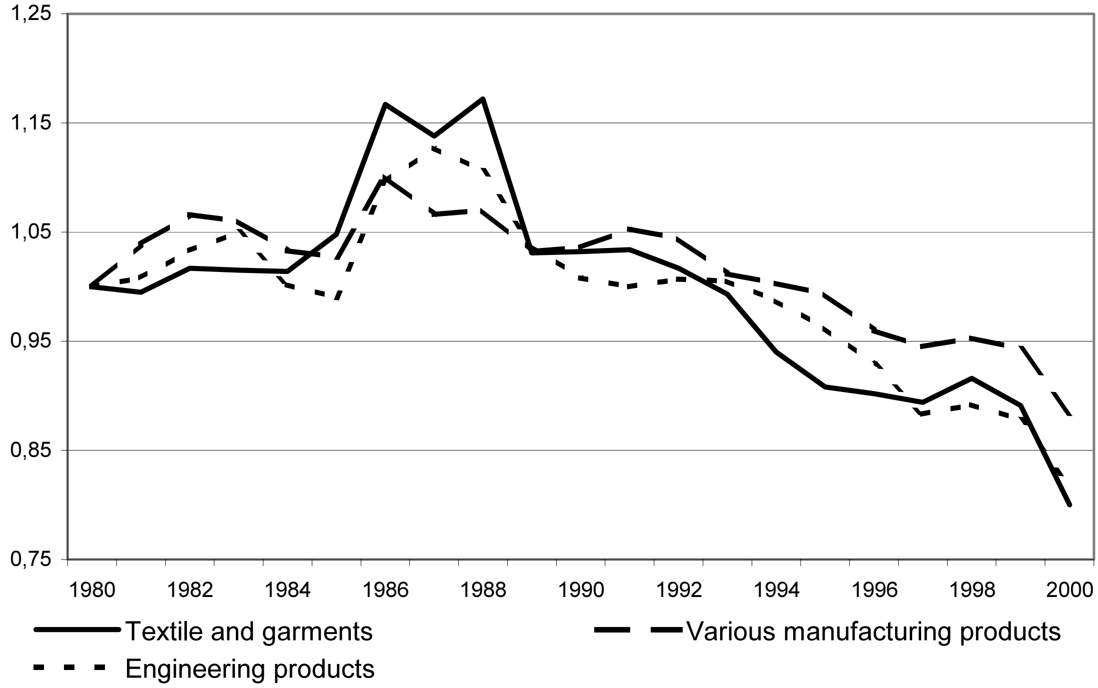
	1985	1990	1995	2000
Private consumption	-0.4	-1.1	-1.3	-1.1
Housing investments	-0.6	-5.4	-4.8	-1.9
Investments in manufacturing	-0.1	-0.1	0.4	0.3
Export, ex. oil and gas	0.2	0.5	0.7	0.3
Import, total	-0.4	-1	-1.1	-1
GDP, ex. oil and gas	-0.2	-0.4	-0.4	-0.3
Gross product, manufacturing	-0.1	-0.1	0.2	0.1
Employment	0.1	0.1	0.3	0.7
Unemployment [a]	0	-0.1	-0.1	-0.2
Supply of labour	0.1	0.1	0.2	0.5
Real disposable income, households	-0.6	-1.4	-1.6	-1.5
Savings rate, households[a]	-0.2	-0.4	-0.3	-0.3

[a]: Absolute deviations in percentage points.

4. Significance of trade with low-cost countries

In the economic literature the point is often made that increased trade with low-cost countries has served to weaken the market for low-educated labour in the wealthy part of the world, cf. for example Wood (1994). An ample supply of cheap labour with low education levels combined with increasingly free world trade has brought increased competition in the markets for products needing little in the way of highly trained labour in the production process. This has created lower prices and profitability problems for such firms in the western world. In contrast to the case of skewed technical progress, which is often assumed to be generalized, trade with low-cost countries will lead to “problems” for low-educated labour in industries exposed to competition. Such changes in industry structure will create lasting unemployment problems for low-educated labour if wages are inelastic, since idle labour is more difficult to employ in other sectors.

Figure 5. Import prices for three product groups relative to other imported goods, 1980=1



In order to calculate the effect of low prices on this type of product for the Norwegian economy and for the Norwegian labour market, we have run a calculation where import prices on three product groups rise in step with prices on other imported goods in the period 1980 to 2000. The three product groups are textiles and garments, various manufacturing products and engineering products[6]. These types of products have increasingly been imported from low-cost countries, and this is reflected in their prices. Figure 5 shows the development in import prices for these three product groups relative to other imports. Where they have a value 1 in the figure, the prices on these goods have shown a development identical to that shown by other groups. Up to the end of 1980s we see that these goods in fact experienced steeper price growth than other imports. Prices on goods in these three groups subsequently fell sharply. It was precisely in this period that trade with the recently industrialized countries of Southeast Asia accelerated. Thus, under this alternative scenario import prices for these three products grow appreciably quicker than they actually did from the end of the 1980s onwards. The direct effect of this is a strengthening of competitiveness of Norwegian import-competing and export-competing manufacturers. Since they employ a good deal of labour with low education levels, they stand to gain from a hypothetical change of this type.

[6] Various manufacturing products includes wood products, graphic products, new ships.

Improved competitiveness along with a switch to greater use of labour at the expense of input factors (which have become more expensive relatively speaking) increases total employment by 10,400 persons in 2000. In isolation, higher import prices reduce households' real disposable income and thereby also consumption, although the expansionary effects of higher import prices dominate overall. Employment of persons with upper-secondary vocational training rises by 5,800 persons, while employment in the two categories with the lowest education levels rises by 5,200 persons all told. The two university-trained categories combined decline by 700 persons. The total unemployment rate falls by 0.2 percentage points. Behind this development lies a fall in unemployment for the three education categories with the lowest education levels, but a rise in unemployment for the two university-trained categories, cf. Table 5. In other words unemployment differentials diminish in step with what might be expected of such a scenario.

Table 5. Effect on unemployment of an increase in some import prices. Deviation from actual unemployment rate in percentage points

Educational group	1985	1990	1995	2000
Total	-0.1	-0.2	-0.1	-0.2
Primary	-0.1	-0.2	-0.1	-0.1
Secondary	-0.1	-0.1	-0.1	-0.2
Vocational	-0.4	-0.3	-0.5	-0.9
Low university	0.1	0	0.2	0.4
High university	0	-0.1	0	0.3

Viewed in isolation, reduced unemployment among those with low education levels and increased unemployment among the well-educated serve to narrow wage differentials. However, higher import prices – and thus higher consumer prices – serve to widen wage differentials in the short run since well-educated persons in manufacturing industry are compensated for higher consumer prices to a greater degree than persons with low education levels. This sets off wage-wage spirals in the sheltered sector of the economy, so that the well-educated experience a relatively sharp increase in wages. To the extent that the growth in consumer prices rises to a higher level on a lasting basis, this effect will also make itself felt in the long term. Wage differentials increase overall as a result of higher import prices on goods that are largely imported from low-cost countries. Moreover, the calculations show that wages rise further in the sector sheltered from international competition than in the competitively exposed sector. This illustrates that higher world market prices not only improve the profitability of firms with a relatively large number of workers with low education levels, but also contribute to further widening the wage differentials between labour with low and high education levels, at the same time as they also bring quicker wage growth in the sheltered sector than in manufacturing industry.

Table 6. Effect on disbursed hourly wage of an increase in import prices. Deviation from actual wage in percent

Main sector	1985	1990	1995	2000
Manufacturing				
Primary education	5.0	3.5	6.6	13.5
Secondary education	5.0	3.5	6.6	13.5
Vocational education	5.0	3.5	6.6	13.5
Low university education	6.0	4.2	7.7	15.9
High university education	4.4	4.5	7.8	13.7
Private services				
Primary education	8.2	5.9	9.8	19.9
Secondary education	8.8	6.4	10.5	21.3
Vocational education	8.3	5.8	9.6	19.7
Low university education	9.9	7.6	12.4	24.5
High university education	8.7	7.9	12.7	23.9
Public services				
Primary education	7	5.6	8.9	18
Secondary education	7.7	6.2	10	19.8
Vocational education	7.7	5.9	9.1	18.5
Low university education	8.1	6.8	11	21.5
High university education	6.9	6.9	11.3	21.2

The effect of this scenario on the development in wages for the various education categories is shown in Table 6. In this scenario the three categories with the lowest education levels in manufacturing industry receive 13.5 percent higher wage income in 2000 than shown by the actual path. This is about the same development as for those with long university training in manufacturing industry. Those with short university training in manufacturing industry receive 15.9 percent higher wage income in 2000 than shown by the actual path that year. In private services the corresponding figures are about 20 percent higher wage for those with low education levels and 24 percent higher wage for those with university training. Wages to the three categories with the lowest education levels in the public sector are 18-20 percent higher in 2000 than the actual path. In the scenario the two categories with university training in the public sector have just over 21 percent higher wage income in 2000 than the actual figure.

Since the consumer prices rises by 16.3 percent in the period to 2000 in this scenario, workers in the three categories with the lowest education levels in private services and in public sectors see a 2-3 percent real wage increase, while all workers in manufacturing industry receive a corresponding reduction in real wages. Workers with university training in manufacturing industry also experience a decline in real wages up to 2000 in this scenario. In comparison, workers with university training in the private services sector and in the public sector receive a real wage increase of 5-8 percent.

Table 7. Effect of an increase in import prices on key macroeconomic variables. Percentage deviation from actual level unless otherwise specified

	1985	1990	1995	2000
Private consumption	0.5	0.1	0.4	1.1
Housing investments	1	0.2	4	6.7
Investments in manufacturing	2.4	2.4	3.3	7.3
Export, ex. oil and gas	0.2	0.4	-0.4	0.4
Import, total	-0.5	-0.5	-0.5	-0.5
GDP, ex. oil and gas	0.6	-0.1	0.5	1.3
Gross product, manufacturing	3.3	3.1	4.4	8.3
Employment	0.3	0	0.3	0.5
Unemployment [a]	-0.1	-0.2	-0.1	-0.2
Supply of labour	0.2	-0.1	0.1	0.3
Real disposable income, households	1.1	0.1	0.4	1.2
Savings rate, households[a]	0.7	0	0.2	0.5

[a]: Absolute deviations in percentage points.

The consequence of higher import prices on some macroeconomic variables is shown in Table 7. This alternative scenario entails higher world market prices on goods also produced in Norway. Hence these segments of manufacturing industry experience greater profitability. Gross product in the engineering industry rises by a large margin, indeed as much as 28.4 percent more than the actual path. However, higher wage costs reduce profitability in the manufacturing sectors, and in metals production the gross product is 21.0 percent lower than in 2000. Even so, total gross product in manufacturing industry rises, and in 2000 gross value in manufacturing in terms of this variable is 8.3 percent higher than the actual figure for that year. No other major effects of this scenario are in evidence. This reflects the negligible change in households' average real disposable income. Compared with the actual path in 2000, the scenario shows households' real disposable income to be 1.2 percent higher. At the same time private consumption is 1.1 percent higher and housing investments as much as 6.7 percent higher.

5. Summary and concluding remarks

Over the past 30 years Norway, like other countries in the western world, has shown a substantial shift in the composition of employment in terms of educational background. This has taken place without appreciable changes in relative wage rates for various education categories. The actual development is related to factors on both the demand and supply side, although institutional conditions have also played a part. Both the demand for and supply of labour have shown a bias towards well-educated labour. However, the development in unemployment for suppliers of labour by education category has been somewhat uneven, although a centralized wage formation regime has largely prevented this from being reflected in major wage differentials.

The focus of this article is on factors on the demand side of the labour market. Skewed technological progress favoring the well-educated along with increased competition facing import-competing industries have been highlighted as two factors explaining the demand bias in favor of high-educated labour. We have quantified the significance of these two factors with the aid of contrafactual calculations run on Statistics Norway's macroeconomic model, MODAG. We have considered two alternative scenarios relative to the actual path for the Norwegian economy. In one we have reduced the education-favoring technological trend, in the other we have increased import prices on three goods where an import-competing manufacturing segment exists.

In both these alternative scenarios for the Norwegian economy we find support for the supposition that such factors have exacerbated the labour market situation for workers with low education levels. Both scenarios show an increase in the number of employed persons with low education levels compared with the observed development. Similarly, employment among the well-educated falls. The relatively stable high rate of unemployment among workers with low education levels compared with well-educated labour falls in both scenarios.

The employment effects are very marked in the scenario where we assume that technological progress favors the well-educated to a somewhat lesser degree than has actually been the case. This is despite the fact that we have reduced the bias by up to 10 percent. In the scenario where import prices on three selected product groups are adjusted up to the development in prices on the other product groups, we have attempted to isolate the bulk of the effect that the trade with low-cost countries has had over the past 20 years. Even so, the consequences of this scenario are modest compared with the technology scenario. Our results are in keeping with the conclusions presented in much of the international literature in the field, i.e. that the observed bias in demand towards more skilled and well-educated labour at the expense of those with lower education levels is largely due to education-favoring technological changes, and not to increased trade with low-cost countries.

Viewed in isolation, lower unemployment among labour with low education levels and higher unemployment among those with higher education points to lower wage differentials. The scenario involving smaller education-favoring technological changes shows precisely this result. In the other scenario, on the other hand, wage differentials are larger. This is due to wage formation factors. Workers with relatively low education levels are well organized and trade unions have historically speaking succeeded in coordinating wage demands such that competitive considerations have weighed heavily in the other wage settlements. However, white-collar workers and workers with higher education are not organized and coordinated to the same extent, and when the factors explaining the wage trend were quantified, it turned out that these workers are more concerned with preserving their purchasing power than with corporate competitiveness. Hence higher import prices – and thus also higher consumer prices – produce quicker wage growth for those with higher education. This effect is stronger than the effect of a modest increase in unemployment for the latter group, such that wage differentials in this calculation widen despite reduced unemployment differentials. Moreover, wage-wage spirals in the sheltered sector result in a larger increase in wages in these sectors than in the competitively exposed sector. Thus the consequence of higher import prices and improved competitiveness for that part of manufacturing industry that employs many workers with low education levels is, somewhat surprisingly, a lower wage to workers with low education levels relative to those with high education levels and a lower wage to workers in the competitively exposed sector relative to those in the sheltered sector.

At the outset the expectation would be that if technological change favored low-educated labour, then this category would experience wage gains. Our calculations do not support this. In the scenario where we quantify the effect of smaller bias towards well educated labour we find that the poorly educated benefit very little in wage terms. We find in other words that technological development, which has resulted in many unskilled and low-educated workers becoming redundant, has also benefited those with low education levels who remain in employment. Here too the reason is to be found in factors related to wage formation. A centralized wage formation regime where equal pay is an important principle has secured a relatively equal distribution of economic wealth creation across occupational groups. Technological development favoring well-educated labour has concurrently raised average productivity, leading to greater wealth creation. This has benefited low-educated workers holding a job despite the fact that each one of the latter has contributed less to building up prosperity.

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The dynamic factor demand system with heterogeneous labour. Detailed results

The demand for variable inputs is based on a two-level production function, with Cobb-Douglas at the upper level and CES at the lower level. The stock of different types of real capital is determined elsewhere in the large scale econometric model, mainly by output, but to some extent also by profitability. At the upper level three inputs are distinguished: materials (M), a CES-aggregate of energy (E) and a CES-aggregate of labour (L). The CES-aggregate of energy is a function of electricity and fuel, whereas the CES-aggregate of labour is a function of manhours worked by skilled (S) and unskilled (U). Below we elaborate more on the latter CES-aggregate. At the upper level we embed the factor demand relations within a dynamic ECM-framework and estimate a set of regression equations. Table A1 gives an overview of the different variables involved in the factor demand system. The industry and time indices, that are i and t, are suppressed.

Table A1. An overview of variables in the dynamic factor demand system with heterogeneous labour

Variable	Interpretation of variable	Unit of measurement
L	CES-aggregate of labour	
X	Real gross output	Million 1997-kroner
K	Capital stock (all categories) at the beginning of the period	Million 1997-kroner
M	Materials input	Million 1997-kroner
E	CES-aggregate of energy	
W_L	Price-index of CES-aggregate of labour	1997=1
P_M	Price-index of materials input	1997=1
P_E	Price-index of CES-aggregate of energy	1997=1
τ	Linear trend	1972=1
K_M	Capital stock of machinery at the beginning of the period	Million 1997-kroner
L_S	Input of skilled labour	1000 man-hours
L_U	Input of unskilled labour	1000 man-hours
W_S	Wage for skilled	Wage per man-hour
W_U	Wage for unskilled	Wage per man-hour

The dynamic factor demand system at the upper level

Separate models are estimated for each industry. The dynamic factor demand system at the upper level consists of the following three econometric equations (lower case letters denote variables after log-transformation):

$$\Delta l_{i,t} = \gamma_{lx,i}\Delta x_{i,t} + \gamma_{lk,i}\Delta k_{i,t} + \gamma_{lm,i}\left(\Delta w_{Li,t} - \Delta p_{Mi,t}\right) + \gamma_{le,i}\left(\Delta w_{Li,t} - \Delta p_{Ei,t}\right) +$$

$$\text{(A1)} \quad \alpha_{l,i}\left[l_{i,t-1} - \rho_{l,i} - \beta_{0,i}x_{t-1} - \beta_{1,i}k_{t-1} - \hat{\beta}_{2,i}\left(w_{Li,t-1} - p_{Mi,t-1}\right) - \hat{\beta}_{3,i}\left(w_{Li,t-1} - p_{Ei,t-1}\right) - \beta_{5,i}\tau_{t-1}\right]$$

$$+ u_{li,t},$$

$$\Delta m_{i,t} = \gamma_{mx,i}\Delta x_{i,t} + \gamma_{mk,i}\Delta k_{i,t} + \gamma_{ml,i}\left(\Delta p_{Mi,t} - \Delta w_{Li,t}\right) + \gamma_{me,i}\left(\Delta p_{Mi,t} - \Delta p_{Ei,t}\right) +$$

$$\text{(A2)} \quad \alpha_{m,i}\left[m_{i,t-1} - \rho_{m,i} - \beta_{0,i}x_{t-1} - \beta_{1,i}k_{t-1} - \hat{\beta}_{4,i}\left(p_{Mi,t-1} - w_{Li,t-1}\right) - \hat{\beta}_{3,i}\left(p_{Mi,t-1} - p_{Ei,t-1}\right) - \beta_{5,i}\tau_{t-1}\right]$$

$$+ u_{mi,t}$$

and

$$\Delta e_{i,t} = \gamma_{ex,i}\Delta x_{i,t} + \gamma_{ek,i}\Delta k_{i,t} + \gamma_{el,i}\left(\Delta p_{Ei,t} - \Delta w_{Li,t}\right) + \gamma_{em,i}\left(\Delta p_{Ei,t} - \Delta p_{Mi,t}\right) +$$

$$\text{(A3)} \quad \alpha_{e,i}\left[e_{i,t-1} - \rho_{e,i} - \beta_{0,i}x_{t-1} - \beta_{1,i}k_{t-1} - \hat{\beta}_{4,i}\left(p_{Ei,t-1} - w_{Li,t-1}\right) - \hat{\beta}_{2,i}\left(p_{Ei,t-1} - p_{Mi,t-1}\right) - \beta_{5,i}\tau_{t-1}\right]$$

$$+ u_{ei,t}.$$

In equations (A1)-(A3) $\hat{\beta}_{2,i}$, $\hat{\beta}_{3,i}$ and $\hat{\beta}_{4,i}$ denotes estimates of the parameters $\beta_{2,i}$, $\beta_{3,i}$ and $\beta_{4,i}$ obtained in an initial estimation sequence. Consistent estimators of these parameters can be obtained by utilising the factor share method. If we let $s_{Li,t}$, $s_{Mi,t}$ and $s_{Ei,t}$ denote the cost shares of labour, materials and energy in industry i in year t, the estimators are

$$\hat{\beta}_{2,i} = -\frac{1}{T}\sum_{t=1}^{T} s_{Mi,t}, \; \hat{\beta}_{3,i} = -\frac{1}{T}\sum_{t=1}^{T} s_{Ei,t} \text{ and } \hat{\beta}_{4,i} = -\frac{1}{T}\sum_{t=1}^{T} s_{L,it},$$

where T denotes the number of observations. The advantage of these estimators is that they impose theory-consistent signs of price effects.

The remaining parameters to be estimated, by maximum likelihood, in (A1)-(A3) are (i) the long-run parameters $\rho_{l,i}, \rho_{m,i}, \rho_{e,i}, \beta_{0,i}, \beta_{1,i}$ and $\beta_{5,i}$, (ii) the adjustment parameters $\alpha_{l,i}, \alpha_{m,i}$ and $\alpha_{e,i}$, (iii) the short-run parameters $\gamma_{lx,i}, \gamma_{mx,i}, \gamma_{ex,i}, \gamma_{lk,i}, \gamma_{mk,i}, \gamma_{ek,i}, \gamma_{lm,i}, \gamma_{le,i}, \gamma_{ml,i}, \gamma_{me,i}, \gamma_{el,i}$ and $\gamma_{em,i}$ and (iv) the second order moments. The vector of errors, $u_{i,t}$=[$u_{li,t}$, $u_{mi,t}$, $u_{ei,t}$]$^{/}$, is assumed to be a white noise vector error process with expectation zero and with an unrestricted contemporaneous covariance matrix denoted by Σ^i. Note that in equations 0-0 there are parameter restrictions across equations.

The CES-aggregate of labour at the lower level

The above discussion implicitly assumes that the parameters in the CES-aggregates of labour and its associated price are known. However these parameters are unknown and must be estimated. We distinguish between two types of labour, which we refer to as skilled (S) and unskilled (U), respectively. The precise definition of these categories varies somewhat between industries. In Table A2 we provide an overview of how skilled and unskilled labour is defined in the different industries which are subject to behavioural modelling of heterogenous labour. Within the groups skilled and unskilled labour we use the historically time varying fixed shares in the counter-factual calculations.

The CES-aggregate of labour in industry i is given by

$$\text{(A4)}\quad L_{i,t} = \left[\delta_{i,t}\left(\frac{L_{Si,t}}{\delta_{i,t}}\right)^{-\varsigma_i} + (1-\delta_{i,t})\left(\frac{L_{Ui,t}}{1-\delta_{i,t}}\right)^{-\varsigma}\right]^{\frac{-1}{\varsigma_i}}$$

and the price of the CES-aggregate is given by

$$\text{(A5)}\quad W_{Li,t} = \left[\delta_{i,t} W_{Si,t}^{\frac{\varsigma_i}{1+\varsigma_i}} + (1-\delta_{i,t}) W_{Ui,t}^{\frac{\varsigma_i}{1+\varsigma_i}}\right]^{\frac{1+\varsigma_i}{\varsigma_i}}.$$

The variable $\delta_{i,t}$ is a time-varying distribution parameter and ς_i is a substitution parameter. These two terms can be derived from the following econometric equation based on minimising the labour cost given a fixed level of the CES-aggregate defined in 0

$$\text{(A6)}\quad l_{si,t} - l_{ui,t} = \lambda_i + \lambda_{km,i} km_{i,t} + \lambda_{x,i} x_{i,t} + \lambda_{\tau,i}\tau_t + \lambda_{w,i}(w_{si,t} - w_{ui,t}) + \varphi_{i,t}.$$

The unknown parameters in 0, $\lambda_i, \lambda_{km,i}, \lambda_{x,i}, \lambda_{\tau,i}$ and $\lambda_{w,i}$ are estimated by OLS. We can now derive estimates of $\delta_{i,t}$ and ς_i by

$$\text{(A7)}\quad \tilde{\delta}_{i,t} = \frac{\exp[\tilde{\lambda}_i + \tilde{\lambda}_{km,i} km_{i,t} + \tilde{\lambda}_{x,i} x_{i,t} + \tilde{\lambda}_{\tau,i}\tau_t]}{1 + \exp[\tilde{\lambda}_i + \tilde{\lambda}_{km,i} km_{i,t} + \tilde{\lambda}_{x,i} x_{i,t} + \tilde{\lambda}_{i\tau}\tau_t]}$$

and

(A8) $\tilde{\varsigma}_i = -1 - \frac{1}{\tilde{\lambda}_{w,i}}.$

In Table A3 we provide the deduced Cobb-Douglas (production function) parameters, whereas in Table A4 we report on the parameters in the CES-aggregate of labour.

Table A2. The production sectors in MODAG and definition of skilled/unskilled in industries in which demand of heterogenous labour is modelled econometrically

MODAG code	Full name	Def. of skilled/unskilled[a]
11	Agriculture	Definition I
12	Forestry	
13	Fishing etc.	
14	Fish Farming	
15	Manufacture of Consumption Goods	Definition I
25	Manufacture of Materials and Investment Goods	Definition I
34	Manufacture of Pulp and Paper	Definition I
37	Manufacture of Industrial Chemicals	Definition I
40	Petroleum Refining	
43	Manufacture of Metals	Definition II
45	Manufacture of Machinery etc.	Definition II
50	Manufacture of Ships and Transport equipment	Definition I
55	Construction	
63	Finance and Insurance	Definition I
64	Production and Pipeline Transport of Oil and Gas etc.	
65	Ocean Transport	
71	Production of Electricity	
74	Domestic Transport	
81	Wholesale and Retail Trade	Definition II
83	Housing Services	
85	Other Private Services	Definition II
92S	Defence	
93S	Education: Central Government	
94S	Health-Care: Central Government	
95S	Other Services: Central Government	
93K	Education: Local Government	
94K	Health-Care: Local Government	
95K	Other Services: Local Government	

[a] Altogether there are 5 educational group: i) GRK: Employees with primary education (including employees with unknown education); ii) VA: Employees with secondary education; iii) VF: Employees with vocational education; iv) HO: Employees with low university education; v) UN: Employees with high university education. Using Definition I we have Unskilled=GRK+VA+VF, Skilled=HO+UN. Using Definition II we have Unskilled=GRK+VA, Skilled=VF+HO+UN.

Table A3: Deduced Cobb-Douglas (production function) parameters

		Marginal elasticity of output with respect to				Neutral technical progress
Industry	Scale elasticity	CES-aggregate of labour	Materials	CES-aggregate of energy	Real capital	
11	1.30	0.16	0.78	0.06	0.30	0.000
15	1.41	0.12	0.59	0.01	0.39	0.000
25	1.28	0.31	0.67	0.02	0.28	0.000
34	1.30	0.19	0.75	0.06	0.30	0.000
37	1.30	0.19	0.74	0.07	0.30	0.025
43	1.27	0.19	0.72	0.09	0.27	0.016
45	1.30	0.35	0.63	0.01	0.30	0.008
50	1.51	0.24	0.56	0.01	0.70	0.002
63	1.00	0.53	0.46	0.01	0.00	0.000
81	1.27	0.50	0.48	0.02	0.27	0.013
85	1.00	0.49	0.50	0.01	0.00	0.000

[a] Since the estimates are based on estimating a static relation no standard errors are reported.

[b] Fixed value.

Table A4. Parameters in the CES-aggregate of labour [a]

Industry	λ_i	$\lambda_{km,i}$	$\lambda_{x,i}$	$\lambda_{\tau,i}$	$\lambda_{w,i}$
11	0[b]	-0.364	0[b]	0.048	-0.454
15	-13.857	0.703	0.371	0.029	-0.695
25	0[b]	0[b]	-0.232	0.045	-0.859
34	-7.221	0.289	0.206	0.030	-0.718
37	-4.626	0[b]	0.343	0.011	-0.5[c]
43	5.374	-0.329	-0.451	0.105	-0.75[c]
45	-7.117	0.618	0[b]	0.063	-0.75[c]
50	0[b]	0[b]	-0.264	0.037	-0.5[c]
63	5.278	0[b]	-0.649	0.049	-0.5[c]
81	-2.978	0.116	0[b]	0.047	-0.961
85	5.151	-0.686	0[b]	0.087	-0.709

[a] Since the estimates are based on estimating a static relation no standard errors are reported.

[b] Fixed value.

[c] Assumed value.

The estimated wage equations

Maintenance of international competitiveness is recognized as important in small open economies since the economic well being of the whole nation depends on fluctuating foreign product markets. The *main-course theory*, also called the *Scandinavian model of inflation*, Aukrust (1977) and Lindbeck (1979), provided early attempts to formalize these mechanisms. Aukrust's main-course theory says that long-run wages in a small open economy are determined by world market prices and productivity. In the more recent bargaining models wages are set in bargaining between unions and firms[7]. Thus, wages depend on both insider factors, such as prices and productivity, and outsider factors, such as outside wage and unemployment. The bargaining models, when unions are coordinated and wage setting is centralized, give a theoretical understanding to the main-course theory, i.e. in the central wage bargaining in small open economies terms-of-trade variables, such as world market prices and productivity, and unemployment are all insider factors.

We use observations on wages and unemployment rates for the five educational groups over the time period 1972-97 to estimate education specific wage equations in manufacturing, public sectors and private services in Norway[8]. The reference point is the stylized aggregated wage-equation in equilibrium correction form introduced by Sargan (1964). Because of its special feature to encompass both the outcome of the wage bargaining model and the main-course theory, it has become especially popular as a description of wage setting in small open economies. Its popularity has resulted in numerous modifications. For application to Norwegian manufacturing wages see Nymoen (1989), Johansen (1995) and Bjørnstad and Nymoen (1999). These studies estimate the aggregated wage-equation for Norwegian manufacturing. Skill heterogeneity opens for more decentralized wage setting where also the education-specific unemployment rates affect wages. A disaggregation of the aggregated wage-equation suggests the following specification of the education specific wage equations:

(B1)
$$\begin{aligned}\Delta wc_{m,i} &= \gamma_{0i} - \gamma_{1i} \cdot \left(wc_{m,i} - \gamma_{qi}\, q - \gamma_{zi} z\right)_{-1} - \gamma_{2i} \cdot u_{-1} - \gamma_{3i} \cdot u_{i,-1} + \gamma_{4i} \cdot \Delta wc_{m,i,-1} \\ &\quad - \gamma_{5i} \cdot \Delta u - \gamma_{6i} \cdot \Delta u_i + \gamma_{7i} \cdot \Delta q + \gamma_{8i} \cdot \Delta z + \gamma_{9i} \cdot \Delta p_{-1} + \gamma_{10i} \cdot \Delta X,\end{aligned}$$

[7] See Nickell and Andrews (1983), Nickell (1984), Hoel og Nymoen (1988), and Nickell and Wadhwani (1990).

[8] In addition, we use relevant aggregated variables and policy dummies.

where $wc = w + tf$ is log of hourly wage cost, w is log of paid wage and $tf = log(1 + pay\ roll\ tax\ rate)$. q is the producer price index in manufacturing, z is labour productivity in manufacturing, the u's are unemployment rates and pc is the consumer price index. These variables are also measured in logarithmic scale. Finally, X is a vector of other explanatory variables, e.g. dummies for incomes policies, ε is an error term, and the γ's are parameters expected to be non-negative, and Δ indicates that the variable is measured in first differences. The subscript i indexes educational group. So, while u is the average rate of unemployment, the u_i's are education specific unemployment rates. A subscript equal to -1 indicates that the variable enters with a time lag, and m is for the manufacturing sector.

The equilibrium correction form enables us to determine the long run and short-run determinants of wages jointly. In the long run the main-course variables, z and q, and the unemployment rates are the explanatory variables, while cost of living, pc, in addition to the dynamic effects of the long-run variables make up the short-run part of the model.

Steady state is defined as growth rates in producer and consumer prices in accordance with the international rate of inflation, ρ, constant productivity growth rate, τ, and constant unemployment rates, wage growth and other factors that may enter the wage equations. Formally:

(B2)
$$\begin{aligned} &\Delta q = \Delta p = \rho, \\ &\Delta z = \tau, \\ &\Delta u = \Delta u_i = \Delta^2 wc_{m,i} = \Delta X = 0. \end{aligned}$$

The zero restrictions $\gamma_{1i} = 0$ imply that (B1) reduces to skill-specific Phillips-curves. If on the other hand, $\gamma_{1i} > 0$, steady state equations for the product shares are:

(B3)
$$wc_{m,i} - \gamma_{qi}\, q - \gamma_{zi} z = \mu_i - \gamma_i \cdot u - \gamma_{ui} \cdot u_i ,$$

where

(B4)
$$\begin{aligned} &\mu_i = \frac{\alpha_i}{\gamma_{1i}}, \\ &\alpha_i = \gamma_{0i} + (\gamma_{4i} + \gamma_{7i} + \gamma_{9i} - 1) \cdot \rho + (\gamma_{4i} + \gamma_{8i} - 1) \cdot \tau, \\ &\gamma_i = \frac{\gamma_{2i}}{\gamma_{1i}} \\ &\gamma_{ui} = \frac{\gamma_{3i}}{\gamma_{1i}}. \end{aligned}$$

We use average productivity as an explanatory variable for education-specific wages. In a centralized wage-setting regime this seems plausible, but ideally we should have tried out education-specific productivity as well. However, we have not found any macro-variables that capture this heterogeneity. It is extremely hard to observe individual productivity in a production process that requires contribution from all input factors. In order to test the model specification, education-specific trend-effects were included in the general specification of the econometric model. The existence of heterogenous trend-effects could mean that demand shifts, such as skill-biased technological changes, affect wage inequality in the long run. However, in the general-to-specific modeling approach these effects were found excludable. So demand shifts affect wage inequality only through skill mismatch in the long run. Layard et al. (1991) show that only supply-side factors, such as costs of attaining education, affect relative wages and unemployment in the long run, demand conditions do not. In steady state, the skill premium is equal to the cost of attaining that particular skill.

Wages in public sector and in private services are also modeled in equilibrium correction form. Since the main-course theory stands as a basis for our modeling strategy, wages to workers in the public sector and in the private services sector follow the profitability in the wage-leading manufacturing sector. This is modeled by including an alternative wage, *wa*, into the wage-equations in the public sector and in the private services sector. The alternative wage is calculated as the wage level in the other sectors weighed by their representative employment shares. We have imposed long run homogeneity between wages and alternative wages in these two sectors. In addition we open for that both average and education specific unemployment rates may have an effect on wages in the sheltered sectors as well. The long-run part of these wage-equations are given by

(B5) $$w_{p,i} = \beta_i + wa_{p,i} + \beta_{ui}u_i + \beta_i u,$$

and

(B6) $$w_{s,i} = \lambda_i + wa_{s,i} + \lambda_{ui}u_i + \lambda_i u,$$

respectively, where w is the nominal wage level. The subscripts p denotes public sector and s is private services. As in manufacturing short run wage growth is affected by changes in the variables that enter in the long run and by changes in consumer price growth and other non-systematic changes in legislation etc.

Before we estimate the wage equations, we need to establish the cointegrating properties of the variables that enter the long run part of the model.

Cointegration

Variables in the long-run part of an error-correction model must either be stationary (*I(0)*) or cointegrate. The variables cointegrate if the residuals in a static regression model between the variables are *I(0)*, for example in manufacturing:

(B7) $$wc_{m,i} - \gamma_{qi}\, q - \gamma_{zi}\, z - \mu_i + \gamma_i \cdot u + \gamma_{ui} \cdot u_i \sim I(0).$$

Table B1 reports the results of the cointegration and stationarity tests. The stationarity tests are augmented Dickey-Fuller tests (ADF-tests), i.e. tests for unit roots in the variables entering the long run part of the model[9]. While the null of non-stationarity (*I(1)*) is not rejected for any of the unemployment rates, The tests show that education specific wage-costs in manufacturing cointegrate with prices and average productivity over the data period[10]. If we include both the average and the education specific unemployment rates in the cointegrating vector, the null of non-stationarity are still rejected. In public sector and in private services the long run part of the model also seems to be stationary, but this conclusion is more uncertain.

If there is a structural shift in a stationary variable, the ADF-test could fail to reject the null of *I(1)*, and may explain why the nulls of non-stationary unemployment rates are not rejected. After a period with stable unemployment at a low level in the 1970's and 1980's, unemployment rose rapidly after 1987. On average unemployment has been much higher after 1987 as compared to previous periods. In the general-to-specific estimation procedure the long-run effects of changes in unemployment are estimated freely. Hence, the unemployment rates can either be considered as stationary variables or as non-stationary variables included in the cointegrating vector.

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[9] A trend is included in the ADF-test to control for potential serial correlation, see Dickey and Fuller (1979).

[10] We have data on first differences for the period 1973-1997. However, the starting point depends on how many lags of the endogenous variable that are included on the right hand side.

Table B1. **Tests for stationarity (Augumented Dickey-Fuller, ADF) and cointegration, 1973-1997**

$$\Delta X_t = a + (b-1)X_{t-1} + \sum_{j=1}^{J} c_j \, \Delta X_{t-j} + d\,t + v_t$$

$$H_0 : X_t \sim I(1) \text{ or } b = 1$$

X_t =	*t-ADF*[1)]				
u_t	-2,57				
i =	*Primary*	*Vocational*	*Secondary*	*Low univ.*	*High univ.*
u_{it}	-2.57	-2.67	-1.55	-2.52	-2.46
$\left(wc_{m,i} - \hat{\gamma}_{qi}\, q - \hat{\gamma}_{zi}\, z\right)_t$ [2)]	-4.70**	-4.28**	-3.30*	-4.83**	-3.59*
$\left(wc_{m,i} - \hat{\gamma}_{qi}\, q - \hat{\gamma}_{zi}\, z\right)_t + \hat{\gamma}_i\, u_t + \hat{\gamma}_{ui}\, u_{it}$ [2)]	-4.85**	-4.09**	-3.07*	-4.28**	-5.38**
$\left(w_{p,i} - wa_{p,i}\right)_t$	-2.17	-3.30*	-3.67*	-3.22*	-2.99
$\left(w_{p,i} - wa_{p,i}\right) + \hat{\beta}_i\, u_t + \hat{\beta}_{ui}\, u_{it}$ [2)]	-3.51*	-3.83**	-3.04*	-3.10*	-3.23*
$\left(w_{s,i} - wa_{s,i}\right)_t$	-2.64	-2.58	-2.28	-2.80	-2.48
$\left(w_{s,i} - wa_{s,i}\right)_t + \hat{\lambda}_i u_t + \hat{\lambda}_{ui} u_{it}$ [2)]	-3.15*	-2.74	-2.72	-3.32*	-3.17*

1) T-value on lagged level variable, * indicates that the null is rejected at a 5 percent level, and ** that it is rejected at a 1 percent level. Critical t-values are -3.0 and -3.8 respectively.

2) The parameters are estimated in static regression models.

About 55 percent of the employed workers with high university education work in public sectors with limited individual wage differences. One could argue that, for this group, workers in public sectors are wage leaders. At least this is a hypothesis that we want to test statistically in the econometric analysis. Therefore wages to workers with high university education in public sector are included in the long-run part of the general specification of the wage equation for this group in manufacturing. Furthermore, when looking at Figure 3 workers with high university education in manufacturing seem to have experienced a substantial fall in wages relative to all other groups after 1988. Actually their relative wage level fell already in 1987, but in 1987 blue-collar workers in manufacturing received an income compensation for a reduction in their normal working hours. The white-collar workers did not have a reduction in their normal working hours. 1988 may therefore have marked a *regime switch* with a fall in wages to high university educated workers in manufacturing as compared to the other workers in the sector.

The explanation of the apparent *regime switch* after 1988 may be the renewed focus on centralized wage settlements during and after the wage-laws in 1988 and 1989. The means taken at the end of the

1980's cumulated into a formalized agreement signed by the national labour union, LO, the national employers' organization, NHO, and the government, called the *Solidarity alternative*. Kahn (1998) refers to this period as a case of *recentralization* during a period where other countries underwent decentralization. If centralized wage-setting regimes depress wages especially at the top of the wage distribution, one might expect that wages to workers with university education would fall relatively to all other groups during this period of recentralisation. It is nevertheless a hypothesis that we do not want to rule out; therefore ADF-tests for two different cointegrating vectors were conducted for the high university educated workers in manufacturing; the first one is reported in Table B1. In the second also public wages and a regime-switching dummy that is equal to 0 before 1988 and 1 otherwise are included in the cointegration vector. Neither of the vectors is found to be non-stationary. Being careful not to erroneously exclude any explanatory variables, both variables are included in the general econometric specification. For the same reason the 1988-step-dummy was included in the general specification of the wage equation for high university educated workers in public sector as well.

Heteroskedasticity and poolability

Single equation estimation gives consistent estimates if the slope coefficients are heterogeneous, cf. Peseran and Smith (1995), but as suggested by Baltagi (1995), the pooled model can yield more efficient estimates at the expense of bias. The hypothesis of homogeneous coefficients has to be tested. Roy (1957), Zellner (1962) and Baltagi (1995) suggested a Chow-test that requires estimation of the model under the restriction of both common and heterogeneous slope coefficients across educational groups. However, the implied fixed effects specification assumes homoscedasticity. The log-likelihood value to the model with fixed effects, where residuals are restricted to have equal variances, are compared to the sum of the log-likelihood values to the five separate education-specific wage-equations, where the variances are unrestricted. The test observator in manufacturing is

$$-2\left(l_{med\ restriksjoner}-\sum_{i} l_{i,\ uten\ restriksjoner}\right)=26.8$$

which is kji-squared distributed with four degrees of freedom. The *l*'s are the log-likelihood values. The test suggests a clear rejection of the null of homoscedasticity. Heterescedasticity implies that the fixed effects estimator will be inefficient and suggests the adoption of a feasible fixed effects GLS estimator with a variance matrix that incorporates heteroskedasticity across educational groups. The variance matrix is estimated without any restrictions across educational groups. A feasible fixed effects GLS estimator allows for poolability tests conducted in a general to specific manner.

The poolability tests are F-tests on the restrictions of common slope coefficients across educational groups. We have tested for two different levels of pooling for each variable. First, we tested for a common slope coefficient across all educational groups. If this failed we looked for skill-specific coefficients. In manufacturing, the tests support that all coefficients in the equations for primary, vocational and secondary educated workers are pooled together. Many of the slope coefficients in the equations for university-educated workers were pooled together as well. The two groups are classified as unskilled and skilled respectively. In this general-to-specific procedure, estimators that are statistically insignificant or that have theory-contradicting signs are restricted to zero. Pooling is accepted if the null of common slope coefficients are not rejected for any of the variables neither when the restrictions are imposed separately on the model with full heteregoneity nor when the restrictions are imposed recursively. The small sample approximation of the Roy-Zellner-Baltagi test for all pooling restrictions showed $F(59,27)=0.73$ in manufacturing, which gave a p-value of *0.84*. Hence, the null of the common slope coefficients was clearly not rejected. The wage-equations in the sheltered sectors turned out to be even more homogenous across the educational groups. The results are reported in Table B2 below.

Dynamic fixed effect models

As showed by Nickell (1981), the bias of a dynamic fixed effect model when there are no exogenous variables included in the model is $O(T^{-1})$ if $N \to \infty$. The bias is negative if the coefficient is positive. Furthermore, Nickell showed that this bias would increase (in absolute value) if exogenous variables were included. In the case with exogenous regressors Kiviet (1995) showed that the bias in the complete coefficient vector in small samples has a $O(N^{-1} T^{-3/2})$ approximation error. Hence, the bias becomes less important as T and N grow and does not depend on the actual number of exogenous variables.

Various implementations of instrumental variable estimators (IV) have been suggested in order to get unbiased estimators that are consistent for either $N \to \infty$ or $T \to \infty$. Anderson and Hsiao (1981) suggested two different instrument sets. The first one uses twice lagged levels of the endogenous variable in a regression model on first differences. The second uses twice lagged differences. However, Arellano (1989) showed that the latter produces inefficient estimates. Arellano and Bond (1991) proposed to use more (or even all) orthogonality conditions as instruments. They used Monte Carlo simulations to show that this GMM[11]-type estimator is more efficient than the Anderson-Hsiao estimator. Furthermore, Kiviet (1995) showed that in typical macro-panels, i.e. with small N and T, a

[11] Generalized Method of Moments

small sample correction of the fixed effects[12]-estimator in many cases proves to be (much) more efficient than the various IV type estimators. The reason for this is that the fixed effects estimator produces more accurate estimates than IV estimators and that a correction of the bias hardly enhances its variance at all. Unfortunately, we found that the bias-corrected fixed effects estimator was not possible to implement. This has shown to be a common problem with this method.

Judson and Owen (1999) test the performance of the various estimators using Monte Carlo simulations in panels with small N and T. They conclude that when bias-correction is not possible and when $T = 30$ the fixed effects estimator performs just as well or better than the viable alternatives. When $T = 20$ both the GMM or the Anderson-Hsiao estimator may be chosen, but a closer look at the results reveals that the fixed effects estimator is almost just as good. In the present data set $N = 5$ and $T = 24$, and the model includes many exogenous variables. The above-mentioned literature is therefore inconclusive as to which of the procedures that produces the appropriate estimators, but it suggests that the bias of the fixed effects estimators probably is small.

[12] Least Squares Dummy Variables

Table B2. Wage-equations by educational groups. Endogenous variables are $\Delta wc_{m,i}$, $\Delta w_{p,i}$ and $\Delta w_{s,i}$ respectively. GLS-estimation with fixed education-specific effects, 1974-1997. Standard deviations in parenthesis except when homogeneity restrictions are imposed.

	Primary	Secondary	Vocational	Low univ.	High univ.
Manufacturing					
$(wc_{m,i}-q-z)_{-1}$	-0.160 (0.009)	-0.160 (-)	-0.160 (-)	-0.160 (-)	-0.160 (-)
u_{-1}	-0.023 (0.005)	-0.023 (-)	-0.023 (-)		
$u_{i,-1}$					-0.009 (0.001)
$(wc_{m,i,-1}-wc_{p,i,-2})$					-0.091 (0.005)
$D_{1988-1997}$					-0.022 (0.002)
$\Delta wc_{m,i,-1}$	0.324 (0.010)	0.324 (-)	0.324 (-)	0.324 (-)	0.324 (-)
Δz	0.116 (0.017)	0.116 (-)	0.116 (-)	0.116 (-)	0.116 (-)
Δh	-0.691 (0.040)	-0.691 (-)	-0.691 (-)	-0.691 (-)	-0.691 (-)
Δp	0.470 (0.103)	0.470 (-)	0.470 (-)	0.813 (0.010)	0.564 (0.017)
$D_{Wage\ freeze}$	-0.024 (0.004)	-0.024 (-)	-0.024 (-)	-0.024 (-)	-0.024 (-)
D_{1993}	-0.012 (0.001)	-0.012 (-)	-0.012 (-)	-0.012 (-)	-0.012 (-)
Δu	-0.011 (0.004)	-0.011 (-)	-0.011 (-)	-0.022 (0.002)	-0.022 (-)
Δu_i				-0.010 (0.0002)	-0.010 (-)
Public					
$(w_{p,i}-wa_{p,i})_{-1}$	-0.185 (0.024)	-0.185 (-)	-0.185 (-)	-0.185 (-)	-0.185 (-)
$u_{i,-1}$	-0.016 (0.003)	-0.009 (0.002)	-0.009 (-)	-0.009 (-)	-0.009 (-)
$D_{1988-1997}$					-0.015 (0.003)
$\Delta w_{p,i,-1}$	-0.035 (0.032)	-0.035 (-)	-0.035 (-)	-0.035 (-)	-0.035 (-)
$\Delta wa_{p,i}$	0.572 (0.038)	0.572 (-)	0.572 (-)	0.572 (-)	0.572 (-)
Δp	0.496 (0.055)	0.496 (-)	0.496 (-)	0.496 (-)	0.496 (-)
Δu_i	-0.018 (0.007)				
Private services					
$(w_{s,i}-wa_{s,i})_{-1}$	-0.057 (0.026)	-0.057 (-)	-0.057 (-)	-0.057 (-)	-0.057 (-)
$\Delta w_{s,i,-1}$	0.241 (0.054)	0.241 (-)	0.241 (-)	0.241 (-)	0.241 (-)
$\Delta wa_{s,i}$	0.720 (0.055)	0.720 (-)	0.720 (-)	0.720 (-)	0.720 (-)
$\Delta^2 p$	0.201 (0.086)	0.201 (-)	0.201 (-)	0.201 (-)	0.201 (-)
Δu	-0.014 (0.006)	-0.014 (-)	-0.014 (-)	-0.014 (-)	-0.014 (-)
Δu_i				-0.012 (0.004)	-0.012 (-)

Panel data estimation results

Table B2 shows the education-specific wage-equations after a general-to-specific pooling and exclusion procedure. The long run solutions are reported in Table B3. Also two different GMM-type of estimators were calculated. In the first all possible lags of the endogenous variable were used as instruments in the baseline model on differences, while in the second three different lags of five exogenous variables were used. The GMM-estimators very closely resembled the fixed effects estimators, and were also fairly similar to the the single-equation estimators. Hence, as suspected, the bias of the fixed effects estimator seems negligible.

In addition to Δh, which is changes in normal working hours, there are three dummy-variables in manufacturing; $D_{1988\text{-}1997}$ which is *1* in the period 1988-1997 and *0* otherwise, D_{1993} which is *1* in 1993 and *0* otherwise (for changes in pay-roll taxes in 1993) and $D_{Wage\ freeze}$ which is *1* in 1979, 1988 and 1989 and *0* otherwise (for the wage laws in these years).

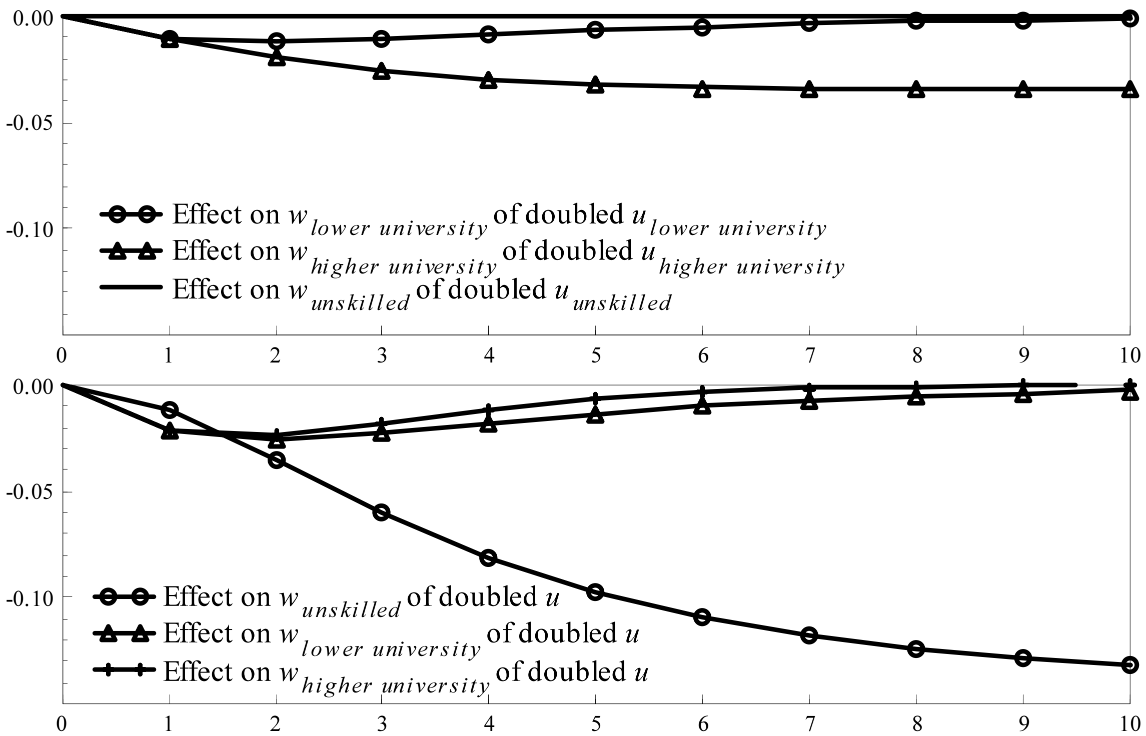
Table B3. Long run solution to the model in Table B2. Endogenous variables are $wc_{m,i}$, $w_{p,i}$ and $w_{s,i}$ respectively. GLS-estimation with fixed education-specific effects, 1974-1997. Standard deviations in parenthesis except when homogeneity restrictions are imposed.

	Exogenous variables				
Manufacturing	$q+z$	u	u_i	$wc_{p,i}$	$D_{1988\text{-}1997}$
i = Unskilled	1 (–)	– 0.140 (0.038)			
Low univ.	1 (–)				
High univ.	0.64 (–)		– 0.034 (0.009)	+ 0.36 (–)	– 0.089 (0.016)
Public	$wa_{p,i}$		u_i		$D_{1988\text{-}1997}$
i = Primary	1 (–)		– 0.093 (0.022)		
High univ.	1 (–)		– 0.051 (0.013)		
Other	1 (–)		– 0.051 (–)		0.084 (0.022)
Private services	$wa_{s,i}$				
i = All	1 ,*i* (–)				

In manufacturing we find support of long run homogeneity between hourly wage costs and the production value per working hour for all groups except for workers with high university education. In the equation for workers with high university education there is a long-run homogeneity between wage costs in manufacturing, production value per man-hour in the same sector and wage costs for workers with the same length of education in public sectors, with a corresponding coefficient vector equal to *(-1, 0.64, 0.36).*

In manufacturing, as can be seen from the top diagram in Figure B1, only wages to skilled workers is affected by education-specific unemployment rates, however both the short-run and the long-run effects are numerically small. In the long run only workers with high university education will experience a fall in their remuneration if own-group unemployment increases. The education-specific unemployment elasticity of pay to workers with high university education in manufacturing is *-0.034*. This means that a hypothetical doubling of the unemployment rate among these workers would be associated with a fall in their relative remuneration of approximately *3.4* percent. However, we have identified a clear long-run effect of own-group unemployment in all the wage-equations in the public sector. The long-run coefficients are estimated to *-0.093* for the primary educated workers and *-0.051* for the other workers in the sector. And there are also some short-run effects both in the public sector and in the private services sector.

Figure B1. Top: Relative changes in wages after a hypothetical doubling of education-specific unemployment rates in year 1. Bottom: Relative changes in wages after a hypothetical doubling of the average unemployment rate in year 1.



The estimated long-run elasticity of pay with respect to average unemployment is equal to *-0.14* for unskilled workers in the manufacturing sector. We have not found any long-run effect of average unemployment in the wage equations for the university-educated workers and there is no long-run effect of average unemployment in any of the wage-equations in the other sectors, other than through the effect of the alternative wage. This means that a hypothetical doubling of average unemployment is expected to decrease wages to all unskilled workers with *14* percent and to leave wages to all university educated workers unchanged in the long run. In the short run, all wages are moderately affected by changes in average unemployment. Bottom diagram in Figure B1 shows the effect on education-specific wages in manufacturing of a permanent doubling of average unemployment over time as predicted by the model. After 1.5 years all wages have dropped approximately 2.5 percent. While wages to skilled workers then return to their original levels, wages to unskilled workers continue to fall until they eventually stabilize 14 percent below the original level.

There are some other distinct differences between the skill groups. While unskilled workers in manufacturing receive 47 percent of the last year's inflation in compensation, workers with low university education get 81 percent. It also seems that the skilled workers in Norwegian manufacturing in fact were very little affected by the wage-laws in 1979, 1988 and 1989. These laws, which aimed at restricting wage growth, had only a small, but still significant effect on wage growth to skilled workers. While wage growth among unskilled workers declined 2.4 percentage points as a consequence of the wage laws, wage growth among skilled workers fell only 0.4 percentage points. However, 1988 represented a new regime for workers with high university education in Norwegian manufacturing as their equilibrium wage level dropped almost 9 percent that year. This is nevertheless consistent with the hypothesis that workers with the highest wages receive less attention in centralized wage settlements. 1988 represented a new era for incomes policies in Norway with the wage laws in 1988 and 1989. Later, in 1992, a government appointed commission introduced the Solidarity alternative, a formalization of the income policies in Norway.

To sum up, profitability in the manufacturing sector is the major factor explaining wages in the long run for all skill-groups in all sectors of the Norwegian economy. Inflation is only moderately compensated in the short run. In the long run inflation has no effect on wage-growth. Furthermore, there is no heterogeneity in the wage curves between unskilled labour in manufacturing. Since the manufacturing sector is wage-leader, this implies that average unemployment has a large and lasting effect on wages to all unskilled workers. Education-specific unemployment rates have a more moderate effect on wages, but the effect is still clear. Finally, the means in the incomes policy seem to have a temporary effect on wage growth. The wage laws had a considerable impact on wage growth to unskilled workers and a moderate impact for workers with low university education. For the workers with high university education, the wage laws in conjecture with the following Solidarity alternative reduced the equilibrium wage level by almost 9 percent. As a further example of a successful incomes policy, the 1.8 percentage point's reduction in payroll taxes in 1993 reduced wage growth by 1.2 percent for all groups the same year. It seems then that the centralized wage-setting regime over time is able to correct for macroeconomic shocks that causes average unemployment to rise through its dampening effect on wages to unskilled workers and through the means in the incomes policy.

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