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Deunionization and job polarization – a macroeconomic model analysis for a small open economy *

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Abstract

Declining unionization rates and job polarization are two important labor market developments of recent decades. A large body of literature has analysed these phenomena separately, but little has been done to see whether there is a link between them. We employ a macroeconomic model for a small open economy with a large input-output core to analyse how deunionization may cause job polarization. Our analysis shows that medium-skilled workers are negatively affected by deunionization, mainly as a result of the heterogeneity of the elasticities of substitution between different types of labor. While the elasticities of substitution between high- and medium-skilled labor are relatively low, the elasticities of substitution between medium- and low-skilled are relatively high. As a result, when deunionization leads to increased wage dispersion, we find that demand for low-skilled increases at the expense of medium-skilled labor, thus yielding a more polarised labor market.

Keywords: Inequality, Wage differentials, Trade unions and Technological change

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1 Introduction

Many OECD countries have experienced higher income inequality, less strict labor markets and declining unionization rates in the last four decades. A vast literature has established a link between these phenomena. The underlying hypothesis is that labor unions work to increase the wages of low-skilled relative to high-skilled workers, and thus that lower unionization rates lead to higher income inequality; see e.g. Freeman (1978), Card (2001), Card et al. (2004), Koeniger et al. (2007), Fichtenbaum (2011). Recently, Töngür and Elveren (2014), using a panel Granger causality approach across 24 OECD countries, also found support for deunionization causing increased wage dispersion.

Another important development in the labor market in recent decades is that of job polarization. Both in the US, and in other OECD countries such as Denmark, France, Germany and the UK, there have been expanding job opportunities in both high- and low-skilled occupations, but contracting opportunities in medium-skilled jobs. The main hypothesis explaining this development is that of "routinization", i.e. routine tasks can be automated by computers, and since routine tasks are characteristic of many medium-skilled jobs, such as bookkeeping and clerical work, technical change has negatively affected medium-skilled workers most; see Acemoglu and Autor (2011). Job polarization can, however, also be driven by other factors, such as deunionization. For example, lower union density may increase the demand for low-skilled occupations at the expense of medium-skilled jobs. Although the literature on deunionization has established a link to increased wage inequality, little, to our knowledge, has been contributed to an understanding of job polarization.

In this paper, we employ a disaggregated macroeconomic model for Norway, a small open economy, to analyse deunionization and job polarization. The model is based on an extensive block of input-output equations covering 18 industries and 38 products; see Cappelen (1992) and Welfe (2013). In the short run, the production level is determined by aggregate demand within a Keynesian framework for an open economy with inflation targeting. In the long run, the level of production is also impacted by the supply side. All structural equations in the model have theoretical underpinnings and are estimated in blocks using a co-integrated VAR framework. Recent documentation of some of the main blocks, such as price setting, factor demand, the consumption function and the distribution sector can be found in Boug et al. (2016), Hungnes (2011), Jansen (2013) and Boug et al. (2013a), respectively.

In the model, the labor market is based on the theoretical framework of a price and wage curve; see Layard et al. (2005). We apply the flexible translog functional form to model the price curve across several educational groups (Gjelsvik 2013a). The model is thus particularly suitable for analysing whether lower union density may generate job polarization, as the translog functional form allows for both skill-biased technical change and (also) identification of skill-specific elasticities of substitution. The wage curve is modelled according to the institutional settings of high union density and a high degree of wage coordination in Norway, where large wage setters for each skill group bargain over wages.

We conduct a scenario analysis of deunionization leading to an upward shift in the wage curve for high-skilled and a downward shift for low-skilled workers, but with no change for medium-skilled workers. In order to isolate the macroeconomic effects of a higher skill premium without affecting the composition of capital, labor, energy and production, the overall wage level is kept unchanged.

Our analysis shows that deunionization, proxied by changes in wage curves for different skill groups, leads to job polarization. We find that a 5 percentage point increase in the skill premium leads to a 0.3 percent reduction in high-skilled employment and a 0.9 percent increase in low-skilled employment. Also, employment of medium-skilled workers is reduced by 0.5 percent. This result is due to the heterogeneity of the elasticities of substitution between the different types of labor. While the elasticities of substitution between high- and medium-skilled are relatively low, the elasticities of substitution between medium- and low-skilled are relatively high. Even if high-skilled workers become more expensive, firms do not substitute high-skilled for medium-skilled workers. In contrast, low-skilled workers can to a greater extent substitute for medium-skilled workers. The lower wage for low-skilled workers increases the demand for low-skilled at the expense of medium-skilled, thus yielding a more polarized labor market.

Our analysis also shows the impact on the overall economy of deunionization. Increased wage dispersion leads to a small increase in employment and a modest increase in demand. An important characteristic of the Norwegian economy is the high skill intensity in the public sector. As a result, the rise in the wage premium following from deunionization reduces the budget surplus. To keep the government surplus unchanged compared to the baseline, tax rates are increased. Increased taxes suppress household demand and crowd out some private-sector production, thereby mitigating the increase in demand due to higher employment. On balance, the macroeconomic effects on consumption, investment, exports, imports, and output of increasing the skill premium by 5 percent are modest.

The paper is structured as follows. Section 2 presents the macroeconomic model with a particular focus on the labor market block. A conceptual illustration is presented of how deunionization may lead to job polarization. Section 3 outlines the deunionization scenario and the main findings. Section 4 provides a conclusion.

2 The macroeconomic model

The macroeconomic model is relatively disaggregated, with an input-output system based on the National Accounts and labor categorised by educational groups. In the short run, the production level is determined by aggregate demand along the lines of the traditional Keynesian framework for an open economy with inflation targeting. In the longer run, the supply side also contribute to determination of production through labor supply and wage formation. The model has been developed continuously since the 1980s and all structural equations in the model have theoretical underpinnings. These equations are estimated in blocks using a co-integrated VAR framework. Cappelen (1992) provides an overview of the model. Recent documentation of some of the main blocks, such as factor demand, the consumption function and the distribution sector can be found in Hungnes (2011), Jansen (2013) and Boug et al. (2013a), respectively. As these articles illustrate, the methodology underlying the macroeconomic model is to specify econometric models that encompasses several economic theories and include only those theories into the model that passes the empirical tests. Bårdsen et al. (2005) provides an overview of the methodology upon which our model is based.

In the following, we provide a general overview of the macroeconomic model[1], outline specifically how factor demand is determined and illustrate conceptually how deunionization may lead to job polarization through increased wage dispersion.

2.1 A general overview

The macroeconomic model has an extensive input-output structure based on the National Accounts, and all blocks are determined simultaneously. This implies that a change in one industry will affect all the other industries. For each of the 38 products, there is a supply and use equation which, slightly simplified, is given by

$$X + I = A + \sum_k d_{Ck} C_k + \sum_r d_{Jr} J_r + \sum_j d_{Mj} M_j + DS = A + D, \tag{1}$$

where X is gross production, I is imports, A is exports, C is various consumer categories, J is gross investment categories, M is other material inputs and DS is changes in total stocks. Total domestic demand, D, is thus the sum of consumption, gross investment, other material inputs and changes in total stocks. The indices k, r and j run over 18 consumer categories, 8 investment categories and 18 industries, respectively.

The level of production X in an industry is given by

$$X = F(K, M, N, Z),$$

where K, N and Z represent capital, labor services and technology, respectively, and where we have dropped industry subscripts for notational convenience. Both capital and intermediates are divided into three categories. Capital includes buildings, transport equipment and machinery, while intermediates include electricity, fuel and other materials. The production function F has a Cobb-Douglas form. We return to the description of factor demand below.

Imports are assumed to be a variety of the corresponding domestically produced goods. Each user minimises the costs of consuming the imported and the domestic variety as in Dixit and Stiglitz (1977). The import share for each user of a composite commodity is thus a constant elasticity of substitution (CES) function of the domestic price (P_D) and the corresponding import price (P_I) for each commodity. Total imports of each commodity thus equal the import share multiplied by domestic demand

$$I = \text{CES}(P_I/P_D) \times D \tag{2}$$

[1]This overview draws heavily upon the model description as outlined in Boug et al. (2013b).

where we have dropped commodity subscripts for notational convenience. Note that eq:I is slightly simplified compared with the actual model, as the structure of imports varies among domestic users. Hence, it is a weighted sum of the various components in eq:X that is inserted into eq:I. The weights are taken from the most recent final National Accounts. For non-competitive imports, domestic production is zero or negligible and imports are given by demand according to eq:I.

Exports are also assumed to be variants of the corresponding domestically produced goods and are modelled using the Armington approach[2]

$$A = G(P_A/P_W \times E, D_W), \tag{3}$$

where the export price (P_A) relative to world market prices for similar goods (P_W) in domestic currency captures price effects and where E is an aggregate of various exchange rates of relevance for Norwegian exports. The function G is log-linear and homogeneous of degree zero in export and world market prices measured in a common currency. The indicator of world demand (D_W), measured by aggregating the imports of Norway's main trading partners, captures income effects; see Boug and Fagereng (2010).

Consumption is modelled in a three-step procedure. At the highest level, aggregate consumption is a log-linear function of disposable income (Y), wealth (W) and the after-tax real interest rate (r)

$$\ln C = 0.85 \ln Y + 0.15 \ln W - 0.7r. \tag{4}$$

Note that the coefficients in front of income and wealth sum to unity, i.e. the consumption function is homogeneous in income and wealth. The estimated aggregate consumption function is modelled in a cointegrated VAR system; see Jansen (2013). At the next level, consumption is spread over non-durable consumption, transportation vehicles and other durable consumer goods using the dynamic linear expenditure system based on the Stone-Geary utility function. At the lower level, expenditure on non-durable consumer goods is spread further in accordance with the Almost Ideal Demand System; see Deaton and Muellbauer (1980).

Investment is determined from the capital accumulation equation

$$J_t = \Delta K_t + DEP_t,$$

where depreciation (DEP) is geometric and depreciation rates vary across investment categories and industries.

Capital, material inputs and employment are determined from factor demand functions. Since the production function in eq:X is Cobb-Douglas, cost minimization implies log-linear factor demand equations, i.e.

$$\begin{aligned} K &= (\alpha_K/P_K)(W/\alpha_N)^{\alpha_N/s}(P_M/\alpha_M)^{\alpha_M/s}X^{1/s}, \\ M &= (\alpha_M/P_M)(W/\alpha_N)^{\alpha_N/s}(P_K/\alpha_K)^{\alpha_K/s}X^{1/s}, \\ N &= (\alpha_N/W)(P_K/\alpha_K)^{\alpha_K/s}(P_M/\alpha_M)^{\alpha_M/s}X^{1/s}, \end{aligned}$$

[2]For exports of natural resource products such as fish, crude oil and natural gas, gross domestic production is exogenous and exports are determined by eq:X.

where α_N, α_K and α_M represent the output elasticities of labor, capital and intermediates, respectively, $s = \alpha_N + \alpha_K + \alpha_M$ denotes the return to scale, P_K is the user cost of capital, W is the unit cost of labor and P_M is the price index for other material inputs. We show below how the price index for other material inputs is determined. The whole demand system for input factors is outlined in Hungnes (2011).

Prices are determined as mark-up over marginal costs where the latter is derived from the production function. The producer price in every industry is determined by maximising real profits, given that producers face a downward declining demand curve for their products both on the domestic market and on export markets. Products are normally assumed to be imperfect substitutes, hence the Norwegian product prices may differ from prices set by foreign competitors. Foreign prices are taken into account by Norwegian producers in their price setting in line with theories of monopolistic competition. In each industry, producer prices for domestic goods and exports (excl. taxes) are the product of mark-up (MU) and marginal cost (MC). Hence, producer prices excl. taxes (P) are determined as

$$P = MU * MC.$$

Standard theory tells us that the mark-up is a function of relative prices and total expenditure. We simplify and let each industry mark-up be a function of the price relative P_F/P only:

$$MU = m_0(P_F/P)^m,$$

where P_F is the competing foreign price and m_0 and m are parameters. In the base year, all price indices are one, MU equals m_0 so this parameter is the mark-up in the base year. Inserting the expression for the mark-up in the price equation gives

$$P = m_0^{1/(1+m)} P_F^{m/(1+m)} MC^{1/(1+m)}.$$

If $m = 0$, the mark-up is constant. In this case, price equals marginal cost multiplied by m_0. If, on the other hand, the export price or the price in domestic markets for each industry/good equals the competitor's price, P_F, there is price-taking behavior and output (gross production) is determined by supply (small open economy case). This is the case in the petroleum industry where the crude oil price is exogenous in the model and all prices are equal (except for some short-run differences). In the standard case with mark-up pricing, output in each industry is determined by a weighted sum of demand categories in the model. The empirical properties of the price equations are outlined in Boug et al. (2016).

In addition to domestic price setting, foreign prices and taxes are important in determining consumer prices. For each component of demand there is a purchasing price index that is determined in accordance with the National Accounts definitions. The price index for other material inputs (P_M) in one industry is used below as an example of how purchasing prices are determined.

$$P_M = \sum_i c_i(1 + VAT_i)\big[(1 - IS_i)P_{Hi} + IS_i P_{Fi} + b_i ET_i + c_{tm} P_{TM}\big].$$

Each price index is basically a weighted sum across products (i) of domestic (P_H) and foreign (P_F) basic prices, a trade margin (P_{TM}) and indirect taxes, where the weights (denoted by small letters) are calibrated constants based on the National Accounts. The P_H variables are determined according to the mark-up pricing model outlined above. IS are import shares and VAT is the value-added tax rate, which varies according to uses. Food has a low rate (15 percent).[3] The price indices for various consumer goods as well as investment categories are determined in exactly the same way. Import prices are mostly exogenous in foreign currency, although for some goods there are pricing-to-market effects; see Benedictow and Boug (2013).

The model also contains an exchange rate equation based on a combination of purchasing power parity and uncovered interest rate parity linking the Norwegian krone to the euro. The interest rate setting of the central bank is captured by a Taylor rule type of equation based on unemployment and inflation.

2.2 The labor market

The labor market, in broad terms, is characterised by firms' demand for labor and the supply of labor, based on the theories of cost minimization and wage bargaining, respectively; see Layard et al. (2005). In the following, we outline these two sides of the labor market for skill-specific labor groups.

Firms decide between aggregate groups of factor inputs at the upper level, as outlined in Section 2.1. Since the Cobb-Douglas function is weakly separable, a firm's decision on how to allocate factor demand to broad categories at the upper level can be made separately from the decision of how to arrange the demand for labor by skill groups. At the lower level, labor is determined by

$$N = G(N_H, N_M, N_L, Z_L),$$

where N_H, N_M and N_L represent high-, medium- and low-skilled labor, Z_L represents labor-augmenting technical change and G is a translog function. We follow convention and view educational attainment as an indicator of skill, where low-skilled includes primary, lower secondary and upper secondary general education, medium-skilled represents upper secondary vocational education, and high-skilled represents tertiary education corresponding to at least a bachelor's degree at university or college.

The translog function is particularly useful for analysing job polarization, as it represents a flexible functional form, i.e. it is a second-order logarithmic approximation of a general function. In particular, the translog function yields elasticities of substitution that may differ between two pairs of labor inputs. To illustrate how different elasticities of substitution between pairs of labor inputs may lead to job polarization, it is useful to

[3] Some services have a low rate, and some even have a rate equal to zero, but the standard VAT rate is 25 percent. Excise tax rates (ET) vary considerably across products; fuels, electricity, alcohol, tobacco and nearly all cars are heavily taxed. Most goods and consumer categories are hardly taxed at all, however. Both VAT rates and ET rates are exogenous variables in the model and are not changed in any of the simulations in our study compared to actual historical values.

Table 1: The Morishima elasticity of substitution

σ_{HM}	σ_{HL}	σ_{LH}	σ_{LM}	σ_{MH}	σ_{ML}
1.9	2.3	0.9	3.3	0.6	3.6

The elasticities of substitution are calculated as a weighted average across industry specific elasticities where the weights are the shares of hours worked in each industry. Cost shares are evaluated in 2010.

first describe how the elasticities are determined within the translog framework. *Labor demand* can be described by the system of wage shares (S) in the translog function

$$S_H = \beta_H + \beta_{HH}\ln(W_H/W_M) + \beta_{HL}\ln(W_L/W_M) + \beta_{HA}Z_L, \tag{5}$$

$$S_L = \beta_L + \beta_{HL}\ln(W_H/W_M) + \beta_{LL}\ln(W_L/W_M)+) + \beta_{LA}Z_L, \tag{6}$$

where W_H, W_M and W_L are wages of high-, medium- and low-skilled labor, respectively and the βs represent parameters. The wage share equation for medium-skilled workers is determined implicitly as $S_M = 1 - S_H - S_L$. The technology variable (Z_L) represents historical developments with skill-biased technological changes, and captures the fact that demand for high-skilled workers has increased while the opposite has happened to low-skilled workers. Hence β_{HA} is positive and β_{LA} is negative in all industries; see the appendix, sec:translog.

Although there are substitution possibilities between capital and labor at the aggregate level, it should be noted that the two-level approach to factor demand implicitly assumes that the marginal rates of substitution between every pair of skill group is independent of capital. This is an assumption that has not been tested but which has been imposed to estimate a complete factor demand system consisting of 9 factor inputs (three capital objects, three types of intermediates and 3 different types of labor). Ideally a flexible functional form, such as translog, should be used when estimating the entire factor demand system. However, such a flexible framework would not be identifiable given our data. To identify the system, we apply the two-level approach outlined above. However, the reader should interpret the results from the scenario analysis below in light of this simplification, where the substitution possibilities between capital and the three different types of labor are ruled out.

The cost share equations can be linked to the change in relative demand between two production factors through the Morishima elasticity; see Blackorby and Russel (1989). The Morishima elasticity of substitution measures the percentage change in relative demand with respect to a percentage change in a wage rate (W). In other words, the elasticity of substitution between the two factors j and i is given by: $\sigma_{ij} = \frac{\partial \ln(N_i/N_j)}{\partial \ln(W_j/W_i)}$. It is defined under the assumption that a change in W_j/W_i is due solely to a change in W_j.

The factors are substitutes if $\sigma_{ij} > 0$, i.e., if the price of j causes L_i/L_j to increase, and conversely, they are complements if $\sigma_{ij} < 0$. In the translog case, the Morishima elasticity of substitution is given by

$$\sigma_{ij} = 1 + \frac{\beta_{ij}}{S_i} - \frac{\beta_{jj}}{S_j},$$

for $i, j = H, M, L$. It is well known that the Morishima elasticities are asymmetrical, i.e. σ_{ij} is not necessarily equal to σ_{ji}. The expression above illustrates the asymmetry in the translog case. For example, while β_{jj} is used to calculate σ_{ij}, it is β_{ii} that is used to calculate σ_{ji}.

Table 1 shows the Morishima elasticities σ_{ij}, calculated in 2010, between high-, medium- and low-skilled labor based on the estimated demand equations. The elasticities of substitution are calculated as a weighted average across industry-specific elasticities, where the weights are the shares of hours worked in each industry. All of the elasticities are positive, i.e. on average, all of the labor inputs are substitutes. Note the wide variation between the elasticities of substitution for different pairs of labor inputs. For example, while the elasticity of substitution between high- and medium-skilled is relatively low ($\sigma_{MH} = 0.6$), the elasticities of substitution between medium- and low-skilled are relatively high ($\sigma_{ML} = 3.6$). This heterogeneity of the elasticities of substitution between the different types of labor is an important force driving job polarization, as we illustrate below.

The labor market is further characterized by large wage-setters that negotiate on wages given the price-setting behaviour of firms (Layard et al. 2005). Unions are assumed to have preference with respect to wages and employment, and the bargaining power of unions increases with low levels of unemployment, implying that the wage response is higher for a low level of unemployment compared to a high level of unemployment. The theoretical framework for the wage-setting results in a wage curve for each skill group. In addition, wage growth in the exposed manufacturing sector leads the wage growth in sheltered sectors of the economy; see Aukrust (1977). Wages by educational groups are accordingly set in three main sectors: manufacturing, other market-oriented services and the public sector. The *wage curves* for high, medium and low-skilled are given by

$$\ln W_i = c_{0i} + c_{1i} \ln U + c_{2i} \ln U_i$$

for $i = H, M, L$, where U_i is the skill-specific unemployment level and U is the overall unemployment level. As will be shown below, changes in the parameter c_{0i} are closely linked to deunionization. Our estimation indicate that the parameters c_{1i} and c_{2i} are either zero or negative across skill groups, reflecting that the wage response is higher for a low level of unemployment. All wage equations are estimated using equilibrium correction models as documented in Bjørnstad and Skjerpen (2006). In manufacturing, the long term wage level depends on value added per hour. The wage share is constant in the long run given that there are no changes in general or education-specific unemployment. In market-oriented services and the public sector, wage levels depend on the reference wage, represented by the sum of wages in the other sectors and unemployment benefits.

The wage level also depends on the level of unemployment, both education-specific and general. The partial effects of education-specific unemployment are relatively small, but larger among highly educated persons in market-oriented services. General unemployment is important in explaining developments in all wages, particularly in the public sector.

The labor force by age and gender distributed by the various resident population groups depends on after-tax consumer real wages in addition to a discouraged worker effect; see Gjelsvik (2013b). These equations are estimated using employment survey data but are in line with the results in Dagsvik et al. (2013) as well as Dagsvik and Strøm (2006). Unemployment is simply the difference between the labor force (supply) and employment.

2.3 Deunionization and polarization

The overall bargaining power and the wage setters' preference for income inequality are not explicitly modelled in the model. A common view in the Nordic countries is that higher unionization rates and coordinated wage-setting reduce wage inequality; see Barth and Moene (2013). Empirical evidence also suggests that a higher level of unionization reduces income inequality in countries like the US and the UK; see Card et al. (2004) and Herzer (2016). In particular, Aidt and Tzannatos (2002) find that higher union density depresses the wage differentials between high- and low-skilled workers. Given these assumptions, lower union density will shift the bargaining power and the mark-up on wages in our model. This corresponds to a shift in the constant term in the wage curve for each skill group.

Figure 1 illustrates conceptually how deunionization may lead to job polarization through the heterogenitiy of elasticities of substitution. The first panel shows the relative demand and relative wage for medium- to low-skilled labor and the corresponding wage curve. A fall in wages for low-skilled labor due to deunionization is represented by an increase in the wage curve. Since medium-skilled workers become relatively more expensive, the relative demand for medium-skilled workers drops, and this reduction is relatively large given the high substitutability between medium- and low-skilled workers. This effect stands in contrast to the effect of increased wages for high-skilled workers, as illustrated in the second panel. When deunionization also causes wages for high-skilled workers to increase through a downward shift in the wage curve, this leads to increased demand for medium-skilled workers. However, since the substitutability between medium- and high-skilled labor is relatively low, the increase in demand for medium-skilled labor is small. The overall effect of deunionization, represented by an increase in the wage-curve for high-skilled and a decrease in the wage-curve for low-skilled workers, is an overall reduction in demand for medium-skilled worker, thereby resulting in a more polarized labor market.

3 Empirical results

We investigate how deunionization, operationalized as a shift in the wage curve, impacts macroeconomic developments, and in particular how it affects employment. Deunionization is operationalized by reducing the wages of low-skilled workers and increasing the wages of high-skilled workers. In the first year after the shift, the overall wage level is by design unaffected by the changes in the wage curves. Substitution among factor inputs at the upper level is thus unchanged, which enables us to isolate the initial effects of deunionization in the macroeconomic model. Alternatively, if skills premia are increased by 5 percent merely as a result of reducing the wage curve of low-skilled workers or increasing the wage curve of high-skilled workers by 5 percent, this would lead to an immediate change in wage costs and in the price of labor. Changes in aggregate wage costs have a direct effect on household income and on the competitiveness of the export sector. A change in the price of labor will lead to substitution of labor for other input factors immediately after the shift. We thus construct the scenario so that the main force driving changes in macroeconomic variables as we move towards 2030 is a change in relative wages. Our analysis is most suited to shedding light on the industry-specific effects of deunionization in the case where inequality increases in both tails of the skill distribution. Since Norway has a compressed wage structure, we believe that this scenario is the most likely outcome, given more flexible labor markets.

Technically, low-skill wages are reduced by 2.5 percent and high-skill wages are increased by 2.25 percent. The baseline scenario is based on the national population forecasts of Norway published by Statistics Norway (see Cappelen et al. (2015)), and the official forecast of labor supply and demand distributed by education published by Statistics Norway; see Cappelen et al. (2013). Wages for medium-skilled persons are kept at the baseline level. The shift in wages is permanent and starts in 2010. Wage inequality increases by almost 5 percent relative to the baseline, and the skill premium (W_H/W_L) is increased from 1.7 to 1.8. This means that the wage relationships are exogenized in the model. Since the feedback mechanisms are important for achieving equilibrium in the labor market, this may seem like an odd choice. However, we have chosen this approach because of lack of a long enough time horizon for both wages and demand to adapt to a new equilibrium. If wages adjust, there is reason to believe that the shift in wage premia would have to be larger since a decrease in the wages of low-skilled workers increases demand for low-skilled labor and counteracts the initial shift. The wage curves are thus shifted while the average wage level is maintained. That we have kept the overall wage level unchanged rules out a priori substitution between labor and capital. This is not a result of the simulation but an assumption made to isolate the impact from deunionization on different skill groups. We also believe that it is worth focusing on the long-term effect on labor market demand of a higher skill premium, since this has received less attention in international research.

Based on the results from Koeniger et al. (2007), we believe that the 5 per cent change in the wage premium is a reasonable proxy for deunionization. The average net union density is nearly 40 percent across 11 large OECD countries in the period 1973 to 1998.

Since then, union density declined and reached 0.28 percent in 2015. The estimated effect of a 10 percentage point decrease in union density increases wage dispersion (w_{90}/w_{10}) with at least 4 percentage points. The effect is nearly 6 percentage points when adding more control variables such as female participation rate. In Norway, union density is higher than the OECD average and was equal to 0.52 in 2015. If the union density rate in Norway moves toward the OECD average by 10 percentage points this suggest an increased wage dispersion of around 5 percent.

The simulation period cover 20 years. It may seem that a 20 year simulation period is excessively long to identify the impact of a one-time permanent shock, such as a shift in the wage curve. One explanation to why such a long horizon is appropriate is due to slow pass-through of prices caused by mark-up pricing and the distribution sector working as a cushion to exchange rate fluctuations. Boug et al. (2013a) finds that pass-through of exchange rate changes to consumer prices is not fully completed within a ten-year horizon due to such inertia in pricing behavior. That said, in the simulations below, most of the effects from the shift in the wage curve are taken out after five to ten years' time.

The public use of resources is exogenous in the model. Since the public sector is high-skill intensive, average public sector wage costs will increase given a higher skill premium. A higher skill premium, ceteris paribus, would lead to a government budget deficit. In the long run, this is not sustainable and can be counteracted by an increase in taxes or reduced public sector employment. We balance public budgets by means of tax financing, a method that is widely used in the literature; see Coenen et al. (2012). The effects on the labor market segmented by skills are discussed below. The detailed results of reduced public employment are relegated to the Appendix, Section C.

The interest rate and the exchange rate remain unchanged relative to the baseline. Since the interest rate and exchange rates react to macroeconomic developments, and since the macroeconomic effects are rather limited, the results are not much affected by this choice.

3.1 Macroeconomic effects of deunionization

The aggregate macroeconomic effects are shown in Table 2. The effect on real household disposable income is mainly attributed to developments in wage income, which rise initially with the increase in employment and later with increased average wages, but are reduced due to the tax increase from 2016. Disposable income is accordingly higher than the baseline in the first part of the shift. Consumption, housing investment and imports shadow income developments, and gradually increase relative to the baseline. After the tax increase in 2016, real disposable income gradually decreases, and is back at the baseline level in 2030. As such, consumption, imports and investments are also at baseline level in 2030.

The positive effects of higher demand are particularly directed at the domestic market. Consumer goods production, miscellaneous manufacturing, wholesale and retail trade and construction pick up, but the positive effect gradually wanes towards 2030. Demand directed at export-oriented industries undergoes little change. The trade balance is weakened somewhat as exports of traditional goods fall by 0.1 percentage point in 2030. The mainland GDP level reflects the demand components, and is relatively unaffected by the changes in wage curves.

By design, the average wage per hour is unchanged compared to the baseline in 2010. On the other hand, factor prices in private sector industries have changed, which potentially implies a large adjustment. The effects of higher skill premia vary across industries, but on average, wage costs are higher than in the baseline scenario. Thus, employment is substituted for other input factors. As a result, gross fixed investment is somewhat higher in 2030 despite the fact that housing investment is back at the baseline level.

On the other hand, substitution between skill groups boosts employment. Industries which benefit from higher skill premia increase their use of labor compared to the baseline, as discussed in more detail below. In 2030, employment is 0.1 percent higher than the baseline, equivalent to 3 200 persons, and unemployment is 0.1 percentage point lower.

Table 2: Macroeconomic effects of deunionization. Deviation from the baseline scenario in percent if not otherwise stated

	2010	2011	2015	2020	2025	2030
Private consumption	0.0	0.1	0.2	0.2	0.1	0.0
Gross fixed investment	0.0	0.0	0.0	0.1	0.2	0.1
Exports, traditional goods	0.0	0.1	0.1	0.1	0.0	0.0
Imports	0.0	0.0	0.0	0.1	0.0	0.0
Mainland GDP	0.0	0.1	0.1	0.1	0.1	0.0
Employment	0.2	0.2	0.2	0.2	0.2	0.1
Unemployment rate (percentage points)	0.0	-0.2	-0.1	-0.1	-0.1	-0.1
Labour force	0.2	-0.1	0.1	0.1	0.1	0.0
Hourly wage, NOK	0.0	0.0	0.1	0.2	0.3	0.3
Household real disposable income	0.2	0.2	0.2	0.2	0.1	0.0
Government budget surplus	-0.7	-0.2	-0.3	-0.2	-0.1	0.2
...Employment, public sector	0.0	0.0	0.0	0.0	0.0	0.0

The increased demand is met by higher output, especially in industries targeting the domesticmarket, such as market-oriented services, wholesale and retail trade, consumer goods production and miscellaneous manufacturing. Industries oriented towards offshore and international demand are less affected. However, wage costs are also higher, and depending on the composition of the workforce and the extent to which labor can be substituted in the various industries, the effect on average wage costs varies across industries and over time.

The resulting government deficit increases gradually, and from 2016, average taxes are raised so that the current deficit is in line with the baseline scenario in Cappelen et al. (2013). Note, however, that we have not designed the shift so as to keep the current budget deficit unchanged in any given year. The accumulated effect on the budget balance over the simulation period is practically zero, however.

The shift in wage dispersion in 2010 is larger than the initial shift in wages for high and low-skilled labor, and is due to composition effects. Low-skill industries increase their production and demand for labor, which reduces the initial shift of low-skill wages. However, high-skill wages increase more than the initial shift, because industries with high profit and wage levels increase employment and the average wage level of high-skilled labor increases. The medium-skilled workers are replaced with low-skilled workers, demand for medium-skilled labor decreases and the aggregate wage level for this skill group falls. This effect is not obvious, since medium-skilled workers could have been substitutes for high-skilled workers, in which this case increased wage dispersion would have led to an increase in the wages of medium-skilled workers. Composition effects in industries will be discussed in more detail below.

Overall, we find limited macroeconomic effects, which implies that changes in employment, investment and output within one industry are counteracted by opposite effects in other industries.

3.2 Industry-specific effects of deunionization

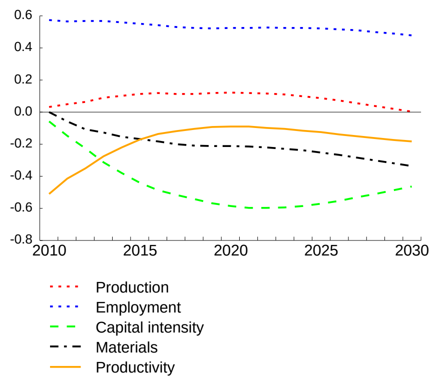
The graphs in Figure 2 show how deunionization affects average wage costs in some industries with high shares of high-skilled and low-skilled workers, respectively. While the effects in 2010 mainly reflect the skills composition, subsequent developments are determined by the substitution possibilities in the various industries, cf. Section 2. The graphs show that initially, wage costs increase in skill-intensive industries, while in industries with a low skill intensity, wage costs are reduced on average. Immediately after the shift, wage costs decrease by 1 percent compared to the baseline scenario in production of consumer goods, domestic transportation and wholesale and retail trade, while in financial intermediates, oil and gas exploration and information and communication, wage costs rise by about 0.6 percent compared to the baseline scenario. Wage costs also decrease relatively more in traditional manufacturing industries like the production of consumer goods and miscellaneous manufacturing than in the manufacture of engineering products. The latter industry supplies goods to the petroleum sector, among others, and employs technicians and engineers. In skill-intensive industries, firms substitute labor for other input factors, particularly investment. This, in turn, serves to increase the capital intensity in these industries, which also affects the use of labor by skill category in oil and gas exploration, in engineering products and in domestic transportation. Figure 2 shows that the response to wage developments is a reduction in employment in terms of hours worked in skill-intensive industries and an increase in the employment in low-skill industries.

Changes in relative wages prompt firms to adjust their demand for labor, depending on the extent to which low-, medium- and high-skilled labor can be substituted. Since the model of demand for labor in the various industries is in the form of error correction equations that take into account that it takes time for firms to adjust their labor stock optimally, these effects occur gradually. There are relatively extensive opportunities for substitution in industries such as petroleum refining, construction, oil and gas exploration and wholesale and retail trade. There are more limited opportunities for substitution in engineering products and financial intermediates.[4] Since wages for high-skilled labor increase, limited opportunities for substitution between high-skilled labor and other skill groups will cause wage costs to rise more in these industries. This is the reason why wage costs gradually pick up in other private services, engineering products and construction.

The initial skills composition and the substitution possibilities between skills in the production process affect the extent to which wages within one industry increase or decrease when skill premia increase. Some industries can substitute all types of skills, such as construction and oil and gas exploration, and enable firms to adjust the types of labor used in production. Such industries would a priori adjust the skill composition more than industries with more limited substitution possibilities. This is also what we find in our empirical investigation; see Table 3, last three columns. These effects serve to change the aggregate skill composition as we move towards 2030. Since it takes time for firms to adjust their labor workforce optimally, these effects will occur gradually.

[4]The industry-specific Morishima elasticities are provided in the appendix, sec:translog.

[Production, hours worked, skill intensity, materials and productivity]



[Relative employment]

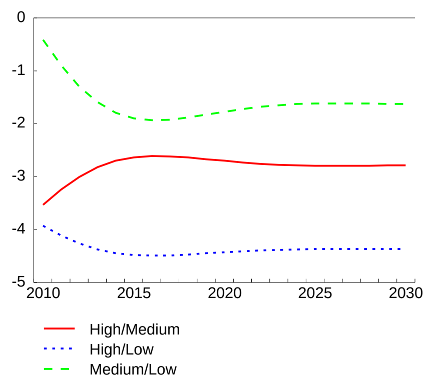
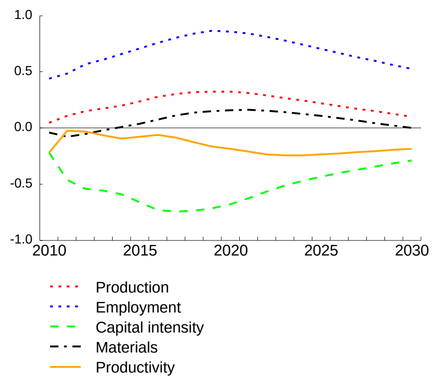
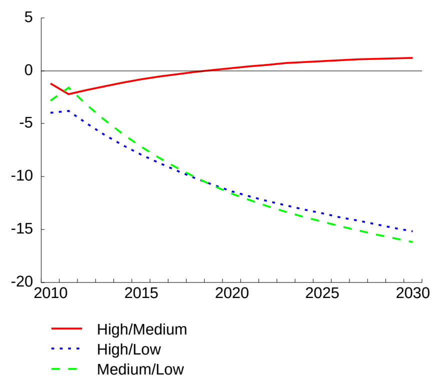


Figure 3: Effects of deunionization in wholesale and retail trade relative to the baseline scenario. Percent

[Production, hours worked, skill intensity, materials and



productivity] [Relative



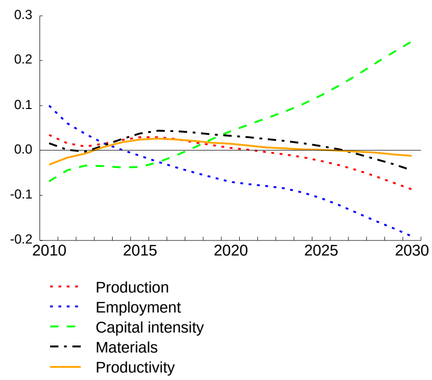
employment]

Figure 4: Effects of deunionization in miscellaneous manufacturing relative to the baseline scenario. Percent

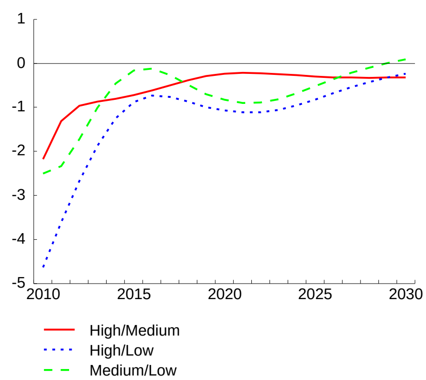
In wholesale and retail trade, there are possibilities for substitution between all types of labor, especially between high- and medium-skilled labor. Figure 3 shows that the employment of medium-skilled relative to low-skilled has decreased by some 2 percent compared with the baseline scenario in 2030, while employment of high- to medium-skilled has decreased by around 3 percent.

In miscellaneous manufacturing, there is a relatively large degree of substitution between high-skilled and low-skilled labor and even greater between low and medium-skilled labor. Figure 4 shows that increasing skill premia leads to reduced relative employment of high to low-skilled by about 15 percent, the same as medium to low-skilled labor. With reference to Table 1, this implies that the employment increase of 0.6 percent leads to a large increase of persons with low skills, particularly at the expense of medium-skilled workers. As in wholesale and retail trade, other input factors are substituted for employment.

[Production, hours worked, skill intensity, materials and



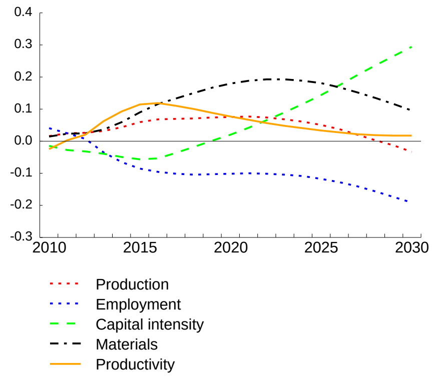
productivity] [Relative



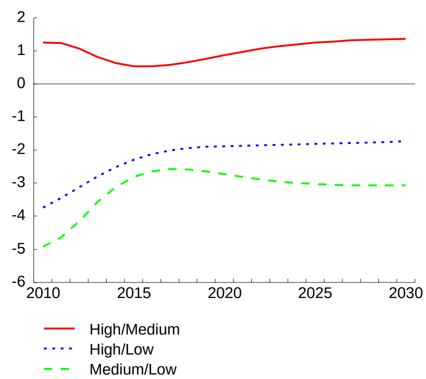
employment]

Figure 5: Effects of deunionization in engineering products relative to the baseline scenario. Percent

[Production, hours worked, skill intensity, materials and

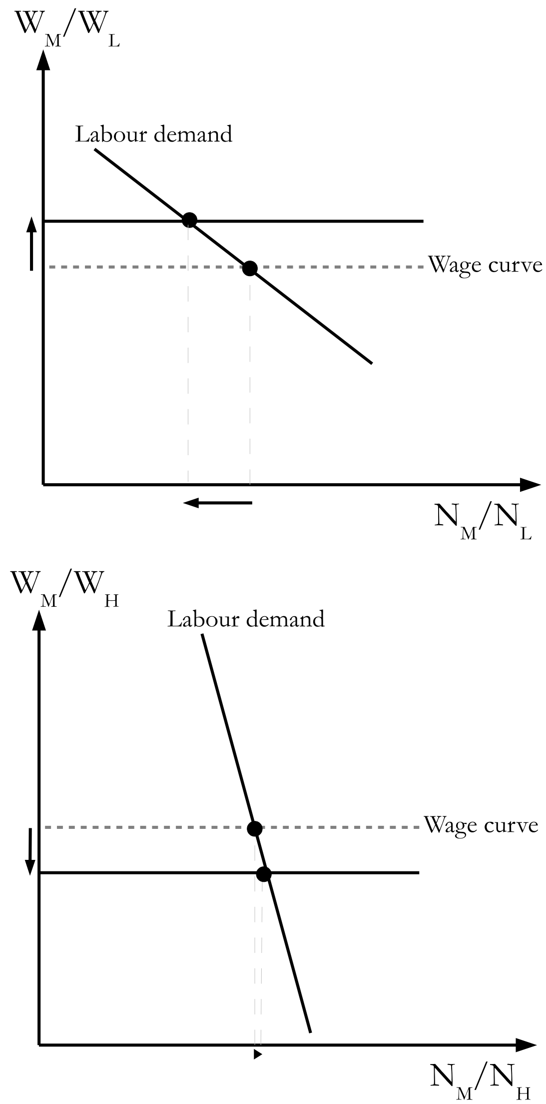


productivity] [Relative



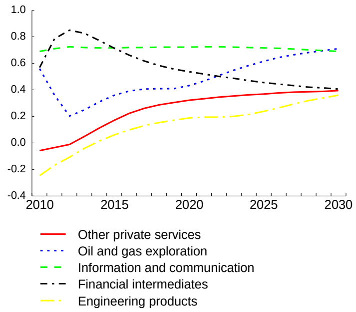
employment]

Figure 6: Effects of deunionization in other private services relative to the baseline scenario. Percent

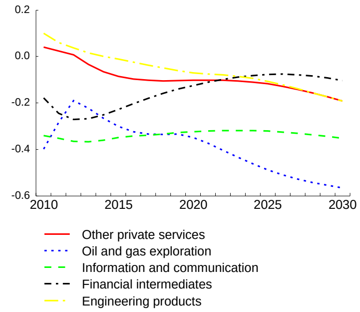


[High substitutability] [Low substitutability]

Figure 1: Deunionization and job polarization



[]



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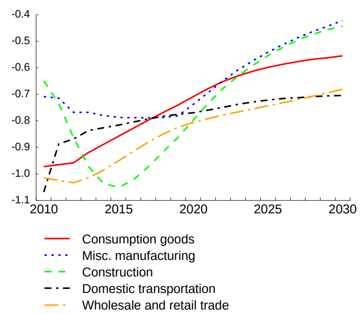
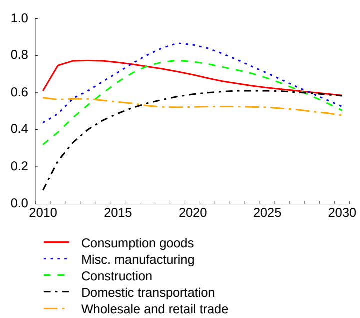


[a][(a) Wage costs per hour (left)] [b][(b) Employment



(right)]

Figure 2: Effects of deunionization and higher taxes on wage cost per hour (left graphs) and employment (right graphs). Relative to baseline in percent. Upper graphs are industries with a high skill intensity and lower graphs are industries with a low skill intensity.

The engineering industry has a relatively high share of skilled workers, and substitution possibilities are somewhat limited. Figure 5 shows that employment is gradually reduced, while investment increases, so that capital intensity gradually picks up towards 2030. In consequence, relative employment between skill groups in engineering is relatively unaffected and employment is cut back.

In other private services, investment is increased relative to the baseline scenario in response to higher wage costs, leading to higher capital intensity and greater use of materials; see Figure 6. Employment decreases by 0.1 percent. Since relative demand for labor is highly inelastic between high and medium-skilled labor, the isolated effects of higher skill premia on demand are modest. The relative demand of high- to low-skilled labor is reduced, as is the relative demand of medium- to low-skilled labor. Overall, this implies that the decrease in employment of high- and medium-skilled workers is greater than the increase in employment of low-skilled workers in 2030.

Table 3 shows the effects of deunionization and increased taxes on employment segmented by skills, total employment, the ratios employment to value added and capital to value added, and finally, the effect on relative employment compared with the baseline scenario in the various industries together with the skills composition in 2010. The change in working hours, capital, and value added for each of the industries is generally lower than in the baseline scenario. This is also the case for the employment ratio between medium- and low-skilled labor. The effects on employment of high-skilled relative to medium-skilled workers, on the other hand, are more ambiguous. It is important to keep in mind that increased production may increase demand for all skill groups, not only the skill group that the industries substitute towards. These scale effects are important in a large scale macroeconomic model, and will also change the labor composition towards 2030.

The increase in low-skill employment is followed by a reduction in high-skill employment across all industries. The decrease in employment is most pronounced in miscellaneous manufacturing, oil and gas exploration and wholesale and retail trade. However, the increase in low-skill employment is primarily at the expense of medium-skill employment. The reduction in medium-skill employment is most pronounced in miscellaneous manufacturing and construction, but is also found in several large industries like information and communication and other private services.

Table 3: Effects of deunionization and increased taxes in 2030.[a]

	Skill composition in 2010			Change in working hours, capital and value added							Change in skill composition		
	N_H/N_M	N_H/N_L	N_M/N_L	N_H [a]	N_M [a]	N_L [a]	N [a]	$\Delta(N/Q)$ [b]	$\Delta(K/Q)$ [b]	Q [a]	$\Delta(N_H/N_M)$ [b]	$\Delta(N_H/N_L)$ [b]	$\Delta(N_M/N_L)$ [b]
Consumer goods	0.31	0.41	1.31	-0.20	0.14	0.65	0.59	-0.24	-1.54	0.69	-0.01	-0.01	-0.02
Misc. manufacturing	0.38	0.70	1.87	-0.73	-2.53	3.79	0.52	0.35	-0.43	0.34	0.00	-0.11	-0.30
Energy-intensive manuf.	0.32	1.80	5.69	-0.10	0.07	-0.01	-0.03	0.14	0.62	-0.21	0.00	-0.01	0.01
Engineering products	0.44	1.69	3.85	-0.11	-0.06	-0.03	-0.19	0.02	0.21	-0.20	0.00	0.00	0.00
Construction	0.17	0.76	4.46	-0.19	-2.72	3.41	0.50	0.24	-0.59	0.40	0.00	-0.14	-0.92
Financial intermediates	1.99	1.33	0.67	-0.20	0.38	-0.29	-0.10	-0.02	0.14	-0.08	-0.04	0.01	0.02
Oil and gas exploration	3.36	4.06	1.21	-2.74	0.70	1.47	-0.57	-0.07	0.00	0.00	-0.26	-0.50	-0.06
Electricity	0.78	5.66	7.28	-0.58	-0.51	0.72	-0.37	-0.08	0.29	-0.05	0.00	-0.59	-0.73
Domestic transp.	0.47	0.38	0.81	-0.19	0.17	0.61	0.58	0.38	-0.95	0.41	-0.01	-0.01	-0.01
Wholesale and retail trade	0.63	0.46	0.73	-0.52	0.10	0.90	0.48	0.29	-0.32	0.29	-0.02	-0.02	-0.01
ICT	3.05	2.10	0.69	-0.26	-0.37	0.28	-0.35	-0.17	0.16	-0.13	0.05	-0.03	-0.02
Other private services	1.79	1.41	0.78	-0.18	-0.43	0.42	-0.19	-0.04	0.30	-0.18	0.02	-0.02	-0.02
Real estate activities	1.73	1.48	0.86	-0.20	-0.42	0.31	-0.31	-0.11	2.12	-0.09	0.02	-0.02	-0.02
Total[c]	0.87	1.01	1.16	-0.31	-0.47	0.88	0.10	0.09	0.00	0.02	0.00	-0.04	-0.05

[a] Columns N_H, N_M, N_L, N and Q show deviation from the baseline scenario in percent.
[b] Δ denotes absolute change in the ratio of the variables N/Q,K/Q, N_H/N_M, N_H/N_L and N_M/N_L.
[c] All industries less public sector.

4 Conclusion

In this paper, we have used a macroeconomic model for a small open economy to analyse how deunionization, proxied by changes in wage curves for different skill groups, may cause job polarization. We found that increasing the skill premium led to a -0.3 percent reduction in high-skill employment and a 0.9 percent increase in low-skill employment due to high-skilled labor becoming more expensive and low-skilled labor becoming less expensive. Interestingly, medium-skill employment decreased by 0.5 percent, despite the wage for medium-skilled workers being kept unchanged in the scenario. This was mainly due to the heterogeneity of the elasticities of substitution between the different types of labor. While the elasticities of substitution between high- and medium-skilled labor are relatively low, the elasticities of substitution between medium and low-skilled are relatively high. Even if high-skilled labor becomes more expensive, firms do not substitute high-skilled for medium-skilled workers. In contrast, low-skilled workers can substitute for medium-skilled workers to a greater extent. As a result, the lower wage for low-skilled workers increases the demand for low-skilled at the expense of medium-skilled workers, resulting in a more polarized labor market.

Our analysis has also shown the impact of deunionization on the overall economy. Increased wage dispersion led to a small increase in employment and a modest increase in demand. An increase in the employment of low-skilled workers is followed by a reduction in the employment of high-skilled workers across all industries. The decrease in employment is most pronounced in miscellaneous manufacturing, oil and gas exploration and in wholesale and retail trade. However, the increase in low-skill employment is primarily at the expense of medium-skill employment, in particular in miscellaneous manufacturing and in construction, but also in several large industries like information and communication and other private sector services.

An important characteristic of the Norwegian economy is the high skill intensity in the public sector. As a result, the rise in the wage premium following from deunionization increased the budget deficit. Since the public sector is exogenous in the model, taxes were raised to prevent a growing government deficit. Higher taxes suppressed household demand and crowded out some private sector production, thereby curbing the increase in demand due to higher employment. The macroeconomic effects on consumption, investments, exports, imports, and gross domestic product of increasing the skill premium by 5 percent were modest.

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A Relative wage curve and labor demand

This appendix presents the calculation of relative demand that is derived from the estimated translog cost functions and the methodological challenges of estimating the translog cost functions.

A.1 Methodological issues related to estimation

A well known problem encountered when estimating translog cost functions is the failure of concavity conditions for input prices; see Jorgenson and Fraumeni (1983), Diewert and Wales (1987), Terrel (1996), Ryan and Wales (2000) and Koebel et al. (2003). Own price elasticity is calculated as:

$$\hat{\eta}_{ii} = (\hat{\beta}_{ii} + \hat{S}_i^2 - \hat{S}_i)\hat{S}_i^2 \tag{A1}$$

and cross price elasticity as:

$$\hat{\eta}_{ij} = (\hat{\beta}_{ij} + \hat{S}_i\hat{S}_j)\hat{S}_i, \tag{A2}$$

where $\hat{S}_i$ is the fitted cost share at a given data point. The own and cross price elasticities differ at every data point, depending on the cost share of the input factor. A necessary and sufficient condition for concavity of the translog cost function in prices is that the Hessian matrix formed by the wage elasticity coefficients, i.e. β_{HH}, β_{HL} and β_{LL}, is negative semidefinite.

We follow Harris et al. (1993) and use the necessary, but not sufficient condition of non-positive own price elasticities over a range of data points. This ensures that the restricted parameter value is as close to the freely estimated coefficient as possible without risking positive own price elasticities. Concavity is assumed if $\hat{\eta}_{ii} \leqslant 0$, i.e. $\hat{\beta}_{ii} \leqslant \hat{S}_i(1 - \hat{S}_i)$, where $\hat{S}$ is the fitted cost share from free estimation of (5) and (6) at a given data point. However, the cost shares vary widely in the data period, where high-skill employment has increased considerably across industries, particularly at the expense of low-skill employment. Since we are using the estimated system to forecast the demand for labor and examine the effects of deunionization, cost shares might also change substantially in the future. The requirement of non-positive own price elasticities may be violated if $\hat{S}_i$ becomes too small or too high. To ensure that the cost shares lie in the exact intervals, we define

$$f(\hat{S}_i) = \hat{S}_i(1 - \hat{S}_i).$$

If $\hat{\eta}_{ii} > 0$ for $i = H, L$, we set the value of β_{ii} to b_{ii} such that

$$b_{ii} = f_{min}(\hat{S}_i),$$

over the estimation period. The implied value of $\hat{\eta}_{MM}$ follows from the characteristics of the translog cost function,

$$\hat{\eta}_{MM} = \hat{\beta}_{HH} + 2 * \hat{\beta}_{HL} + \hat{\beta}_{LL},$$

so a non-positive n_{MM} implies that

$$\hat{\beta}_{HL} \leqslant \frac{1}{2}(\hat{\beta}_{HL} - (\hat{\beta}_{HH} + \hat{\beta}_{LL})).$$

If $\hat{\eta}_{MM} \leqslant 0$, we restrict the parameter β_{HL} to b_{HL}:

$$b_{HL} = \frac{1}{2}(f_{min}(\hat{s}_M) - (\hat{\beta}_{HH} + \hat{\beta}_{LL})).$$

In the case where all three βs are set, this implies

$$b_{HL} = \frac{1}{2}(b_{MM} - (b_{HH} + b_{LL})).$$

The estimation procedure tests for different combinations of βs and bs.

Table A1: Estimated coefficients in the restricted translog system of cost shares by industry, 1972-2007.

	β_H	β_{HH}	β_{HL}	β_{HA}	β_L	β_{LL}	β_{LA}
Consumer goods	0.005^{**}	0.037^a	-0.041	0.196^{**}	0.977^{**}	0.079^a	-0.811^{**}
Misc. manufacturing	0.018^{*}	0.068^a	0.245	0.368^{**}	0.804^{**}	-1.051	-0.896^{**}
Energy-intensive manuf.	0.076^{**}	0.073^a	-0.106	0.255^{**}	0.942^{**}	-0.005	-1.078^{**}
Engineering products	0.125^{**}	0.198	-0.096	0.183^{**}	0.391^{**}	-0.526	-0.553^{**}
Construction	0.105^{**}	0.149^a	-0.077^a	0.215^{**}	0.811^{**}	0.088^a	-0.932^{**}
Financial intermediates	0.050	0.046^a	0.021	0.075^{**}	0.602^{**}	-0.997	-0.707^{**}
Oil and gas exploration	0.143^{**}	0.158^a	-0.152	0.502^{**}	0.823^{**}	0.178^a	-0.543^{**}
Electricity	0.301^{**}	-0.602^{**}	0.029	0.418^{**}	0.258^{**}	-0.305	-0.160^{**}
Domestic transp.	0.451^{**}	0.159^a	0.056^a	0.275^{**}	0.593^{**}	-0.114	-0.832^{**}
Wholesale and retail trade	0.003	0.043^a	-0.038^a	0.301^{**}	0.865^{**}	0.138^a	-0.611^{**}
ICT	0.035	-0.019	-0.009	0.286^{**}	0.866^{**}	0.051	-0.563^{**}
Other private services	0.243^{**}	0.230^a	-0.132	0.225^{**}	0.627^{**}	0.033	-0.370^{**}

[a]The coefficient is restricted
*The coefficient is significant at the 5 percent level
**The coefficient is significant at the 1 percent level

Table A1 shows the estimated system of cost shares with the restricted parameters[5]. The table shows that in the majority of industries, the parameter β_{HH} is restricted. The

[5]Unrestricted estimates are available on request. The translog functions are estimated in Eviews by FIML using annual data spanning the period 1972–2007. For some industries, i.e., engineering products, oil and gas exploration and electricity, capital intensity was included and found to be significant as a control variable.

parameter β_{HL} is restricted in three industries while β_{LL} is restricted in four industries. Except in the case of wholesale and retail trade, the parameters are restricted to a value that lies in the confidence interval of the estimated coefficient in the unrestricted system. As in the unrestricted system, the estimated effects of relative wages are statistically insignificant. The coefficientsβ_{HL} are mostly insignificant in the restricted system, and hence disregarded.

The table shows that although the estimated coefficients reflecting the effects of relative wages may be large, they are statistically insignificant. This might be due to the fact that relative wages have been fairly constant over the estimation period. Further, the trend coefficients are strongly significant in all industries, supporting the SBTC hypothesis. Increased use of technology thus leads to increased demand for high-skilled labor and to decreased demand for low-skilled labor.

Although there is limited support in the data for the hypothesis that relative wages can explain the use of labor segmented by skills across industries, we believe that the price mechanism is more important than the data suggest. The failure to estimate precise effects could be a result of little variation in relative wages in the data period. This could also be the reason why the effect of capital on value added is statistically insignificant in most industries.

The static relationship which we impose on the cost shares for high-skilled and low-skilled labor in the translog system, given by equations (5) and (6), cannot be expected to hold in the short run. In the macro model, all equations are dynamic. The ideal way to impose dynamics on this system is to add variables that are part of the long-run solution in difference form. However, with an annual data set spanning from 1972 to 2007, there are too few observations to estimate the entire system simultaneously and we do not obtain precise estimates. Consequently, the equations in the translog system are estimated as error correction equations.

The general equation explaining the change in cost shares for high- and low-skilled labor is:

$$\begin{aligned}\Delta S_{Ht} = \alpha_{H0} + \alpha_{HH} * ecm_{Ht-1} + \alpha_{HL} * ecm_{Lt-1} \\ + \gamma_{HH}\Delta\ln(W_{Ht}/W_{Ht}) + \gamma_{HL}\Delta\ln(W_{Lt}/W_{Ht}) + \gamma_{HK}\Delta\ln(K_{t-1}/Y_t) \\ + \gamma_{HH1}\Delta\ln(W_{Ht-1}/W_{Ht-1}) + \gamma_{HL1}\Delta\ln(W_{Lt-1}/W_{Ht-1}) + \gamma_{HK1}\Delta\ln(K_{t-2}/Y_{t-1}) \\ + \theta_{HH}\Delta S_{Ht-1} + \omega_H, \quad \text{(A3)}\end{aligned}$$

$$\begin{aligned}\Delta S_{Lt} = \alpha_{L0} + \alpha_{LH} * ecm_{Ht-1} + \alpha_{LL} * ecm_{Lt-1} \\ + \gamma_{LH}\Delta\ln(W_{Ht}/W_{Ht}) + \gamma_{LL}\Delta\ln(W_{Lt}/W_{Ht}) + \gamma_{LK}\Delta\ln(K_{t-1}/Y_t) \\ + \gamma_{LH1}\Delta\ln(W_{Ht-1}/W_{Ht-1}) + \gamma_{LL1}\Delta\ln(W_{Lt-1}/W_{Ht-1}) + \gamma_{LK1}\Delta\ln(K_{t-2}/Y_{t-1}) \\ + \theta_{LL}\Delta S_{Lt-1} + \omega_L, \quad \text{(A4)}\end{aligned}$$

where K/Y represents capital intensity, i.e. the ratio of capital to production, the error correction term is $ecm_{it} = S_{it} - \hat{S}_{it}$ and $\hat{S}_{it}$ is the equlibrium cost share for skill groups $i =$

H, L. The equations are estimated by OLS in Eviews and are reduced to specific equations with significant coefficients. However, as pointed out in Gjelsvik (2013a), some variables are kept in the dynamic equation even if they are insignificant if they help to improve the dynamic specification and the statistical properties of the ω_i's. The coefficients α_{HH} and α_{LL} are negative in all dynamic specifications, supporting the assumption that there is error correction in the cost shares of high- and low-skilled labor. Of a total of 26 estimated coefficients, 15 are significant at the 5 percent significance level, while 23 are significant at the 10 percent significance level.

Table A2: The Morishima elasticity of substitution (σ_{ij})

	σ_{HM}	σ_{HL}	σ_{LH}	σ_{LM}	σ_{MH}	σ_{ML}
Consumer goods	0.93	0.61	0.71	0.83	0.81	0.72
Misc. manufacturing	0.72	4.90	1.31	4.31	-0.10	5.72
Energy-intensive manuf.	1.43	0.63	0.32	1.74	0.80	1.26
Engineering products	0.58	0.41	0.22	0.76	0.36	0.63
Construction	2.18	4.28	0.73	5.72	0.54	5.91
Financial intermediates	0.27	0.23	0.29	0.20	0.60	-0.11
Oil and gas exploration	4.54	3.13	2.41	5.26	3.82	3.85
Electricity	0.09	1.77	1.00	0.86	0.03	1.83
Domestic transportation	0.66	0.50	0.67	0.49	0.73	0.42
Wholesale and retail trade	1.08	0.86	1.07	0.87	1.19	0.75
ICT	0.86	0.66	0.11	1.41	-0.24	1.76
Other private services	0.80	0.63	0.13	1.30	-0.02	1.45
Real estate activities	0.80	0.63	0.14	1.28	-0.07	1.50

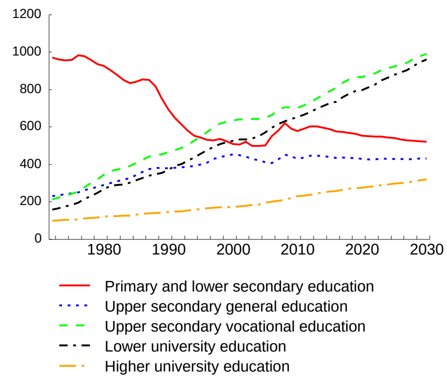
Table A2 shows the Morishima elasticities σ_{ij} calculated in 2010 for all industries between high-, medium- and low-skilled labor based on the estimated demand equations. The Morishima elasticities vary greatly between industries and they are far from symmetrical. For example, in four industries, the elasticity between high- and medium-skilled σ_{HM} and the elasticity between medium- and high-skilled σ_{MH} have opposite signs.

B The baseline scenario

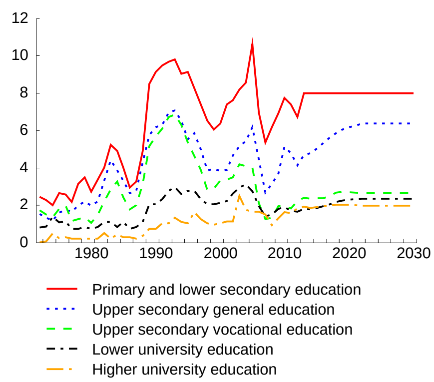
The projection in Cappelen et al. (2013) is the baseline scenario. It is based on a cyclically neutral path for the Norwegian economy from 2014 to 2030, with the key macroeconomic variables moving close to their long-term trend. This ensures that the projections for labor demand and supply laborare a result of structural rather than cyclical conditions.

Figure A1 shows employment by educational level from 1972-2010 from the National Accounts along with the projected unemployment rates according to the baseline scenario. The previous trends of increasing demand for workers with tertiary education[6] is

[6] Defined as persons with lower and higher university education.



[Employment] [Unemployment



rates]

Figure A1: Employment (1000s of persons) and unemployment rates by level of education, 1972-2030. Projections from 2010 and onwards. 1000s of persons.

projected to continue. This is due both to changes in industry structure, with increasing employment in industries that use a high share of skilled labor, as well as changes within industries, where technical change seems to be biased in favor of those with tertiary education. Demand for medium-skilled persons, i.e. persons with upper secondary or vocational education, is projected to increase strongly. Conversely, demand for low-skilled persons, i.e. persons with primary and lower secondary education, is projected to drop towards 2030, leading to excess demand for persons with medium skills, but an excess supply of persons with low skills. For university graduates the projections show a small excess demand from 2020 onwards, while demand for and the supply of laborpostgraduates seems roughly in balance. The largest imbalances thus seem to be in the labormarket for low and medium-skilled labor. This tendency results in a total unemployment rate of around 3.5 percent throughout the projection period, which is close to its historical average since 1980.

Real consumer wages grow by approximately 1.5-2 percent annually. Wage determina-

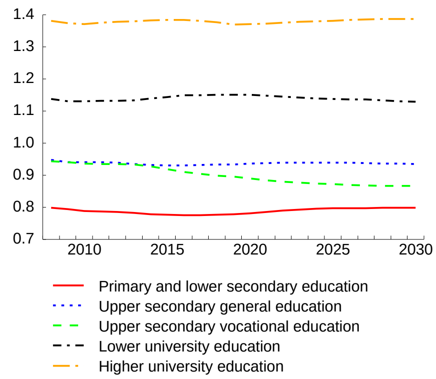


Figure A2: Hourly wage rates by level of education relative to the average hourly wage rate, 1972-2030. 1000s of persons

tion in Norway is quite centralized and has resulted in relatively stable wage differences in past decades. Relative wages are forecast to be quite stable also in the next two decades; see Figure A2. However, relative wages for medium-skilled workers are forecast to decline somewhat. The declining relative wages are consistent with demand for this group, which is assumed to increase more than demand for other skill groups in the projections.

C Effects of deunionization and reduced public sector employment

In the following, government budgets are balanced by maintaining wage costs at the baseline level. Hence, increased wage costs are followed by reduced public sector employment. Employment is scaled back according to the composition in local and central government. There is thus no substitution in the government adjustment.

Since the average wage per hour is unchanged compared to the baseline scenario in 2010 by design, one would expect minor macroeconomic effects. We find relatively limited macroeconomic effects, but sizeable effects for individual industries; see Table A3 and Figure A3. As in the case with a tax increase, this combination suggests that changes in employment, investment and output within one industry are counteracted by opposite effects in other industries.

Table A3: Macroeconomic effects of deunionization and lower public sector employment. Deviation from the baseline scenario in percent unless otherwise stated

	2010	2011	2015	2020	2025	2030
Private consumption	0	0	0.1	0.2	0.2	0.2
Gross fixed investment	0	0	-0.1	0.1	0.2	0.2
Exports, traditional goods	0	0.1	0.1	0.1	0	0
Imports	0	0	0	0.1	0.1	0.1
Mainland GDP	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
Employment	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2
Unemployment rate[1]	0.2	0	0.1	0.1	0.1	0.1
Labour force	0.1	-0.1	0	-0.1	-0.1	-0.1
Hourly wage, NOK	0	0	0.1	0.2	0.3	0.4
Household real disposable income	0	0.1	0.1	0.2	0.2	0.3
Government budget surplus	0	0.3	-0.2	0	-0.1	-0.9
...Employment, public sector	-0.9	-0.9	-0.9	-1	-1.1	-1.2

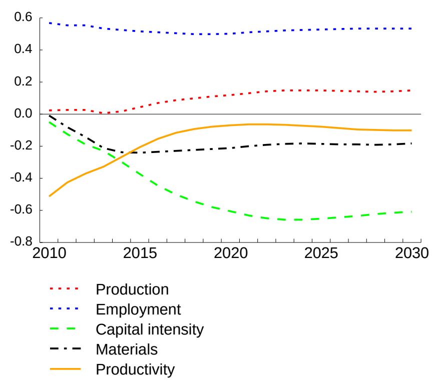
[1]Deviation in percentage points

The macroeconomic effects are interesting. Table A3 summarises the macroeconomic effects of increased wage dispersion and reduced public employment relative to the baseline scenario. Overall wages increase with income distribution, which gradually boosts household disposable income and household consumption. Growth in disposable income is dampened by lower public sector employment. The reduced public sector employment leads to a 0.1 percent reduction in aggregate employment percent in 2010, while employment increases in the rest of the economy. Gradually, the increase in household disposable income leads to higher consumption, housing investment and imports.

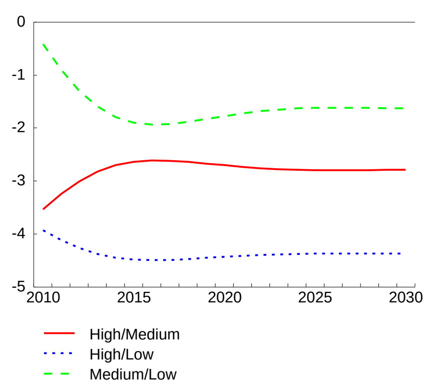
In 2030, employment has decreased by 0.2 percent compared to the baseline level and unemployment has increased by 0.1 percentage point. Lower employment is a direct consequence of lower public demand and lower demand from industries that have a disadvantage due to increased wage dispersion, such as lower production of export goods. Across private sector industries, however, employment is higher than in the baseline scenario; see Table A4. The somewhat less tight labor market leads to lower labor participation rates, which mitigates the negative effect on unemployment.

The limited macroeconomic effects hide more pronounced effects in the individual industries. The graphs in Figure A3 show how deunionization affects average wage costs and employment in some industries with high and low skill intensity. As a general rule, industries with many low-skilled workers (Figure A3, lower panel) increase their use of labor by around 0.6 percent in 2030. In the skill-intensive industries (Figure A3, upper panel), wage costs are 0.4–0.7 percent higher than in the baseline scenario over the whole simulation period. The effect is largest in oil and gas exploration and in information and communication. As a result, employment is permanently reduced by 0.6 percent in oil and gas exploration and by 0.3 percent in information and communication.

The initial skill composition and the skill substitution possibilities in the production process affect the extent to which wages in one industry increase or decrease when skill premia increase. Since it takes time for firms to adjust their labor stock optimally, these effects will occur gradually. Some industries can substitute all types of skills, like construction and oil and gas exploration, thereby enabling firms to adjust the types of labor used in production more flexibly. Such industries would a priori adjust the skill composition of their labor more than industries with less substitution possibilities. This is also what we find empirically; see Table A4, last three columns. These effects change the aggregate skill composition towards 2030.



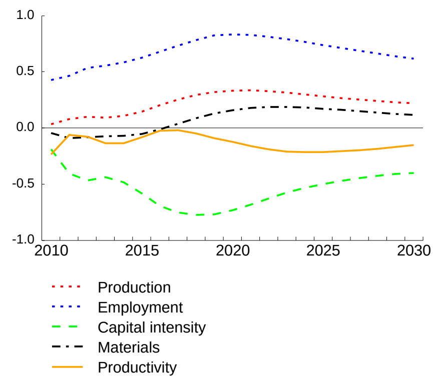
[Production, hours worked, skill intensity, materials and productivity]



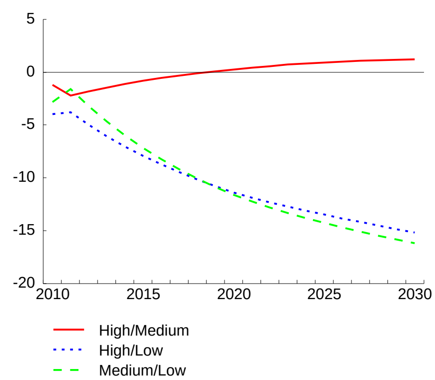
[Relative employment]

Figure A4: Effects of deunionization on wholesale and retail trade relative to the baseline scenario. Percent

[Production, hours worked, skill intensity, materials and



productivity] [Relative



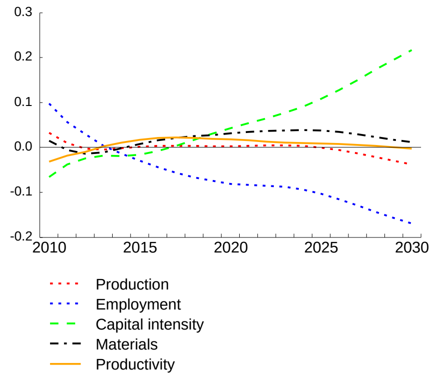
employment]

Figure A5: Effects of deunionization on miscellaneous manufacturing relative to the baseline scenario. Percent

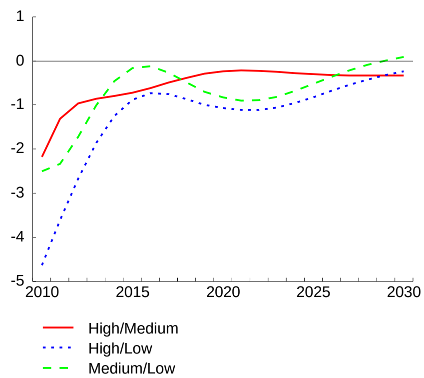
In wholesale and retail trade, there are substitution possibilities between all types of labor, especially between high- and medium-skilled labor. Figure 3 shows that employment of medium-skilled relative to low-skilled labor has decreased by some 2 percent relative to the baseline scenario in 2030, while employment of high- relative to medium-skilled labor has decreased by around 3 percent. Thus, the reduction in relative demand between high- and low-skilled labor is even larger.

In miscellaneous manufacturing, there is a relatively large degree of substitution between high-skilled and low-skilled labor and even higher between low and medium-skilled labor. Between high-skilled and medium-skilled, there is a small degree of complimentarity. Figure 4 shows that increasing skill premia lead to a reduction of about 15 percent in employment of high-skilled relative to low-skilled laborpercent, the same as medium- relative to low-skilled labor. With reference to Table A4, this implies that the employment increase of 0.6 percent leads to a large increase of persons with low skills, particularly at the expense of medium-skilled workers.

[Output, hours worked, skill intensity, materials and



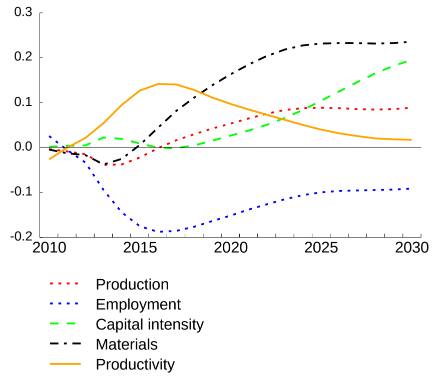
productivity] [Relative



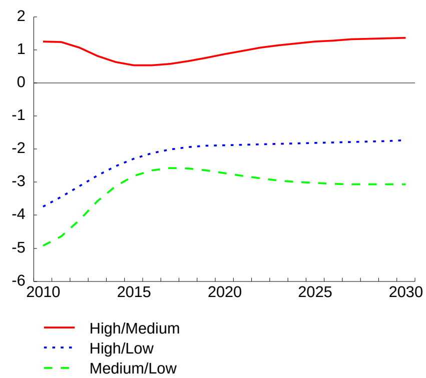
employment]

Figure A6: Effects of deunionization on engineering products relative to the baseline scenario. Percent

[Output, hours worked, skill intensity, materials and

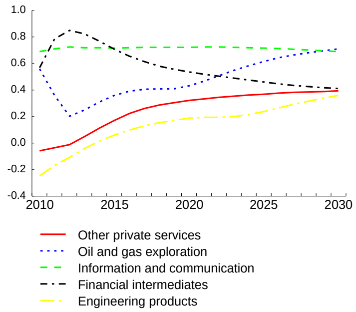


productivity] [Relative



employment]

Figure A7: Effects of deunionization in other private servicesrelative to the baseline scenario. Percent



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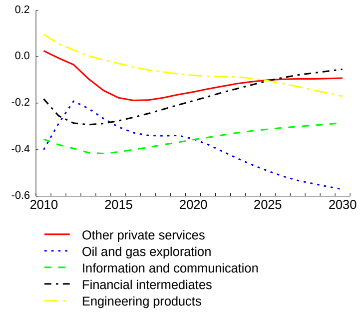

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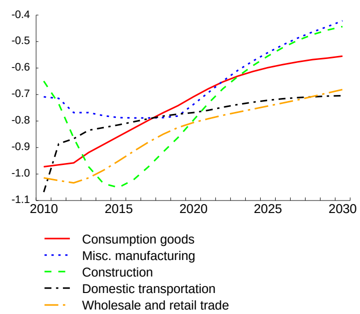
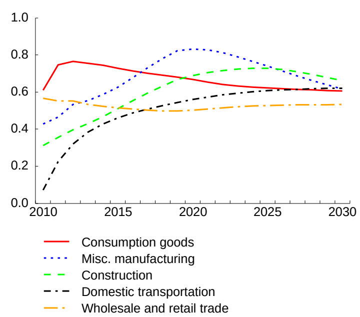


[a][(a) Wage costs per hour (left)]

[b][(b) Employment



(right)]

Figure A3: The top two graphs represent industries with a high skill intensity and the bottom two industries with a low skill intensity. Relative to the baseline scenario.

The engineering industry has a relatively high share of skilled workers and substitution possibilities are somewhat limited, which leads to increased wage costs. Figure 5 shows that employment is gradually reduced, while investment is increased, so that capital intensity gradually picks up towards 2030. Relative employment between skill groups accordingly remains unchanged in engineering production and employment is cut back.

In other private services, investment is increased relative to the baseline scenario in response to higher wage costs, leading to higher capital intensity and higher consumption of materials; see Figure 6. Employment is reduced by 0.1 percent. Since demand for relative labor is highly inelastic between high- and medium-skilled labor, the isolated effects of increased relative wages have a negligible effect on relative demand. Demand for high-skilled relative to low-skilled labor and demand for medium-skilled relative to low-skilled labor is reduced. In sum, this implies that the decrease in employment of high-skilled and medium-skilled labor outweighs the the increase in employment of low-skilled labor in 2030. The last three rows show the change in skill composition expressed as absolute changes in skill ratios relative to the skill ratios in the baseline scenario.

Table A4 shows the skill composition in 2010 and the changes in working hours, capital and value added for each of the industries in the sample in 2030. The bottom line, last three columns, shows that the employment ratio of high-skilled relative to low-skilled labor is generally reduced compared to the baseline scenario. This is also the case for the employment ratio of medium- to low-skilled workers. The effects on employment of high-skilled relative to medium-skilled workers are, more ambiguous, however.

It is important to keep in mind that increased demand for labor segmented by skills group can lead to increased demand for all skill groups. These scale effects are important in a large scale model, and will also change the labor composition towards 2030.

The increase in the employment of low-skilled workers is followed by a reduction in the employment of high-skilled workers across all industries. The decrease in employment is most pronounced in miscellaneous manufacturing, oil and gas exploration and wholesale and retail trade. However, the increase in employment of low-skilled workers is primarily at the expense of medium-skilled workers. The reduction in medium-skilled labor is most pronounced in miscellaneous manufacturing and in construction, but is also present in several large industries like domestic transportation and other private sector services.

In absolute terms, the long run effect of deunionization combined with reduced public employment is a 0.9 percent increase in the employment of low-skilled labor. Employment of high-skilled labor is reduced by 0.3 percent, while the long-run effect on employment of medium-skilled labor is a reduction of 0.4 percent.

Table A4: Skill composition in 2010 and effects of deunionization and reduced public employment.[a]

	Skill composition			Change in working hours, capital and value added							Change in skill composition		
	N_H/N_M	N_H/N_L	N_M/N_L	N_H [a]	N_M [a]	N_L [a]	N [a]	$\Delta(N/Q)$ [b]	$\Delta(K/Q)$ [b]	Q [a]	$\Delta(N_H/N_M)$ [b]	$\Delta(N_H/N_L)$ [b]	$\Delta(N_M/N_L)$ [b]
Consumer goods	0.31	0.41	1.31	-0.20	0.15	0.66	0.61	-0.21	-1.56	0.70	-0.01	-0.01	-0.02
Misc. manufacturing	0.38	0.70	1.87	-0.71	-2.49	3.81	0.62	0.31	-0.56	0.46	0.00	-0.11	-0.30
Energy-intensive manuf.	0.32	1.80	5.69	-0.10	0.07	-0.01	-0.03	0.13	0.60	-0.20	0.00	-0.01	0.01
Engineering products	0.44	1.69	3.85	-0.10	-0.04	-0.02	-0.17	0.00	0.19	-0.17	0.00	0.00	0.00
Construction	0.17	0.76	4.46	-0.17	-2.61	3.44	0.66	0.30	-0.72	0.52	0.00	-0.14	-0.92
Financial intermediates	1.99	1.33	0.67	-0.16	0.39	-0.28	-0.05	-0.09	0.06	0.11	-0.04	0.01	0.02
Oil and gas exploration	3.36	4.06	1.21	-2.74	0.70	1.47	-0.57	-0.07	0.01	0.00	-0.26	-0.50	-0.06
Electricity	0.78	5.66	7.28	-0.59	-0.52	0.72	-0.39	-0.08	0.29	-0.06	0.00	-0.59	-0.73
Domestic transp.	0.47	0.38	0.81	-0.18	0.18	0.62	0.62	0.26	-1.11	0.52	-0.01	-0.01	-0.01
Wholesale and retail trade	0.63	0.46	0.73	-0.51	0.12	0.92	0.53	0.17	-0.40	0.43	-0.02	-0.02	-0.01
ICT	3.05	2.10	0.69	-0.23	-0.36	0.30	-0.28	-0.19	0.11	-0.04	0.05	-0.03	-0.02
Other private services	1.79	1.41	0.78	-0.14	-0.41	0.45	-0.09	-0.04	0.22	-0.07	0.02	-0.02	-0.02
Real estate activities	1.73	1.48	0.86	-0.20	-0.42	0.31	-0.31	-0.16	1.52	0.03	0.02	-0.02	-0.02
Total [c]	0.87	1.01	1.16	-0.29	-0.44	0.90	0.18	0.08	-0.13	0.06	0.00	-0.04	-0.05

[a] Columns N_H, N_M, N_L, N and Q show deviation from the baseline scenario in percent.
[b] Δ denotes absolute change in the ratios of the variables N/Q,K/Q, N_H/N_M, N_H/N_L and N_M/N_L.
[c] All industries less public sector

D Reduced public sector employment vs. increased taxes

The macroeconomic results of the alternative with government financing are presented in Table A5 and Table A6. The effects of deunionization are quite similar whether the budget deficit is counteracted by increased taxes or by reduced public sector employment.[7] There are mainly two mechanisms that lead to differences in the labor market in the two scenarios. The first effect is through lower demand when taxes are raised. Increased taxes suppress the demand from households and crowds out some of the private production, while reduction in public employment has the contrary effect. The fiscal multiplier for changes in taxes is also lower compared to reduction in public employment.

Table A5: Macroeconomic effects of deunionization and higher taxes.
Deviation from the baseline scenario in percent unless otherwise stated

	2010	2011	2015	2020	2025	2030
Private consumption	0.0	0.1	0.2	0.2	0.1	0.0
Gross fixed investment	0.0	0.0	0.0	0.1	0.2	0.1
Exports, traditional goods	0.0	0.1	0.1	0.1	0.0	0.0
Imports	0.0	0.0	0.0	0.1	0.0	0.0
Mainland GDP	0.0	0.1	0.1	0.1	0.1	0.0
Employment	0.2	0.2	0.2	0.2	0.2	0.1
Unemployment rate (percentage points)	0.0	-0.2	-0.1	-0.1	-0.1	-0.1
Labour force	0.2	-0.1	0.1	0.1	0.1	0.0
Hourly wage, NOK	0.0	0.0	0.1	0.2	0.3	0.3
Household real disposable income	0.2	0.2	0.2	0.2	0.1	0.0
Government budget surplus	-0.7	-0.2	-0.3	-0.2	-0.1	0.2
...Employment, public sector	0.0	0.0	0.0	0.0	0.0	0.0

[1]Deviation in percentage points

[7]As a reference, the calculation in which the government budget is not balanced is documented in the appendix, Section E.

Table A6: Macroeconomic effects of deunionization and reduced government employment. Deviation from the baseline scenario in percent unless otherwise stated

	2010	2011	2015	2020	2025	2030
Private consumption	0	0	0.1	0.2	0.2	0.2
Gross fixed investment	0	0	-0.1	0.1	0.2	0.2
Exports, traditional goods	0	0.1	0.1	0.1	0	0
Imports	0	0	0	0.1	0.1	0.1
Mainland GDP	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
Employment	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2
Unemployment rate[1]	0.2	0	0.1	0.1	0.1	0.1
Labour force	0.1	-0.1	0	-0.1	-0.1	-0.1
Hourly wage, NOK	0	0	0.1	0.2	0.3	0.4
Household real disposable income	0	0.1	0.1	0.2	0.2	0.3
Government budget surplus	0	0.3	-0.2	0	-0.1	-0.9
...Employment, public sector	-0.9	-0.9	-0.9	-1	-1.1	-1.2

[1]Deviation in percentage points

This leads to somewhat lower production in industries that are directed towards the domestic market, which is the case for some manufacturing segments and for service industries. Due to a lower level of investments, both in housing and across industries that substitute towards investment, construction production is lower in response to a lower level of investment, both in housing and in the industries that substitute towards investment in response to higher wage costs. These industries increase the use of labor, and a comparison of Table 3 and Table A4 shows that in the case of tax financing, employment is a little lower than in the alternative with reduced public sector employment in most industries. However, the differences are small. All in all, this leads to an increase in employment of 0.1 percent across industries if we disregard the public sector. This corresponds to an employment increase of 3,200 persons in market-oriented industries compared to the baseline scenario when the public budget deficit is offset by increased average taxes. On the other hand, relative employment between skill groups are quite similar in the two shifts, since this is primarily determined by the estimated effects of relative wages, i.e. the possibilities of substitution between skill groups.

The second source of differences between the two alternatives is the reduction in the use of public sector employment, which directly impacts the labor market. The employment reduction is thus less pronounced when taxes are increased. In the alternative with reduced public sector employment, labor costs are unchanged in the public sector, which means that higher labor costs are offset by a gradual decline in the employment of all skill groups. This means that the public sector does not respond to higher labor costs by substituting between skill groups, but scales down according to the composition of labor. The effect in 2030 is that public sector employment is 12,100 persons lower than in the baseline scenario. Of this number 7,500 people are high-skilled, 2,500 are medium-skilled and just over 2,000 are low-skilled.

In the case where households bear the cost of an increased public budget deficit through higher taxes, the increase in demand resulting from higher average wages is dampened by higher average taxes, so that the effect on household disposable income is unchanged in 2030. Thus, most sources of changes in employment by skill groups in 2030 are through changes in relative wages between skill groups.

In both shifts, the macroeconomic effects of increasing the skill premium by 5 percent are modest. This is likely a consequence of the dimension of the shift, in which the effect on average wages is zero in 2010 in both calculations. As such, our main aim is to outline some trends that will prevail if we move towards a higher skill premium in Norway.

Our analysis thus indicate that the effects of deunionization is an increase in the employment of low-skilled workers, particularly at the expense of medium-skilled workers. The impact on high-skilled workers is not as strong compared to the baseline scenario when taxes are increased, but the rise in unemployment is the same for high-skilled as for medium-skilled when public employment is reduced. This is a direct effect of the employment downscaling in the public sector. Our analysis can therefore shed light on recent development in Portugal, Ireland, Greece and Spain (the PIGS countries), which have experienced higher wage differentials, higher unemployment and reduced public employment following the financial crisis.

E Unbalanced budget

In the main text, and in the appendix, section C, the government budget was balanced by tax increases and reduced public employment. In this section we consider the impact of deunionization when the government budget is not balanced.

Compared to the wage level in the baseline scenario, the wages in all three sectors (i.e. manufacturing, public sector and market-oriented services) are initially increased by 2.25 percent for high-skilled persons and decreased by 2.5 percent for low-skilled. The deviation is kept throughout the calculation period. Wages for medium-skilled persons are kept unchanged in all three sections. By design, overall wages are the same in the baseline scenario and in the shift in 2010.

Table E1 shows macroeconomic developments along with developments in wages and relative wages for skill groups. As demonstrated in more detail below, employment distributed by skill group and by industry changes along with the macroeconomic effects. For example, higher employment of low-skilled workers in construction will, ceteris paribus, result in a lower average wage level for low-skilled workers, since the average wage level among low-skilled workers is lower in construction than elsewhere in the economy. An increase in the employment of low-skilled workers in financial intermediates or in information and communication will have the opposite effect on the wage level of low-skilled workers, since wage levels are higher in these industries. The effects on wages distributed by skill group depend on these composition effects when we aggregate across sectors. Nevertheless, the wages of low-skilled persons are close to 2.5 percent lower in 2030 in the scenario which we present here, compared to the wages of low-skilled workers in the baseline scenario. For medium-skilled workers, the average wage level is the same as in the baseline scenario, and for high-skilled workers, wages are 2.2 percent higher. Accordingly, the wage differential between low-skilled and medium-skilled is reduced by 2.5 percent compared to the baseline scenario in 2010.

Table E1: Macroeconomic effects of a wider wage dispersion. Deviation from the baseline scenario in percent unless otherwise stated

	2010	2011	2012	2015	2020	2025
Private consumption	0	0.1	0.1	0.2	0.2	0.2
Gross fixed investment	0	0	0	0	0.1	0.2
Exports, traditional goods	0	0.1	0.1	0.1	0.1	0
Imports	0	0	0	0	0.1	0.1
Mainland GDP	0	0.1	0.1	0.1	0.2	0.1
Employment	0.2	0.2	0.2	0.2	0.2	0.2
Unemployment rate[1]	0	-0.2	-0.2	-0.1	-0.2	-0.1
Labour force	0.2	-0.1	0	0.1	0.1	0.1
Hourly wage, NOK	0	0	0	0.1	0.2	0.3
Households real disposable income	0.2	0.2	0.2	0.2	0.2	0.2
Government budget surplus	-0.7	-0.2	0.4	-0.3	-0.2	-0.5
...Employment, public sector	0	0	0	0	0	0

[1]Deviation in percentage points

Since overall wages are roughly unchanged compared to the baseline scenario immediately after the shift, the macroeconomic effects are small. However, wage costs vary across industries, depending on the composition of the workforce. Initially, wage costs are reduced on average in the private sector. Firms thus substitute towards labor in production. In the public sector, a high share of the workforce is high-skilled, and wages are accordingly higher than in the baseline scenario. Public sector adjustment is exogenous, and employment in the public sector is unaffected by the wage increase. The government thus runs a budget deficit amounting to 0.7 percentage point in 2010 and 0.5 percent in 2030.[8]

As a result of lower labor costs, employment is somewhat higher in the market-oriented industries. Labor participation is increased and unemployment is unchanged compared with baseline. Together with small effects in consumption, investments, imports and exports, mainland GDP is the same as in the baseline scenario.

Household real disposable income is higher than in the baseline scenario throughout the calculation period. This is attributable to both higher employment and wages. Housing investment, consumption and imports reflect the development in income, and are

[8]The actual government budget surplus in a given year depends on many factors in addition to total wage costs, for example payment of taxes, unemployment benefits and pensions. For this reason, we focus on the accumulated budget balance in the text and when we design the shifts that balance budgets, see Section 3 and the appendix, Section C.

higher than in the baseline scenario, directing demand towards industries in the private sector. The effects are however reduced over time.

In the private sector, wage costs are important for employment developments. In the first part of the shift, wage costs are lower than in the baseline scenario, but costs gradually pick up and are higher than the baseline scenario after 2016. The isolated effect of this is that employment is reduced while investment gradually picks up. However, since aggregate demand is higher than in the baseline scenario, production also increases, and the employment level is still higher than in the baseline scenario in 2030.

All in all, the macroeconomic effects are modest also after 2010. Aggregate demand is primarily directed at production of goods and services in Norway. The export sector does not benefit from this, but on the other hand, wage costs do not increase as much. In 2030, exports are a little lower than in the baseline scenario. Aggregate employment is 0.2 percent higher, amounting to 5,500 persons. Unemployment is reduced by 0.1 percentage point in 2030 and the level of mainland GDP is relatively unaffected by the increase in skill premia.

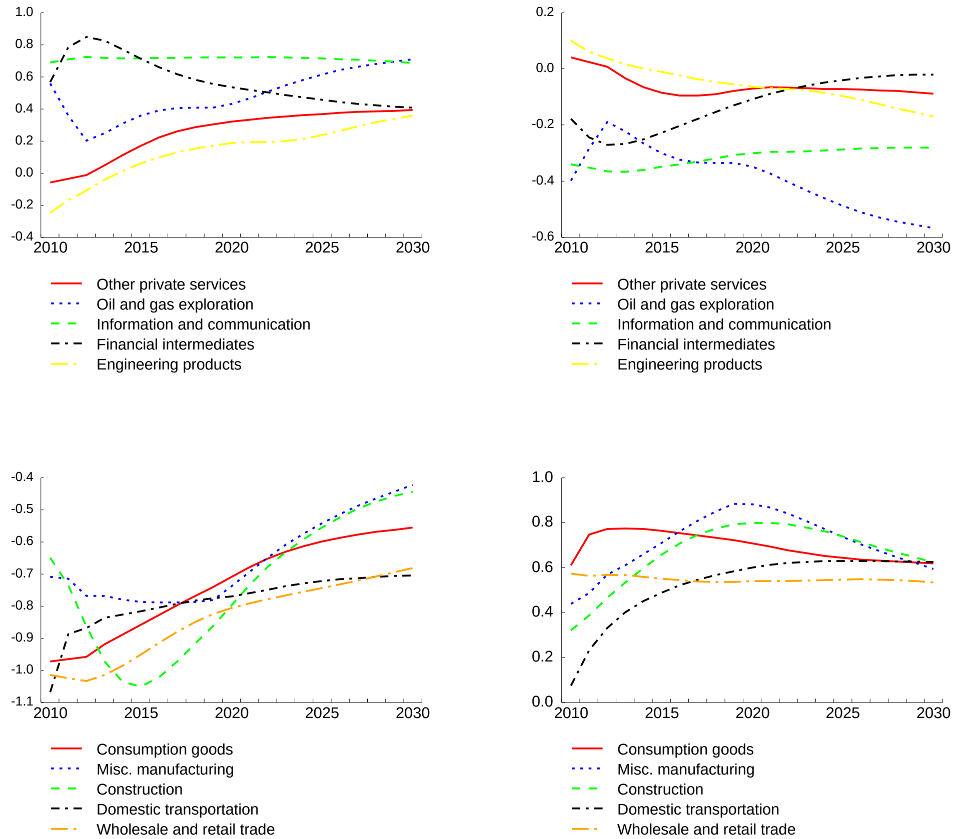
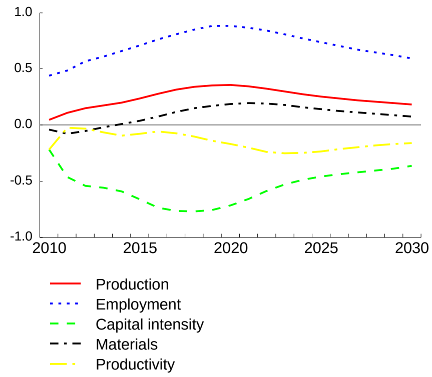


Figure E1: Effects on hourly wage costs (graphs on the left) and employment (graphs on the right) in some industries as a result of deunionization. The graphs at the top are for industries with high skill intensity and the graphs at the bottom represent industries with low skill intensity. Relative to the baseline scenario in percent.

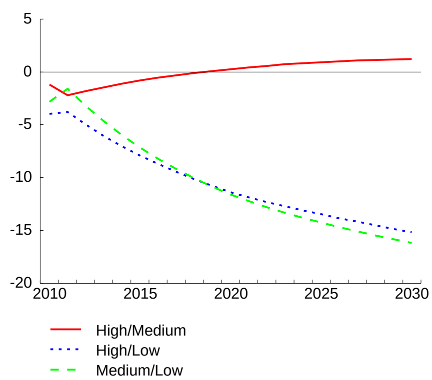
Figure E1 shows how deunionization affects average wage costs and employment in some industries. The top two graphs show the effects on wage costs and employment in industries with a high skill intensity. Initially, wage costs increase and employment is reduced in these industries. At the same time, industries with a low-skill composition face lower wage costs. Wage costs in consumer goods production, domestic transportation and wholesale and retail trade decrease by around 1 percent compared to the baseline scenario, while wage costs in financial services, information and communication and oil and gas exploration increase by about 0.6 percent.. In skill-intensive industries, firms direct demand towards other input factors, particularly investment. Hence, capital intensity increases in skill-intensive industries, an effect that feeds through to the use of labor distributed by skill category. However, only the industries engineering products, oil and gas exploration and electricity are affected; see Table A1 in the appendix, Section

A, where β_{HK} and β_{LK} denote the effects on the cost share equations of high-skilled and low-skilled labor of an increase in capital intensity. If demand for high-skilled labor increases in response to higher capital intensity, i.e. a positive sign on β_{HK}, this will, ceteris paribus, result in a shift outwards in the demand curve for high-skilled labor. Figure E1 shows that employment is reduced relatively more in industries with a large share of high-skilled workers.

[Production, hours worked, skill intensity, materials and



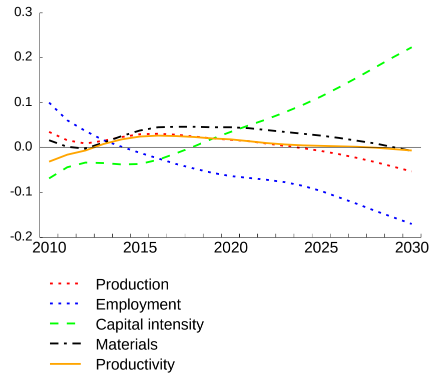
productivity] [Relative



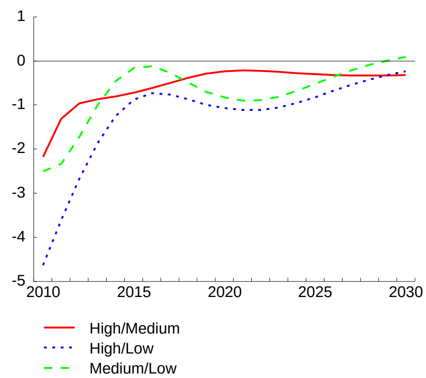
employment]

Figure E2: Miscellaneous manufacturing. Effects of deunionization on production, hours worked, capital intensity, materials, productivity and relative employmentization relative to the baseline scenario. Percent.

[Production, hours worked, skill intensity, materials and



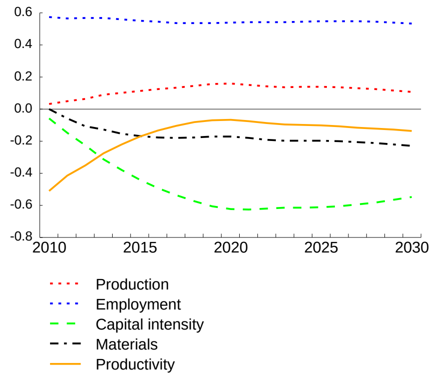
productivity] [Relative



employment]

Figure E3: Engineering products. Effects of deunionization on production, hours worked, capital intensity, materials, productivity and relative employmentization relative to the baseline scenario. Percent

[Production, hours worked, skill intensity, materials and productivity]



[Relative employment]

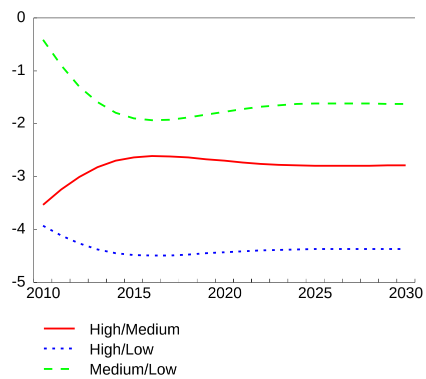
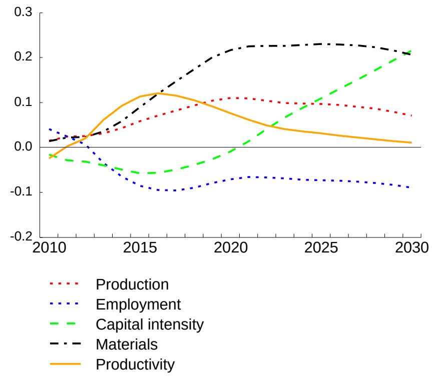
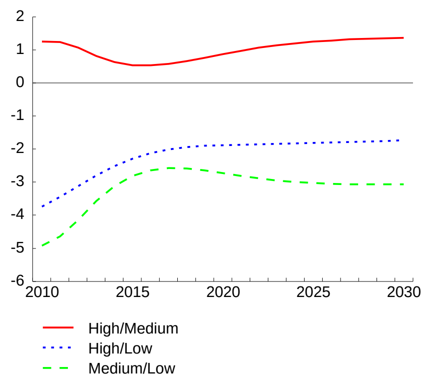


Figure E4: Wholesale and retail trade. Effects of deunionization on production, hours worked, capital intensity, materials, productivity and relative employmentization relative to the baseline scenario. Percent

[Production, hours worked, skill intensity, materials and



productivity] [Relative



employment]

Figure E5: Other private services. Effects of deunionization on production, hours worked, capital intensity, materials, productivity and relative employmentization relative to the baseline scenario. Percent

Figures E2, E3, E4 and E5 shows the effects on the production structure and on relative employment in four large industries. Since demand mainly increases in industries which are directed towards the domestic market, production increases more in wholesale and retail trade and in other market-oriented services than in the manufacture of engineering products. The level of consumer goods production is also higher than in the baseline scenario. However, the effects are small and decline over time. In other private services, production is skill-intensive, and the effect on gross production is negative; see Table E2. Employment is accordingly substituted for investment, so capital intensity picks up towards 2030. This, in turn, dampens the decline in production through higher productivity. This development is also seen in the manufacture of engineering products.

In line with the average slope parameters in miscellaneous manufacturing, Figure E2 shows that relative employment between high and medium-skilled labor is reduced on the same scale as between medium- and low-skilled labor. Since relative wages are reduced most between high and low-skilled labor and the elasticity of substitution is higher between medium- and low-skilled labor, this is reasonable. Relative employment remains fairly unchanged between high and medium-skilled labor.

In engineering products, substitution possibilities are more limited and the effect on relative employment of all skill groups is small; see Figure E3. The slope parameter for wholesale and retail trade is negative and quite similar between high-skilled and low-skilled labor and between medium-skilled and low-skilled, while substitution possibilities are more pronounced between high-skilled and medium-skilled. Since the shift in the wage curve is about twice as large between high and low-skilled labor, the effect is most pronounced between these labor inputs in Figure E4. The relative employment of high- and medium-skilled labor is reduced more than the relative employment of medium- and low-skilled labor. In other market oriented services, relative demand for labor is highly inelastic between high and medium-skilled, and they are found to be complements. Substitution possibilities are larger between medium and low-skilled than between high and medium-skilled labor. As such, Figure E5 shows that the effect of increased relative wages is a small increase in the employment of high-skilled relative to medium-skilled labor in 2030. Relative employment of high and medium-skilled labor has decreased by 2 percent while medium-skilled labor is substituted for low-skilled labor, resulting in a reduction in relative employment of about 3 percent in 2030.

Table 3 shows the effects of deunionization and increased taxes on employment broken down by skill groups, total employment, the ratio of employment to value added, the ratio of capital to value added and finally, the effect on relative employment compared with the baseline scenario for the various industries together with the skill composition in 2010. In general, employment of high-skilled relative to low-skilled labor is reduced compared to the baseline scenario. This is also the case for relative employment between medium and low-skilled labor. Between high-skilled and medium-skilled labor, the effects are more ambiguous.Iin absolute terms, the demand for labor by skill group also depends on the effects on overall demand for labor in the various industries and how large the industries are. Abstracting from the public sector, demand for persons with low skills is almost 1 percent higher, while demand for medium-skilled persons is 0.5 percent lower. Demand for high-skilled persons is 0.3 percent lower. Thus, even though medium-skilled labor has not become more expensive in this scenario, the demand effects outside the public sector are more pronounced among medium-skilled than among high-skilled labor. This is mainly because substitution possibilities between high-skilled and other skill groups are limited. Medium-skilled persons are to a larger extent substitutes for low-skilled persons.

Table E2: Skill composistion in 2010 and effects of deunionization in 2030.

	Skill composition			Change in working hours, capital and value added							Change in skill composition		
	N_H/N_M	N_H/N_L	N_M/N_L	N_H [a]	N_M [a]	N_L [a]	N [a]	$\Delta(N/Q)$ [b]	$\Delta(K/Q)$ [b]	Q [a]	$\Delta(N_H/N_M)$ [b]	$\Delta(N_H/N_L)$ [b]	$\Delta(N_M/N_L)$ [b]
Consumer goods	0.31	0.41	1.31	-0.20	0.15	0.66	0.62	-0.23	-1.58	0.72	-0.01	-0.01	-0.02
Misc. manufacturing	0.38	0.70	1.87	-0.72	-2.5	3.81	0.59	0.31	-0.53	0.43	0.00	-0.11	-0.3
Energy-intensive manuf.	0.32	1.80	5.69	-0.10	0.07	-0.01	-0.03	0.13	0.59	-0.20	0.00	-0.01	0.01
Engineering products	0.44	1.69	3.85	-0.10	-0.04	-0.02	-0.17	0.01	0.19	-0.18	0.00	0.00	0.00
Construction	0.17	0.76	4.46	-0.17	-2.63	3.43	0.62	0.29	-0.65	0.49	0.00	-0.14	-0.92
Financial intermediates	1.99	1.33	0.67	-0.15	0.40	-0.27	-0.02	-0.06	0.07	0.08	-0.04	0.01	0.02
Oil and gas exploration	3.36	4.06	1.21	-2.74	0.70	1.47	-0.57	-0.07	0.00	0.00	-0.26	-0.5	-0.06
Electricity	0.78	5.66	7.28	-0.58	-0.51	0.72	-0.37	-0.08	0.28	-0.05	0.00	-0.59	-0.73
Domestic transp.	0.47	0.38	0.81	-0.18	0.18	0.63	0.62	0.29	-1.08	0.50	-0.01	-0.01	-0.01
Wholesale and retail trade	0.63	0.46	0.73	-0.51	0.12	0.92	0.53	0.22	-0.37	0.39	-0.02	-0.02	-0.01
ICT	3.05	2.1	0.69	-0.23	-0.36	0.3	-0.28	-0.18	0.12	-0.05	0.05	-0.03	-0.02
Other private services	1.79	1.41	0.78	-0.14	-0.41	0.45	-0.09	-0.03	0.23	-0.08	0.02	-0.02	-0.02
Real estate activities	1.73	1.48	0.86	-0.19	-0.42	0.32	-0.29	-0.14	1.76	0.00	0.02	-0.02	-0.02
Total[c]	0.87	1.01	1.16	-0.28	-0.44	0.91	0.18	0.09	-0.10	0.06	0.00	-0.04	-0.05

[a] Columns N_H, N_M, N_L, N and Q show deviation from the baseline scenario in percent.
[b] Δ denotes absolute change in ratio of the variables N/Q,K/Q, N_H/N_M, N_H/N_L and N_M/N_L.
[c] All industries less public sector