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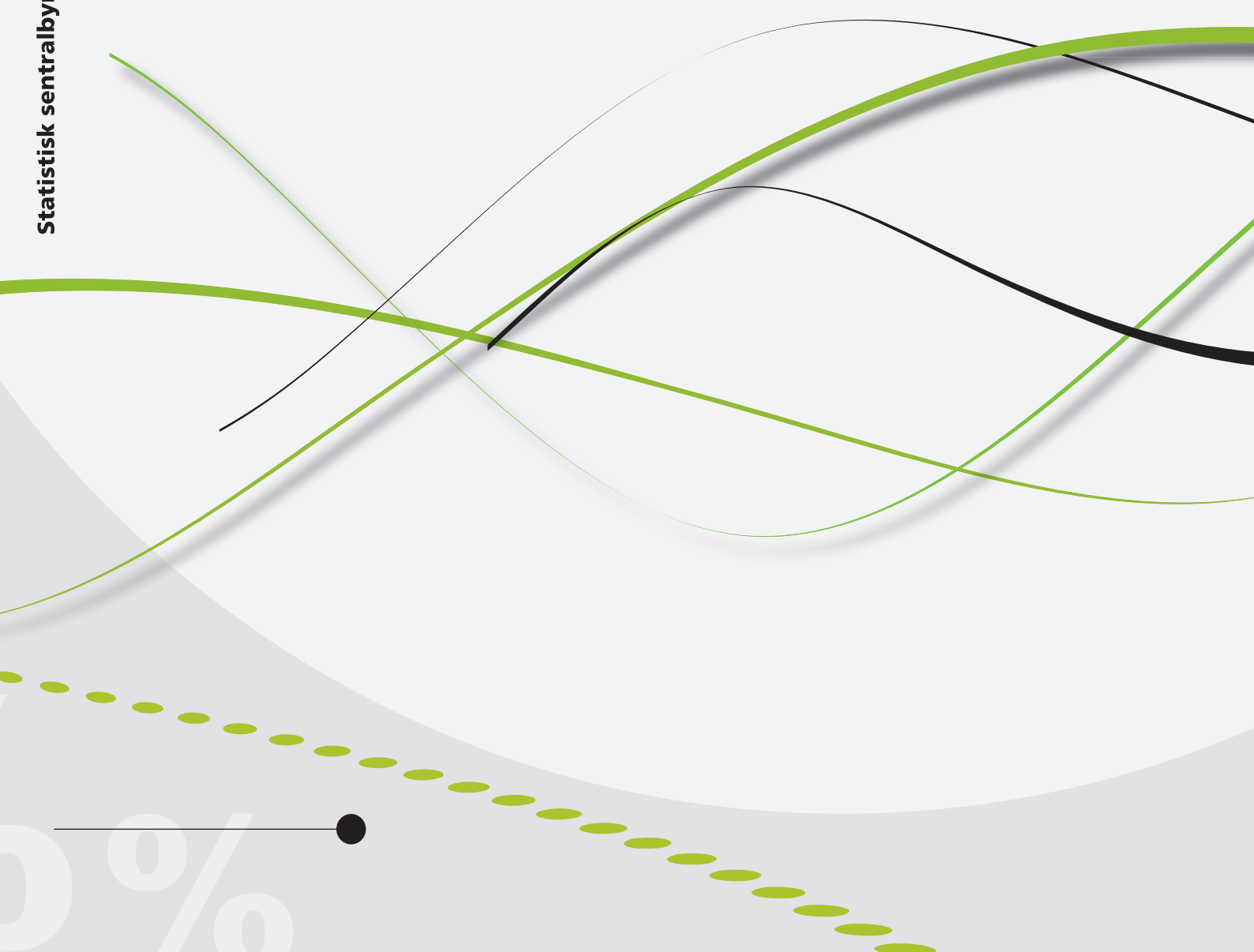
Kristine Wika Haraldsen, Roger Hammersland, Victoria Sparrman

Wage equations and labour demand by education



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Preface[1]

Since the early 1990s, Statistics Norway has produced model-based projections on demand and supply of labour by education. The demand and supply side have been modeled separately, but in a consistent manner. The multi-sectoral macroeconomic model MODAG has been the core model on the demand side, and the model is constantly being updated taking into account new data and research. The projections from this model system are uncertain because the projection period is quite long and because they are based on simplifying and discussable assumptions. Therefore, the results must be used with caution.

This report presents new research on the demand side of the model. New wage relations and demand functions are estimated using new knowledge and latest available data. Kristine Wika Haraldsen has estimated wage equations and updated the sub-model by educational fields. Roger Hammersland has estimated demand functions. Victoria Sparrman has contributed in all parts of the report.

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Statistics Norway, 8 November 2015.

Christine Meyer

[1]Many thanks also to Bjorn Dapi, Håvard Hungnes and Torbjørn Hœgeland for their valuable comments on the report and the projections, and to Robin Choudhury for implementing the new relations to the model. Thank you, Jørgen Ouren, Ådne Cappelen, Nils Martin Stølen and Torbjørn Eika, for valuable discussions related to the projections.

Abstract

This report presents new research on the labour market in a special version the macroeconomic model MODAG. New wage relations and demand functions are estimated using new knowledge and the latest available data. These relations are the basis for new projections of demand for labour until 2030, and the results are compared to the previous report on employment by education by Cappelen, Gjefsen, Gjelsvik, Holm and Stølen (2013). The wage relations describing education-specific wage formation were previously estimated by Bjørnstad and Skjerpen (2006), and Gjelsvik (2013) provided a documentation of the previous model of demand for labour by education and industry. The previous wage relations were constructed using data from 1972 to 1997, and the previous demand functions used data from 1972 to 2007.

Much has changed in the Norwegian economy since 1997, including the introduction of inflation targeting in 2001 and a surge in immigration since the expansion of EU in 2004. These incidents may have changed the bargaining power and the relative size of the different educational groups and may have affected the system of wage pattern bargaining. To account for these recent incidents, new equations are estimated to describe wage growth using data from 1972 to 2012. Compared to the previous results, wages above or below equilibrium will be counteracted more rapidly through reduced or increased wage growth. However, the group of workers with education corresponding to at least a Master degree can deviate from equilibrium for a longer time period. This difference in wage setting may affect the bargaining power and the degree of coordination in wage bargaining. In addition, the aggregation level of industries has changed since the previous estimations were constructed. To account for such changes, new cost shares representing demand for labour are estimated for three educational groups.

The model with new wage relations and demand functions is used to project demand for labour by education until 2030. The projections show that the previous trends of increasing demand for workers with tertiary education and upper secondary vocational education will continue. A decreasing share of demand is directed towards primary, lower secondary and upper secondary general education as the highest level of completed education. In addition, for employees with tertiary education, the projections show growth in demand for most educational fields, and particularly for candidates in economics and administration, as well as in nursing and social care.

To illustrate the importance of including immigration in the wage relations, a stylized shift in gross migration flow is conducted. The aim of this exercise is to illustrate the wage formation properties of the model. An increase in immigration by 15 000 people from 2015 to 2030, combined with an increase in the outflow of labour by 15000 from 2016 to 2030 is considered. Results show that this will reduce hourly wages by 4.1 percent in real terms in 2030 relative to the baseline scenario. This increases the employment rate, reduces unemployment and improves the competitiveness of the internationally exposed sector. The decline in real wages is so large that the impact of reduced consumption dominates the competition improvement and GDP decreases. The effect on the economy depends on the skill composition of the immigrants. The effect on the economy, i.e. the effect on GDP, is less negatively affected when the increase in supply has a skill distribution that is similar to the hosting country. One potential explanation is related to the degree of mismatch in the labor market, as reflected by the effect on unemployment. When the supply shock has the same skill composition as the host country each education-group experiences a reduction in unemployment. In contrast, when the supply shock has a skewed skill com-

position the education-group that is directly affected experiences an increase in unemployment.

The model used for projection of demand for labour does not take into account the latest developments in oil price, petroleum investments and unemployment. The last part of the report presents the latest developments and discusses how these may affect the projections until 2030. Changes in the composition of industries may affect demand for labour by education. Increasing activity in the building and construction industry is expected to increase the demand for workers with vocational education while decreasing activity in the petroleum sector reduces demand for some types of engineers.

Both for future students, employers and the authorities, projections on demand and supply of labour by different kinds of education are valuable information. Students must decide on which subjects to study, for employers it is important for long-term planning, and the authorities must plan educational capacity, industrial development and welfare reforms. In this respect it is interesting how increased immigration affects the composition of the labour force.

Sammendrag

Denne rapporten presenterer ny forskning om arbeidsmarkedet i den makroøkonomiske modellen MODAG. Nye lønns- og etterspørselsfunksjoner er estimert basert på ny kunnskap og siste tilgjengelige data. Disse relasjonene er grunnlaget for en ny framskrivning av etterspørsel etter arbeidskraft fram til 2030, og framskrivningen sammenliges med Statistisk sentralbyrås forrige rapport om sysselsetting etter utdanning av Cappelen, Gjefsen, Gjelsvik, Holm and Stølen (2013). Lønnsrelasjoner som beskriver utdanningsspesifikk lønnsdannelse er tidligere estimert av Bjørnstad and Skjerpen (2006), mens Gjelsvik (2013) dokumenterer den forrige modellen av etterspørsel etter arbeidskraft fordelt på utdanning og industri. De tidligere relasjonene ble estimert ved bruk av data fra 1972 til henholdsvis 1997 og 2007.

Mye har endret seg i norsk økonomi siden 1997, blant annet innføringen av inflasjonsmål i 2001 og en økning i innvandringen siden utvidelsen av EU i 2004. Disse hendelsene kan ha endret forhandlingsstyrken til ulike utdanningsgrupper og påvirket systemet for lønnsfølging. For å ta høyde for disse endringene er nye lønnsligninger estimert over perioden 1972 til 2012. Sammenlignet med tidligere resultater beveger lønn for fire av fem utdanningsgrupper seg raskere mot likevekt i lønnsledende sektor. Det tyder på at lønnsnivåer over eller under likevekt vil bli motvirket raskere gjennom lønnsveksten. For arbeidstakere med utdanning tilsvarende en mastergrad eller mer er resultatet motsatt slik at lønningene i denne gruppen kan avvike fra likevekt i en lengre tidsperiode. At lønnsdannelsen i denne gruppen skiller seg fra de andre gruppene kan på sikt påvirke forhandlingsstyrken og graden av koordinering i lønnsforhandlingene. I tillegg er aggregeringen av næringer endret og derfor er nye etterspørselsrelasjoner estimert for tre utdanningsgrupper. Bedrifters etterspørsel etter ulike typer arbeidskraft varierer på tvers av bransjer og endringer i næringsstrukturen vil påvirke den relative etterspørselen etter ulike typer arbeidskraft.

Modellen med nye lønnsrelasjoner og etterspørselsfunksjoner brukes til å framskrive etterspørsel etter arbeidskraft fordelt på utdanning fram mot 2030. Framskrivningene viser at tidligere trender med økende etterspørsel etter arbeidstakere med bachelor- og mastergrad samt videregående yrkesutdanning fortsatt vil øke fram mot 2030. Etterspørselen rettet mot arbeidstakere med grunnskole og videregående allmennutdanning som høyeste fullførte utdanning avtar. Framskrivningene viser særlig sterk vekst i etterspørselen etter arbeidstakere med høyere utdanning innen økonomi og administrasjon samt innen pleie- og omsorgsfag og helse- og sosialfag.

For å belyse betydningen av å inkludere innvandring i lønnsrelasjonene, er det utført et stilisert skift i inn- og utvandringen. Skiftet sikter på å belyse hvordan lønnsrelasjonene virker i modellen. Resultatene viser at en økning i bruttoinnstrømningen av arbeidsinnvandrere på 15 000 personer, kombinert med en økning i utvandringen slik befolkningen er om lag uendret fra 2015 til 2030, vil redusere reallønn per time med 4.1 prosent i 2030. Dette bidrar til å øke sysselsetingen, redusere arbeidsledigheten og bedre rammevilkår for konkurranseutsatt sektor. Imidlertid er reallønnsnedgangen så stor at den innenlandske effekten med redusert konsum dominerer konkurranseforbedringen og dermed reduseres BNP. Effekten på økonomien avhenger av utdannings- sammensetningen av innvandrerne. Effekten på økonomien er mindre når økningen i tilbudet har en utdanningsfordeling som ligner vertslandet. En mulig forklaring er knyttet til graden av mistilpasning i arbeidsmarkedet, noe som reflekteres av effekten på arbeidsledigheten. Når innvandrerne har samme utdanningsfordeling som vertslandet vil hver utdanningsgruppe oppleve en reduksjon i arbeidsledigheten. Når innvandrerne har en skjev utdanningsfordeling vil utdanning-

gruppen som er direkte berørt oppleve en økning i arbeidsledigheten.

I siste del av rapporten diskuteres de seneste utviklingstrekk i norsk økonomi. Lav oljepris, redusert aktivitet i oljesektoren og økende arbeidsledighet kan påvirke framskrivningene i rapporten. Endringer i sammensetningen av næringer påvirker etterspørselen etter arbeidskraft fordelt på utdanning. Særlig øker aktiviteten i bygg- og anleggsnæringen etterspørselen etter arbeidstakere med yrkesrettet utdanning.

Kunnskap om hvordan etterspørsel for ulike typer arbeidskraft kan utvikle seg kan være til nytte for studenter, arbeidsgivere og myndighetene. For studenter kan det være nyttig for valg av utdanning, mens det gir arbeidsgiverne informasjon om framtidige rekrutteringsmuligheter. For myndighetene vil informasjonen spesielt være viktig i forbindelse med planlegging av utdanningskapasitet, nœringspolitikk og velferdsordninger.

Contents

1 Introduction

In Norway, the system of collective wage bargaining is a tripartite cooperation between trade unions, employer organizations and the government. This system makes the parties in the wage setting process face a trade-off between wages and employment which may moderate their wage claims. Like in most OECD-countries, Norway has experienced shifts in the composition of labour by education, but differences in wages and unemployment rates between educational groups have been more stable.

However, the Norwegian economy has changed over the last decades, which may affect the wage bargaining process and demand for labour. The introduction of inflation targeting in 2001 may have affected the importance of the system of wage leader and wage followers in the Scandinavian model of inflation (Calmfors and Larsson Seim (2013)). The surge in immigration since 2004 may also have changed the bargaining power of the different educational groups (Bratsberg et al. (2014)).

The aim of this report is to investigate whether some of the recent changes have affected the wage setting process, the demand relationships, and the previous projections of demand for labour by education in Cappelen, Gjefsen, Gjelsvik, Holm and Stølen (2013). The former model was based on data from 1972 to 1997, for the wage relations, and 1972 to 2007, for the demand relations. Based on these relations, demand for labour by education was projected for the period 2013 to 2030. As already mentioned, much has changed since 1997, but there are also substantial changes since 2007, including a major revision in National Accounts in 2014. The revision resulted in new data for labour by industry and education. Gjelsvik (2013) shows how firms demand for labour by education varies across industries. Therefore changes in industry structure, such as decreased activity in the petroleum sector, may have affected the relative demand for different types of labour. Changes in demand for labour within industries are studied in the projections by educational fields.

The new wage relations are estimated for five educational groups in three sectors using data for the years 1972 to 2012. The results display that wages adjust towards the equilibrium wage share or reference wage, and that this movement is somewhat faster than previously reported for all groups in manufacturing except workers with tertiary education, higher degree. When considering cross-group effects, the group of workers with tertiary education, higher degree, differs from the other educational groups in several respects. Especially, wage growth for this group relative to other educational groups is more strongly affected by productivity growth in manufacturing and by reference wage in the other sectors. This may have implications for the distribution of bargaining power and in the long run it may affect the degree of coordination in Norwegian wage formation.

In addition, the aggregation level of industries has changed since the previous estimations were constructed. To account for such changes, new cost shares representing demand for labour are estimated for three educational groups. The estimation results show that the demand for labour with vocational education and tertiary education increases relative to demand for labour with shorter education.

The model with new wage relations and demand functions is used to project demand for labour by education up to 2030. Demand for labour by five educational groups is modeled for each industry. The five groups are partly substitutes within each industry, and the employment shares depend on relative wages and technological change. The projections show that the previous trends of increasing demand for workers with tertiary education and upper secondary

vocational education will continue towards 2030. A decreasing share of demand is directed towards primary education, lower secondary and upper secondary general programs as the highest level of completed education. In line with previous projections, the disaggregate employment by education and industry into employment by 28 educational fields, show a growth in demand of all fields within tertiary education. In particular, there is an increase in demand in economic and administration, and nursing and social care.

To illustrate the importance of including immigration from land code 1 and 2 in the wage relations, a stylized shift in gross migration flow is conducted[2]. The aim of this exercise is to illustrate the wage formation properties of the model. An increase in immigration flow of 15 000 people from 2015 to 2030, combined with an increase in the outflow of people by 15 000 from 2016 to 2030 is considered. Results show that this will reduce hourly wages by 4.1 per cent in real terms in 2030. This increases the employment rate, reduces unemployment and improves the competitiveness of the internationally exposed sector. The decline in real wages is so large that the impact of reduced consumption dominates the competition improvement, and GDP decreases.

The method used to project labour by education in this report is in line with the suggestion in a survey by Wilson et al. (2004), where it is stressed that the best practice is to use a disaggregated macroeconomic model to project demand for labour. By using information about input of commodities and services from other industries, the model includes an important aspect of industry interaction. In addition to projecting demand for labour by industry in a consistent way, the use of a macroeconomic model also facilitates the analysis of different policy assumptions. A disaggregated model can also distinguish between inter- and intra-industry changes in demand for labour by length of education. For example, not all teachers work in education and the disaggregated approach allows for projecting the number of teachers in different sectors.

The projections in the main part of this report neglect recent and important development in many economic variables. For instance, investments in the petroleum industry began to fall towards the end of 2013, after a decade of contributing massively to the growth of the Norwegian economy. Reduced profitability due to high costs initiated the investment decline, and the fall in oil prices from mid-summer 2014 has contributed to further reduction of investments. The fall in demand from the petroleum sector helped trigger a slowdown in the Norwegian economy. This contributed to lower housing investment and a fall in mainland business investments. The fall continued in 2015, but has been counteracted by expansionary monetary and fiscal policies. The drop in oil prices contributed to reduce inflation from already low levels. Weaker production growth has resulted in low employment growth and increasing unemployment. The decline in oil prices decreases the value of Norwegian exports, resulting in a weaker krone (NOK). Lower profitability in manufacturing together with higher unemployment has curbed wage growth which now is at its lowest level in 20 years. In addition, weak growth in the global economy has contributed to low export growth. Hence, the Norwegian economy is below trend growth. These changes in economic variables from 2013 to 2015 affect the projections of the economy and labour market towards 2030. Towards the end of this report, main characteristics of the current economic situation is to some extent implemented into the model, and used to project the development of endogenous variables, like wage growth and unemployment. The projections show that oil prices will increase from the low level and that the inflation rate will increase gradually. As the economic situation picks up, unemployment is

[2]Land code 1 refers to countries in EU/ EEA in Western Europe in addition to USA, Canada, Australia and New Zealand, while land code 2 consists EU-countries in East Europe.

projected to decline and stay fairly stable at around 3.5 percent. Wage growth is projected to increase from 2017, but to stabilize at a somewhat lower level than in the years around 2010.

The report is structured as follows. The core model is described in Section 2. Section 3 clarifies the data used and how the labour force is classified by education. The subsequent section presents new wage and demand relations and how they affect the projections of composition of labour. In Section 5, projections of the labour force based on the new relations illustrate how demand for labour will change compared to our previous analysis. The main driving force is the effect of immigration on wages, and the effect of changes in immigration flow on the economy is highlighted in Section 6. However, the recent changes in the economy are not incorporated into the projections in Sections 5 and 6. The recent macroeconomic development and how it affects the aggregate economy is discussed in Section 7, but without education specific implications. Section 8 concludes on how the new model is assumed to affect the projections forward.

2 The core model

MODAG is a macroeconomic model of the Norwegian economy developed by Statistics Norway. The model is used for projections and policy analysis. Norway is a small open economy where natural resources such as oil, natural gas and fishing are the basis of large industries. The development in prices of these goods on the world market is important for Norwegian exports and the overall economic situation. In order to construct projections there has to be made a number of assumptions regarding fiscal and monetary policy.

Long run behaviour is based on fairly standard neoclassical economic theory. However, the dynamic adjustments towards the long run are largely estimated to fit the data. It takes time before the effects of exogenous shocks die out and economic developments follow the equilibrium relations. Wage- and price-rigidities lead to Keynesian effects in the short and medium run. For a more detailed documentation see Cappelen, Gjefsen, Gjelsvik, Holm and Stølen (2013), or the Norwegian detailed presentation of MODAG with homogeneous labour by Boug and Dyvi (2008).

The main structure of MODAG implies that prices along with interest rates, exchange rates and wages determine demand from households and firms as well as foreign demand. Interest rates increase with a higher core inflation rate and with a lower unemployment rate in line with flexible inflation targeting introduced in Norway in March 2001.

2.1 Production, capital and labour

The main focus in this report is on the labour market. The development in the labour market is strongly affected by the product market as production volume and price setting affect wages and employment. It is reasonable to assume that the link between the product market and the labour market varies across industries and products. The macroeconomic model MODAG differentiates between 45 products and 22 industries. The advantage of the disaggregated production structure in MODAG is that it can account for considerable heterogeneity between production processes; some are labour-intensive, while others employ relatively little labour. Material inputs are divided in two subgroups and the stock of real capital by industry is disaggregated into five components.

The model contains a large number of final uses (consumption, investment, and exports) of products, and these products have different prices depending on supply (home produced or imports) and destination (exports or home market). Specifically, MODAG balances all products in terms of supply and demand equations. The input-output structure and the account-based relationships are supplemented with econometric equations describing how the agents tend to respond to different options.

Products are generally assumed to be imperfect substitutes. This implies that Norwegian product prices can differ from prices set by foreign competitors. But foreign prices are taken into account by Norwegian producers in their price setting in line with theories of monopolistic competition. Norwegian prices on exports and home market are set as a mark-up on the firms variable costs. The mark-ups usually increase if prices on competing goods produced abroad increase. Foreign prices also affect the firms costs through imported inputs of production.

The volume of exports for each product depends on a world market demand indicator and the Norwegian export price divided by the foreign competitors price in a common currency. Thus exports are in general demand driven. Import of each product is in general an imperfect substitute for the correspond-

ing Norwegian product. The import share for each product is a function of the home price divided by the import price only. The detailed input-output structure captures variations in import shares by user in the base year of the model. An increase in domestic use will lead to more imports for a given import share. Some imports are considered as non-competitive in the sense that there is really no corresponding Norwegian production. In these cases imports are basically determined directly from the supply and use equations of the model.

In MODAG, unemployment is determined residually and labour supply is mainly determined by demographic variables and variables that capture labour market pressure. Labour supply increases if after tax wages increase while demand for labour falls if wage costs increase. Consequently, there are two relationships between real wage and unemployment: (i) the wage setting, resulting in higher real wages when unemployment is low and (ii) the demand for and supply of labour, creating higher unemployment as real wages increase through lower demand for labour. These two relationships jointly determine unemployment such that the real wage implied by the wage setting is consistent with the price setting and the demand for labour. If the unemployment rate is lower than this level, real wages will be higher, leading firms to reduce the demand for labour. The level of unemployment will increase until there is correspondence between the real wage rate implied by wage setting and the real wage rate consistent with the firms price setting and demand for labour.

In line with institutional aspects of Norwegian wage formation, the model distinguishes between three main sectors when modeling wage formation: manufacturing, market oriented service activities and public sector. The sector exposed to international competition, the manufacturing sector, negotiates first and the wage settlement in this sector is the wage norm of the following negotiations in the other sectors. The manufacturing sector adjusts wage towards an equilibrium wage share, and the other sectors use the manufacturing wage as a reference wage, see Gjelsvik et al. (2015). Relative wages for the various industries within each of these three sectors will normally be constant in the long run.

3 Data and Classification by education

Classification of the labour force by skill is common in the literature, as in Machin (2001) and Kremer and Maskin (2006). Skills are not directly observable and therefore length of education is often used as a measure of skills. This is a practical way of distinguishing between different workers. However, there are weaknesses associated with the use of these variables. The distinction between different occupations is not always evident, and a persons occupation may change if he or she moves from one industry to another, even though the person's skills do not change. Also, one may be employed in an occupation that does not match the person's skills. Length of education does not capture skills acquired at work.

In this study, the labour force is disaggregated by education instead of occupation because of fewer shortcomings and good data availability. Information about a person's education is available from administrative registers covering almost the entire population, and a person's educational level is fixed until he or she eventually fulfills a higher level of education. Hence, formal education is used as an indicator of the worker's skills. The educational programs are grouped according to Norwegian Educational Standard (NUS) which was established by Statistics Norway in 1970 and was updated in 2000 (NUS2000). The standard corresponds closely with the International Standard Classification of Education (ISCED) developed by UNESCO to facilitate comparisons of education statistics and indicators across countries on the basis of uniform and internationally agreed definitions. The main levels of classification and further sub-classification of the educational fields are presented in Appendix A.

In this study, the labour force is disaggregated into five educational groups. Workers are grouped based on completed educational level. The first group (GRK) includes workers with primary education and lower secondary education, defined as less than 11 years of formal education. This group also includes those with unreported education level. The workers with upper secondary education are divided into two groups; upper secondary education, general programs (VA), and upper secondary education, vocational programs (VF). Workers with tertiary education, lower degree (HO), have completed education which corresponds to a Bachelor degree. The top educational group contains workers with tertiary education, higher degree (UN), which corresponds to a Master degree or more.

Post-secondary non-tertiary education (fagskole) in Norway is based on upper secondary education or equivalent informal competence. The educational courses cover a wide range of educational programs in several disciplines. The duration is at least half a year and maximum two years. In this study it is classified as upper secondary education, vocational programs (VF). Separate statistics for this particular group is recently developed, see Gjefsen (2015).

By merging information about educational level and industry, it is possible to meet the needs for information about the labour force on a more disaggregated level. The five educational groups are disaggregated into 28 educational groups by defining educational fields with close correspondence to occupation. In the division of employment fields, the aim is to achieve the greatest possible homogeneity within subgroups regarding supply and demand for labour is taken into account.

The projection procedure of the 28 educational fields is presented in Bjørnstad et al. (2010). The National Register of Employers and Employees made by the Norwegian Labour and Welfare Administration (NAV) are matched with the Norwegian Register of the Populations Highest Level of Education and the Central Register of Establishments and Enterprises. By calculating education-specific employment shares and assuming a continuing trend in these shares,

industry-specific employment is projected by field of education. The projection method implies that if employment of persons with an educational field in a specific industry has increased strongly in the data period, the future employment also increases, but at a slower pace. The results of the projection procedure are in accordance with employment by education in MODAG at the aggregate level.

3.1 Data by education

This report uses new data from the National Accounts. There have been some changes in the aggregation of industries in the data since the previous report in 2013. The petroleum industry is disaggregated into the extraction industry and services related to the petroleum industry. Likewise the information and communication industry and real estate activities are separated from other administrative and support service activities. In addition, there is one new industry covering research and development. This new aggregation is implemented in the model.

The National Accounts provide data on hours worked, employment and hourly wage rates for various production sectors by the five educational categories for the period 1972-2012. Time series for labour supply by education category were constructed using education-specific unemployment rates from Statistics Norways Labour Force Survey.

This study uses data on educational fields, not on different tasks or jobs. In principle an employee may have long education, but the job does not correspond to this level of education. This employee will be aggregated together with other employees with a similar education although they may perform different tasks.

4 The labour market by education

Total employment has increased by more than one million workers since 1970. In Figure 1, employment is disaggregated into five educational groups, which makes it possible to see that there has been a dramatic change in the composition of employment in this period. Employment of workers with primary education has declined and employment of workers with tertiary education has increased. Disaggregation by education makes it possible to compare groups and to project demand for different types of labour.

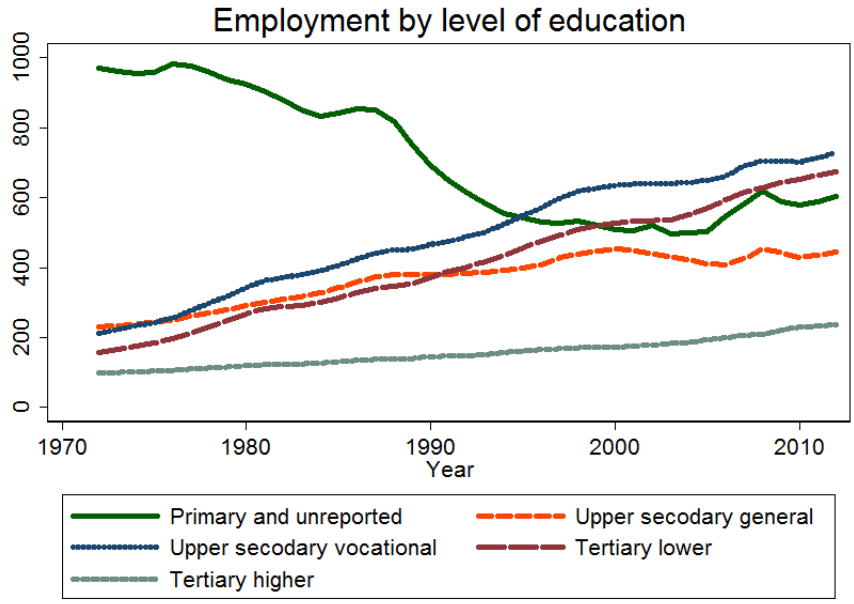

Figure 1: The development of employment by level of education from 1972 to 2012.

The model used in this report is a version of MODAG with heterogeneous labour as labour is divided into five educational groups by length of completed education, see Section 3 for further details. The groups are primary education, which includes workers with unreported education, upper secondary education, general programs, upper secondary education, vocational programs, tertiary education, lower degree, and tertiary education, higher degree. The two last groups correspond to Bachelor degree and Master degree. Upper secondary education, vocational programs, also contains workers with post-secondary non-tertiary vocational education (fagskole). The model is used in this study to investigate differences between workers with different educational levels.

Labour supplies for the five educational groups are also included in the model by linking equations for labour market participation by age and gender to the corresponding group of individuals in working age. The wage equations are estimated for each of the five educational groups in each of the three main sectors to obtain an explicit measure of wage flexibility, see Section 4 for a detailed explanation. However, changes in relative wages have no effect on peoples choices of education in the model. Firms demand for various types of labour varies across industries, and therefore changes in industry structure affect the relative demand for different types of labour at the aggregate level, see Section 4.4 for details.

However, equilibrium correction mechanisms are not strong enough to secure the steady state path when labour is disaggregated by five educational levels. Therefore total unemployment is exogenously distributed on the five ed-

ucational groups by using the historical differences in unemployment between educational levels, and labour supply is defined as the sum of employed and unemployed. Hence future mismatch on the labour market by level or field of education cannot be analyzed using MODAG alone, see Bjørnstad et al. (2010). This happens as wages are set in five educational groups in manufacturing and the groups in the other sectors follows wages within their educational group. Therefore there is error correction within each group, but the general error correction across groups is not strong enough to ensure a steady level of unemployment. It is reasonable to assume that the workers compare wages to others within the educational group rather than to other educational groups within the sector. The consequence is to suspend an important error correction mechanism when setting the unemployment rate as exogenous.

Detailed information on employees by fields of education is provided by using register data for all workers in Norway. The register data is grouped into 28 educational fields, see Appendix A for a complete list. The sub-model providing the projection by educational fields is a procedure where education-specific employment shares are calculated by use of micro data on workers completed educational field, before the employment shares are matched with macro data on employment by educational groups. A continuing trend is assumed in the employment shares and they extrapolated using data from 1986 to 2012. Industry-specific employment is projected by field of education. The projecting method implies that if employment of persons with an educational field in a specific industry has increased strongly in the data period, the future employment also increases, but at a slower pace. All in all, the current method of projecting employment by educational field is the same as in the projections from 2010 and 2013.

4.1 Method of estimating new wage relations

Much has changed in the Norwegian economy the last fifteen years, including the introduction of inflation targeting in 2001 and a surge in immigration since 2004. Immigration may change the bargaining power of the different educational groups, and the introduction of inflation targeting may have affected the system of wage leader and wage followers. It is likely that changes in the Norwegian economy affect wage setting and hence cause further changes in the wage relations of different educational groups.

The Norwegian wage settlements are characterized by a specific pattern in wage bargaining in three sectors; manufacturing, market oriented service activities and public sector. The unions and employer federations in manufacturing which is exposed to international competition negotiate first, while the other sectors usually follow the wage norm set by manufacturing. This is captured in the wage relations through error correction terms that bring wage rates towards an equilibrium wage share for the manufacturing sector and toward an equilibrium reference wage for the other sectors. In addition, unemployment, immigration, consumer prices and other variables affect the determination of growth in hourly wages for Norwegian workers.

Estimation of the wage relations are based on previous work by Bjørnstad and Skjerpen (2006). The wage relations presented here may be compared to previous wage relations reprinted in Appendix C.2 . This section is based on Haraldsen (2015) where market oriented service activities is referred to as private services, hence private services and market oriented service activities are used interchangeably.

The wage relations are estimated with seemingly unrelated regression (SUR) while the previous relations used fixed effects analysis where they control for

education fixed heterogeneity for each sector. Estimation with SUR allows for correlation in the error-terms of the wage equations for five educational groups. The advantage of this method is that it accounts for correlation between wages for the educational groups, and that the explanatory variables can differ across equations. Equations for each educational group within a sector are estimated jointly in a system of equations. The SUR-approach is used to estimate a fully heterogeneous model, test the restrictions implied by the model and ensure that the estimated coefficients are efficient to correlation in the error-terms. Heterogeneity allows for fixed educational effects in all sectors. The full heterogeneous model presented in Appendix B.1 is rich and is restricted to attain more precise estimates following a general to specific approach.

The model is reduced by imposing restrictions on the full heterogeneous model, either by assuming that the variables have equal or no effect on the wage growth. Imposing equal coefficients is considered less strict than omitting variables and this procedure is therefore conducted first. All restrictions are evaluated by F-tests. Some of the estimated coefficients in Appendix B.1 are equal across educational groups. As an example, the estimated coefficients for the wage share-term ($(wc_{m,i} - q - z)_{t-1}$) in manufacturing differ with a numerical value of only 0,03 for all groups except for the top educational group. The null-hypothesis of equal coefficients for the four educational groups is not rejected by data. This means that there is no significant difference in the speed in which the four lowest educational groups move towards the equilibrium wage share, although their equilibrium wage shares are different. The top educational group seems to experience a significantly lower effect, implying that adjustment towards the equilibrium wage share is slower for this group.

The wage equations are in error-correction form and they model changes in hourly wage costs in manufacturing (m) and hourly wages in public (g) and private (s) sector for five educational groups (i) at time t measured in years.

Manufacturing:

$$\begin{aligned}\Delta wc_{mit} = \gamma_{0mi} - \gamma_{1mi}(wc_{mi} - q - z)_{t-1} - \gamma_{2mi}u_{it-1} + \gamma_{3mi}\Delta wc_{mit-1} + \gamma_{4mi}\Delta z_t \\ -\gamma_{5mi}\Delta h_t + \gamma_{6mi}\Delta p_t - \gamma_{7mi}\Delta u_t - \gamma_{8mi}Immigration + e_{mit}\end{aligned} \tag{1}$$

Public sector:

$$\begin{aligned}\Delta ww_{git} = \gamma_{0gi} - \gamma_{1gi}(ww_{gi} - kwa_{gi})_{t-1} - \gamma_{2gi}u_{it-1} + \gamma_{3gi}\Delta ww_{git-1} \\ +\gamma_{4gi}\Delta kwa_{git-1} + \gamma_{5gi}\Delta p_t - \gamma_{6gi}Immigration + e_{git}\end{aligned} \tag{2}$$

Private services:

$$\begin{aligned}\Delta ww_{sit} = \gamma_{0si} - \gamma_{1si}(ww_{si} - kwa_{si})_{t-1} - \gamma_{2si}u_{it-1} + \gamma_{3si}\Delta ww_{sit-1} + \gamma_{4si}\Delta kwa_{sit-1} \\ +\gamma_{5si}\Delta^2 p_t - \gamma_{6si}\Delta u_t - \gamma_{7si}Immigration + e_{sit}\end{aligned} \tag{3}$$

Here ww is hourly wages and $wc(= ww + tf, tf = log(1 + payroll\ tax\ rate))$ is hourly wage cost, an additional term to capture the difference between the wage cost and the wage received by workers (ww) due to the payroll tax paid by employers. q is producer prices; z is labour productivity; u is general unemployment; u_i is education specific unemployment; p is the consumer price index; h is normal working hours. Furthermore, some dummy variables from Bjørnstad and Skjerpen (2006) and some dummy variables for large outliers are included. $D_{1988-1997}$ represents a regime-switch in the wage equation for workers with high university education and D_{WF} represents wage freeze laws in 1979,

1988 and 1989 [3]. *Immigration* captures the flow of immigration in percent from land code 1 and 2[4], *kwa* is the reference wage for public and private sector, and e_{it} is the error-term. In the equations for the public and private sector the error-correction-term is substituted by a wage following-term, and fewer of the explanatory variables are included. All variables, except *Immigration*, are in logarithmic scale and Δ indicates that the variables are measured in first differences.

4.2 Economic implications of new wage relations

The estimation results of the restricted model are presented in Table 1. The estimated coefficients of the pattern bargaining model, the wage share-terms and reference wage-terms, are all negative. The interpretation is that if a shock should increase actual wage share above/below the equilibrium wage share the wage growth will decrease/increase until the wage share reaches its equilibrium. In the manufacturing sector, a shock to productivity, producer prices or wages would change the actual wage share away from its equilibrium, and the negative effects of the wage share term ensures that wage growth adjusts wages towards it's equilibrium. The estimated effect is -0,18 for the four lowest groups, as presented in the first line in Table 1. For the top educational group the estimated effect is -0,10, implying that this group has a slower adjustment toward the equilibrium wage share. This means that wages in the top educational group can deviate from the equilibrium wage share for a longer time period compared to the other groups. Hence, wage growth for this group is determined differently than for the other groups, and this may have implications for the bargaining power of this group.

In the other sectors, the estimated negative effect of the reference wage-terms implies error-correction towards a reference wage. The interpretation of the long run relationship is that the wage growth will adjust towards equilibrium as a response to a sector-specific shock. As seen in first row of the middle panel in Table 1, the estimated elasticity in public sector is -0,17 for the two top educational groups, and significantly higher in the group of workers with upper secondary education, general programs where it is -0,41. This means that the actual wage share in the two top groups can deviate from the equilibrium wage share longer, compared to the group of workers with shorter education. The estimated effects of the groups of workers with primary and vocational upper secondary education are not significant.

In the private services, presented in the bottom panel of Table 1, the estimated coefficient on the reference wage-term is -0,15 for all groups. Hence a sector-specific shock would affect wage growth equally across educational groups.

The effects of the level of education-specific unemployment ($u_{i,t-1}$) are negative in all sectors, indicating that an increase in unemployment is associated with a decrease in wage growth for each educational group. The effects are numerically small and barely significant, but they are part of the long term dynamics shaping wage growth in the long run. Gjelsvik et al. (2015) consider the same sectors, but do not distinguish between educational groups and have similar findings. In the long run, changes in unemployment affect the incentives to coordinate and may lead to a higher or lower degree of coordination. Hence, the variable is an important part of the wage relations, and is included in all sectors although the estimated effects are not significant at usual levels and the numeri-

[3] $D_{1988-1997}$ = 1 in the years 1988-1997 and zero otherwise. D_{WF} = 1 in 1979, 1988 and 1989 and zero otherwise.

[4] Land code 1 refers to countries in EU/ EEA in Western Europe in addition to USA, Canada, Australia and New Zealand, while land code 2 consists EU-countries in East Europe.

Table 1: Growth in wage costs in manufacturing and hourly wages in public sector and private services.[1]

Manufacturing	Primary		Sec. General		Sec. Vocational		Low univ.		High univ.	
	Estimate	Std	Estimate	Std	Estimate	Std	Estimate	Std	Estimate	Std
Wage share$_{i,t-1}$	-0.18	(0.03)	-0.18	(0.03)	-0.18	(0.03)	-0.18	(0.03)	-0.09	(0.02)
$u_{i,t-1}$	-0.01	(0.01)	-0.01	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)
$\Delta wc_{m,i,t-1}$	0.32	(0.06)	0.32	(0.06)	0.32	(0.06)	0.32	(0.06)	0.27	(0.07)
Δz_t			0.12	(0.04)	0.12	(0.04)	0.12	(0.04)	0.25	(0.05)
Δh_t	-0.29	(0.10)	-0.29	(0.10)	-0.29	(0.10)	-0.29	(0.10)		
Δp_t	0.79	(0.13)	0.95	(0.09)	0.95	(0.09)	0.95	(0.09)	0.95	(0.09)
Δu_t	-0.04	(0.01)	-0.04	(0.01)	-0.04	(0.01)	-0.04	(0.01)	-0.04	(0.01)
Immigration	-0.02	(0.01)	-0.00	(0.01)	-0.00	(0.01)	-0.01	(0.01)	-0.02	(0.01)
D_{2008}	-0.03	(0.01)	-0.07	(0.01)						
D_{1991}			0.03	(0.01)						
D_{1992}			-0.04	(0.01)						
D_{1978}					0.04	(0.01)				
D_{2003}					-0.01	(0.01)				
D_{WF}							0.00	(0.00)		
$D_{1988-1997}$									-0.01	(0.00)
Constant	1.23	(0.20)	1.23	(0.21)	1.22	(0.21)	1.27	(0.22)	0.69	(0.17)

Public sector	Primary		Sec. General		Sec. Vocational		Low univ.		High univ.	
	Estimate	Std	Estimate	Std	Estimate	Std	Estimate	Std	Estimate	Std
$(ww_{g,i} - kwa_{g,i})_{t-1}$	-0.09	(0.10)	-0.41	(0.08)	0.00	(0.00)	-0.17	(0.07)	-0.17	(0.07)
$u_{i,t-1}$	-0.03	(0.02)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)
$\Delta ww_{g,i,t-1}$	-0.30	(0.06)	-0.30	(0.06)	-0.17	(0.07)	-0.09	(0.10)	-0.40	(0.12)
$\Delta kwa_{g,i,t-1}$	0.30	(0.16)	0.43	(0.08)	0.43	(0.08)	0.43	(0.08)	0.71	(0.14)
Δp_t	0.38	(0.18)	0.81	(0.08)	0.54	(0.07)	0.54	(0.07)	0.54	(0.07)
D_{1976}	0.04	(0.02)	0.03	(0.01)	0.05	(0.01)				
D_{1979}	-0.04	(0.02)								
D_{1975}			0.02	(0.01)	0.03	(0.01)	0.03	(0.01)	0.05	(0.02)
D_{1988}			-0.04	(0.01)	-0.04	(0.01)	-0.01	(0.01)		
D_{2008}			0.08	(0.01)	0.03	(0.01)			-0.07	(0.01)
D_{1982}					0.04	(0.01)	0.04	(0.01)		
D_{2001}							0.02	(0.01)		
D_{2009}									0.04	(0.01)
Constant	0.10	(0.04)	-0.04	(0.01)	0.02	(0.01)	-0.02	(0.02)	-0.02	(0.02)

Market oriented	Primary		Sec. General		Sec. Vocational		Low univ.		High univ.	
	Estimate	Std	Estimate	Std	Estimate	Std	Estimate	Std	Estimate	Std
$(ww_{s,i} - kwa_{s,i})_{t-1}$	-0.15	(0.03)	-0.15	(0.03)	-0.15	(0.03)	-0.15	(0.03)	-0.15	(0.03)
$u_{i,t-1}$	-0.00	(0.01)	-0.00	(0.00)	-0.01	(0.00)	0.00	(0.00)	0.00	(0.00)
$\Delta ww_{s,i,t-1}$	0.15	(0.07)	0.15	(0.07)	0.34	(0.05)	0.34	(0.05)	0.34	(0.05)
$\Delta kwa_{s,i,t}$	0.68	(0.04)	0.68	(0.04)	0.68	(0.04)	0.68	(0.04)	0.58	(0.08)
$\Delta^2 p_t$	0.18	(0.06)	0.18	(0.06)	0.18	(0.06)	0.18	(0.06)	0.18	(0.06)
Δu_t	-0.01	(0.01)	-0.01	(0.01)	-0.01	(0.01)	-0.01	(0.01)	-0.01	(0.01)
Immigration	-0.01	(0.01)	-0.00	(0.01)	-0.02	(0.01)	-0.00	(0.01)	-0.01	(0.01)
D_{1978}	0.04	(0.01)								
D_{1982}	0.02	(0.01)								
D_{2008}			-0.06	(0.01)	-0.03	(0.01)	-0.04	(0.01)		
D_{2009}			0.04	(0.01)						
D_{1987}					0.02	(0.01)				
D_{2007}									0.03	(0.01)
Constant	0.02	(0.01)	0.02	(0.01)	0.01	(0.01)	0.01	(0.01)	0.02	(0.01)

[1] Corrected 1. December 2015.

cal value is close to zero. It can be argued that general unemployment may be as important as education-specific unemployment, but it is problematic to include both as they are highly correlated. The estimation shows that education-specific unemployment is more significant for wage growth in private services.

Finally, immigration flow affects the wage level. The estimated effects of immigration are not significant, but following Gjelsvik et al. (2015) they are included in the long term dynamics. The estimated effects are negative, indicating that an increase in immigration reduces wage growth. This may imply that the bargaining power of unions is reduced, but that there are not enough observations in the data set to obtain significant results. The estimated negative effect is in line with basic theory of labour supply and demand. An increase in the supply of labor would lead to an outward shift in the supply curve, causing unemployment to increase, for a given level of demand unless wages decline.

The short term effects in the manufacturing sector are presented in the following. A decrease in normal working hours (Δh_t) is estimated to increase wage growth with an estimated impact of 0,31. A decrease in normal working hours implies that each worker supplies less labour, and hence the supply decreases and the pressure on wage growth increases. The effect is opposite to the effect described above with increased immigration. However, normal working hours are politically determined and have not changed since 1987 when it was changed from 40 to 37,5 hours per week. If normal working hours were changed to six hours per day, i.e. 30 hours per week, the estimated elasticity indicates a substantial increase in hourly wages, all else equal. The estimated effect is equal across educational groups in manufacturing, but there is no estimated effect for the top group. This may be because this group includes managers and other workers who do not adhere to normal working hours.

The short term dynamics in manufacturing are caused by changes in productivity, working hours, consumer prices and hourly wages in the previous period. The coefficient on changes in hourly wages ($\Delta wc_{m,i,t-1}$) is 0,28 for the three lowest educational groups, implying that a one percent increase in this variable is estimated to increase the wage growth with 0,28 percent. This means that growth in hourly wages is associated with further growth. The estimated effects are lower for the two top groups, with 0,27 for the workers with low university education, and 0,24 for workers in the top group.

A one percent increase in changes in productivity (Δz_t) is estimated to increase wage growth with 0,09 percent for the three middle educational groups, 0,24 for the top group, and no effect on the lowest educational group. The estimated short term effect for the top group is more than 2,5 times larger than for the middle groups. However, these are short term effects, while the long term effects of productivity are captured in the wage share-term discussed above. Hence, productivity affects wage growth also in the lowest educational group in the long run.

A one percent increase in changes in consumer prices (Δp_t) is associated with a 0,78 percent increase in wage growth for all groups in manufacturing. This elasticity is high and indicates that a one percent increase in consumer prices leads to a close to one percent, 0,87 percent, increase in wages. Hence, workers are immediately almost fully compensated for changes in inflation. Following Calmfors and Larsson Seim (2013), the wage leader internalizes the effect on prices of wages in all sectors.

A one percent increase in general unemployment (Δu_t) from one year to the next is estimated to decrease wage growth with 0,04 percent for all educational groups. The terms capturing unemployment may also capture other elements of the economic situation, as unemployment is a key indicator of the business cycles, see Sparrman (2012). Low unemployment normally coincides with high

economic activity and high unemployment coincides with low activity. Okuns law describes this inverse relationship between unemployment and growth in GDP, see Okun (1962) and Cuaresma (2003).

Next, the short term effects in the public sector are presented. The short term dynamics are caused by changes in hourly wages, the reference wage and the consumer price index, and these are presented in the second panel of Table 1. An increase in wage growth last year ($\Delta ww_{g,i,t-1}$) is associated with a reduction in wage growth this year. The estimated effect is largest for the top educational group where a one percent increase in wage growth last year is associated with a 0,41 percent decrease in wage growth. The estimated effects differ across groups and are significantly smaller for workers with vocational and lower university education. These educational groups include teachers and nurses which is a large share of public employed workers.

An increase in growth in the reference wage ($\Delta kwa_{g,i,t-1}$) in the public sector is associated with an increase in wage growth. This means that growth in wages in the other sectors coincides with growth in wages in this sector, and this underpins the long term effect of the reference wage-term. The estimated positive effect of changes in the reference wage is largest in the top educational group with an elasticity of 0,71. This might be because workers with high university education have greater mobility between sectors than other groups, hence wages adjust more rapidly to short term changes in the reference wage to prevent the workers from leaving public sector.

Changes in consumer prices (Δp_t), lead to an increase in hourly wages in public sector, and the estimated elasticity is 0,55 for the top three educational groups. The estimated effect is lower for workers with primary education and higher for workers with upper secondary education, general programs. The estimated coefficient must be regarded in conjunction with the effect in manufacturing due to pattern bargaining. Changes in consumer prices, in addition to having a direct effect on wage growth in the sector, have an indirect effect through the reference wage. An increase in consumer prices increases wage growth in manufacturing, which increases the reference wage in the other sectors. Hence, the total effect of changes in consumer prices is the estimated effect plus the indirect effect.

Finally, the short term effects in the private services are presented. The short term dynamics are caused by changes in hourly wages, the reference wage, consumer prices, and changes in general unemployment. An increase in wage growth last year ($\Delta ww_{s,i,t-1}$) is associated with an increase in growth of hourly wages, as in manufacturing. The estimated elasticity is 0,34 for the top three educational groups and 0,20 for the two lowest educational groups.

An increase in growth in the reference wage ($\Delta kwa_{s,i,t-1}$) is associated with an increase in hourly wage growth, as in the public sector. The estimated effect is 0,58 for the top group and 0,65 for all other groups. Again, the top group may have a higher effect because it includes more managers with fixed wages and because workers with high university education may be more mobile.

The estimated effect of changes in general unemployment (Δu_{t-1}) is negative in private services, implying that an increase in the growth of unemployment reduces wage growth. This estimated short term effect is equal across the educational groups. A one percent increase in growth of unemployment would lead to a 0,01 percent decrease in wage growth, put differently a doubling of the growth of unemployment would lead to a one percent decrease in wage growth.

The effects of including new wage equations in the model are obtained by comparing projections until 2030 with the previous baseline scenario wher the only difference in model is the new wage relations. This is presented in Appendix B.3.

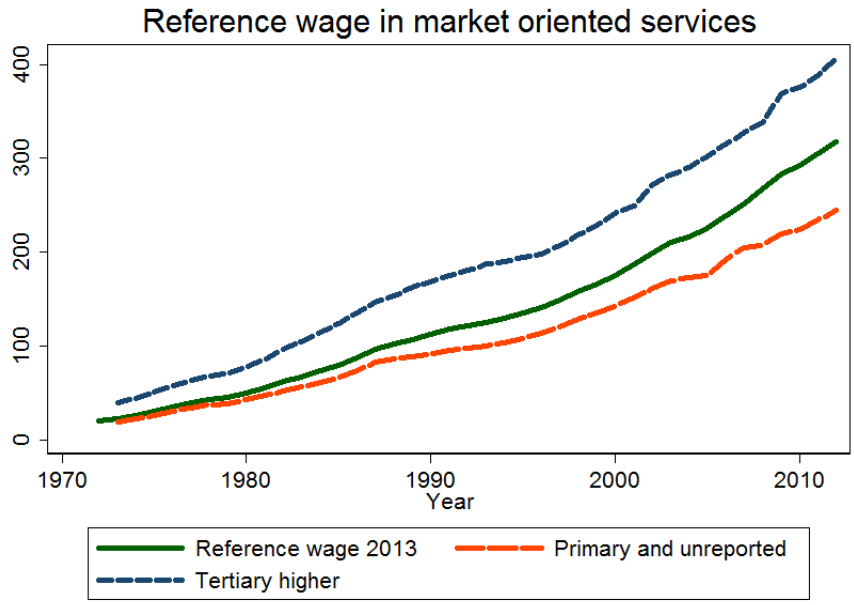

Figure 2: The reference wage of primary education and tertiary education, higher degree compared to the aggregated reference wage in 2013.

4.3 Major changes in the wage relations

The new wage relations are not very different from the wage relations by Bjørnstad and Skjerpen (2006), see reprint in Appendix C2. However, some changes are present due to new data and the growing importance of immigration. Gross immigration flow is included as a new variable in the new set of equations in manufacturing and private services. The effect is not significant for all educational groups, see Table 1.

The new data set provides information on reference wage disaggregated by five educational groups in private services and in public sector. In Cappelen, Gjefsen, Gjelsvik, Holm and Stølen (2013), reference wage was aggregated for the groups in the sectors. Figure 2 displays how the reference wage for workers with primary or tertiary higher education differs from the aggregate level. This difference in reference wage affects the estimated wage growth for the educational groups.

First, the equations describing wage growth in manufacturing are compared to the old equations. The level of general unemployment and the change in education specific unemployment are excluded as explanatory variables in the new equations, while the level of education specific unemployment and the change in general unemployment were kept. General and education specific unemployment are highly correlated, and to ensure significant results the two first variables were excluded. Despite these changes in variables, the overall estimated effects of the level and the changes in unemployment on wage growth in manufacturing have not changed much.

Compared to the old estimation results in manufacturing, the error correction towards the equilibrium wage share is somewhat faster for four educational groups, and slower for the top educational group. This implies that the top educational group can deviate from the equilibrium for a longer time period, while it used to be equal to the other groups. The estimated effects of changes in wage costs, productivity and hourly wages are somewhat smaller than before while the estimated effects of changes in consumer prices are significantly larger.

Comparing the equations describing wage growth in the public sector to

the old equations, the change in education specific unemployment is the only variable that is excluded. Except for this and some dummy variables capturing time specific effects, the equations are equal. The estimated effects of the variables are similar with some minor differences. The two top educational groups have a larger estimated effect of the reference wage than before. This implies that wage growth in manufacturing and private services affect wage growth for these groups in the public sector to a larger degree than before. The largest difference is a significantly larger estimated effect of lagged wage growth for all educational groups. The negative effect of lagged wage growth is almost ten times as large as before. This is a large change in wage setting and ensures that wage growth in one year dampens the wage growth next year.

Finally, comparing the equations describing wage growth in private services to the old equations, the level of education specific unemployment is included in the equations as unemployment is an important part of the long term dynamics shaping wage growth. Changes in education specific unemployment is excluded as changes in general unemployment capture effects of this development. Otherwise the equations are rather similar to the equations in Appendix C2. The estimated effects of the variables are similar with some minor differences. In this sector, wage growth for all educational groups have a larger effect of the reference wage than before, ensuring that wage growth follows the growth in the other sectors more closely. This is the most significant change in wage setting in private services. Immigration and unemployment have a small, but significant negative effect on wage growth in the new relations.

There are some changes in the differences across educational groups from the previous relations. In the old relations, the two groups with tertiary education were equal in most respects and differed from the other groups in many respects. In the new relations, it is the top educational group that stands out from the others in all sectors, indicating that wage setting for the group of workers with tertiary education, higher degree, is different from the other groups. This may be due to more use of local wage bargaining in this group, and a larger difference between lower and higher degree of tertiary education than before.

4.4 Demand for labour

Demand for labour is estimated as cost shares describing the cost structure of using labour in the production process. These cost shares determine employers demand for labour and hence affect the level of employment in the economy. The main results of estimating new cost shares are presented in this Section, while technical details are presented in Appendix B.4.

Changes in relative wages across educational level affect the demand for labour by education. The relative cost shares which determine the demand for education specific labour are estimated for workers with short relative to medium education and long relative to medium education. The cost shares of workers with medium education are determined by these as the sum of cost shares are equal to unity. Changes in wages of labour with short education have a larger effect on the demand for labour with vocational education than on the demand for labour with tertiary education. This is because the possibilities for substitution between labour with short and vocational education are quite important in large industries like construction and in information and communication. In contrast, labour with vocational education and labour with tertiary education are found to be complements only in consumption industry.

The relative demand for each educational group is determined by the production level, relative wages, the stock of capital relative to output and a trend. The functional form of the trend is assumed to represent skill biased technol-

ogy change (SBTC), but this is not vital for the significance as the trend variable may represent any trend that has increased demand for labour with tertiary education. The trend term controls for unobservable variables that have increased demand for labour with long education. The estimated trend coefficients are strongly significant in all industries. This lends support to the SBTC hypothesis stating that better technology leads to increased demand for labour with tertiary education and to decreased demand for labour with short education.

The production level in MODAG is in most industries determined by demand ex post price development. Prices are set according to the principle of monopolistic competition ex ante. The production technology is in general assumed to be Cobb Douglas, which implies that the factor cost shares are constant with an elasticity of substitution equal to one. This implies that the cost shares for the different input factors are independent of the corresponding prices of the input; an increase in the price in one input factor will lead to a reduction of that input factor such that the cost shares are unchanged.

Given the aggregate level of production, cost minimization determines factor demand on two levels. The first level relates to the determination factor inputs; labour (wage earners and self-employed), electricity, fuels, transportation oil and other materials and five real capital stocks (including Research and development) in 16 industries. In this level, all industries are assumed to have increasing return to scale which implies that if the use of all input factors is increased by one per cent, the level of production will increase by more than one per cent. The second level relates to the determination of demand for labour by education conditioning on the aggregate level of labour which was determined in the first step. At the second level, the assumption of a constant elasticity of substitution between different groups of educational level has been abandoned in favour of a more flexible technology that implies time-varying substitution elasticitys, as the cost shares are not restricted to be constant (as they are with a Cobb-Douglas technology in the first level). The choice of functional form allows for the trend of increased demand for labour with tertiary education relative to other educational groups and more flexible substitution possibilities between the different groups of skilled workers.

The overall effects of including new education specific demand functions and the wage equations derived in the previous section to the model are obtained by comparing a simulation of this model over the time period 2013 to 2030 with the simulations in Cappelen, Gjefsen, Gjelsvik, Holm and Stølen (2013). Apart from new demand- and wage relations, the model is the same as in 2013.

4.5 Economic implications of new demand functions

The demand for labour of each educational group is determined by the production level, relative wages, the stock of capital divided by gross output and a trend. The trend represents increased demand for labour with tertiary education, which is consistent with skill biased technological change (SBTC), an expression describing changes in the composition of labour where skill is equivalent to the length of education. The trend is imposed in absence of observable variables that capture this specific development in the composition of labour. The estimated trend coefficients are strongly significant in most industries. Hence, demand for labour with tertiary and medium length of education increases in line with technological change while relative demand decreases for labour with primary or upper secondary education, general programs, referred to as short education for simplicity.

With the exception of the industries consumption goods (15), financial intermediation (63) and electricity (71), changes in the wages of labour with short

education will have a larger effect on the demand for labour with vocational upper secondary education than on the demand for labour with tertiary education. This is partly due to the fact that the possibilities for substitution between labour with short and vocational upper secondary education are quite profound in some industries, like consumption goods and construction.

Labour with vocational upper secondary education and labour with tertiary education are found to be complements in the consumption goods industry (15). This means that the demands or each of these input factors are negatively affected by each-others prices. Furthermore demand for labour with tertiary education is more sensitive to the wage of labour with vocational upper secondary education than vice-versa.

4.6 Major changes in the demand functions

The demand functions presented in this report are compared with the demand functions used in Cappelen, Gjefsen, Gjelsvik, Holm and Stølen (2013) and are documented in Gjelsvik (2013). The demand functions in the previous report have the same theoretical framework where the translog cost function is minimized. The theoretical framework of skill biased technological changes (SBTC) in Norway has been supported by data, see von Brasch (2012). The paper shows that trends are the most important contributions to the development in wage shares in Norway, which may reflect the importance of SBTC.

In both the present and the previous report most of the parameters on the time trend which may represent SBTC are significantly estimated. In both reports the coefficients for the non-linear trend (which picks up skill biased technological changes) are negative in all industries for low skilled workers. This implies a relative reduction in the use of low skilled works that is not explained by relative wages or the effect of capital to value added. For high skilled the corresponding coefficients are positive in both reports (with one exception), though generally lower than for low skilled workers measured in absolute value.

There are, however, a few changes in these effects of the time trend compared to the previous report Cappelen, Gjefsen, Gjelsvik, Holm and Stølen (2013) to the present. The estimated trend coefficient for workers with short length of education in industry 64 — service activities related to petroleum and natural gas — is in the present report much higher than in the previous report, and it is now much more in line with the effect in other industries. On the other hand, the estimated effects for workers with long length of education are reduced in industries 40, 64 and 71. The new estimates are close to zero, indicating that in these industries workers with short educational level are replaced by vocational educated workers. In fact, in industry 64, the coefficient for the trend for workers with long educational length is negative, though close to zero and insignificant, indicating an insignificant tendency of a reduction in the use of workers with long education not explained by relative wages.

The coefficients for the capital to value added express if a skill group is a complement or an alternative to real capital. A positive coefficient implies an increased use of workers with a particular educational level when the use of real capital increases more than vale added. In the demand functions used in this report, only three industries include effects of the capital to value added. These are industry 63, financial services; 64, service activities related to petroleum and natural gas; and 71, electricity generation. In the previous report capital to value added was included in all industries even though it was not found significant in all of the industries.

Table 3 shows that only three out of 39 coefficients for the relative wages are significant. This is in line with previous findings, where only a few of the

coefficients for the relative wages are estimated significantly. The high standard errors are probably due to lack of variation in the relative wages and do not necessary cast doubt on the importance of including these variables. One should also note that the coefficients in this report are somewhat more significant than in the previous report indicating that relative wages are important in explaining the demand for educational specific labour.

Table 3 also displays that many of the coefficients for relative wages are restricted. These restrictions are imposed to get economically meaningful own price elasticizes. As can be seen from the own price elasticity it is a function of the wage share and, hence, changes over time. For the demand functions in the present report stronger restrictions on the parameters are imposed than in the previous report to secure negative own price elasticizes for a bigger range of wage shares. The stronger restrictions on these coefficients combined with the little variation in relative wages have led to large changes in these estimates. The coefficients for relative wages in the demand functions presented here have better properties than the corresponding coefficients used in the previous report.

5 Projection of employment by education

There have been changes in the composition of the labour force during the last decades. While employment of workers with primary education has declined, there has been massive growth in employment of workers with vocational and tertiary education as displayed in Figure 3.

In this section, the wage- and demand equations derived in the previous section are used to project employment by five educational groups and 28 educational fields towards 2030. The new model is simulated over the period 2013 to 2030 and compared with the results of our former projection in Cappelen, Gjefsen, Gjelsvik, Holm and Stølen (2013). The projections for five educational groups are presented before employment is further disaggregated by 28 educational fields. Data on educational fields are collected from register data.

The main results of this section show that the historical development of demand for different types of education will continue also in the future. The results are in line with previous projections for educational specific demand in Cappelen, Gjefsen, Gjelsvik, Holm and Stølen (2013).

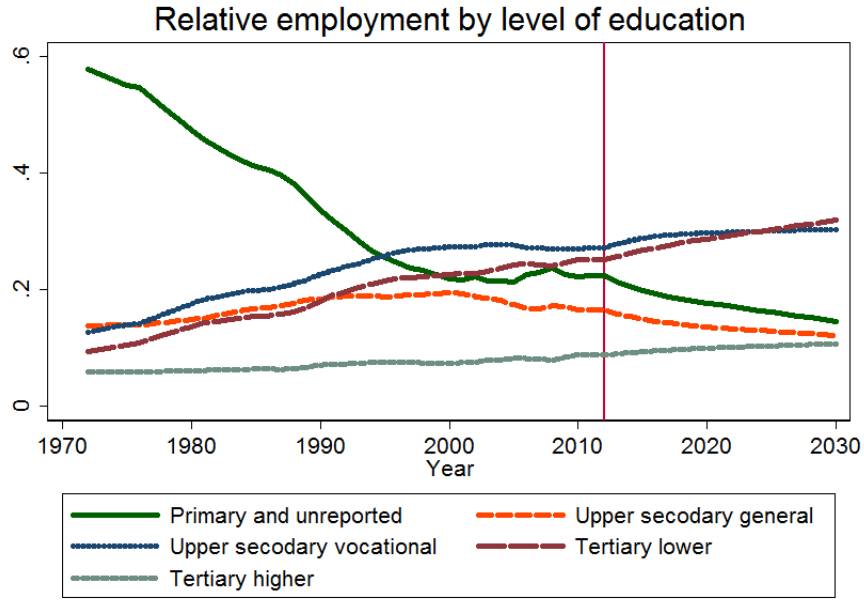

Figure 3: Employment by level of education relative to total employment.

5.1 Macro effects of new wage relations and demand functions

The effects of new wage- and demand functions are studied by simulating the model over the time period 2015 to 2030 (Projection 2015). The simulation is compared to the projection in Cappelen, Gjefsen, Gjelsvik, Holm and Stølen (2013) , which will be referred to as the baseline scenario or Projection 2013. The projections are constructed such that the main difference between the projections and the baseline is due to differences in the new wage- and demand functions, as described in Section 4. Important mechanism such prices, productivity and demand for labour are accounted for. However this remains a stylized analysis because there is reason to expect policy responses to the new economic environment, which are not accounted for in this report.

Small changes in estimated equations imply small changes in projections. However, there are some noteworthy deviations from the baseline scenario. Table 2 displays accumulated changes in macroeconomic projections in two years

Table 2: Changes in macroeconomic projections, in percent.[1]

	2020	2030
National accounts data		
Household consumption	-1.47	-3.44
General government consumption	-0.00	-0.00
Gross fixed investment mainland	-0.06	-0.53
Exports, traditional goods	2.05	6.40
Imports	-1.74	-3.84
GDP mainland	-0.06	-0.53
Labour market		
Hours worked, wage earners	1.70	2.13
Total employment	1.30	1.65
Labour force	-0.14	-0.29
Unemployment rate, percentage points	-0.01	0.01
Prices and wages		
Wage per hour	-4.76	-10.94
Real disposable income	-1.98	-3.45
Real public transfers	-3.58	-5.78
Consumer price index (CPI)	-1.11	-5.58

[1] Corrected 1. December 2015.

2020 and 2030, in percentage points, between the projection and projection 2013. Wage per hour is 4.8 per cent lower compared to the baseline scenario in 2020 and 10.9 per cent lower in 2030. However, prices are also lower, so the difference in real wage is smaller than the difference in nominal wages (see discussion below).

Figure 4, left panel, displays the development in hourly nominal wages in the two projections. Growth in aggregate wages is lower at the start of the projection period, until 2020, and hourly wages are therefore at a lower level compared to the baseline scenario. As described in Section 4, this is partly because immigration reduces the wage levels. Unemployment also reduces wages.

Lower wages affect households' real disposable income and in turn consumption and imports. Figure 5 displays that the projection of consumption is lower compared to the baseline. This reduction implies that firms producing consumer goods face lower demand. In line with reduced consumption, total imports are reduced in the projection period by 1.7 per cent in 2020 and 3.8 per cent in 2030 compared to the baseline scenario. The effect on investments is moderate.

The lower wage growth implies a lower price growth. The consumer price index is at a lower level through the entire projection period and ensures that the change in real disposable income is small between the projections. Also housing prices are a little lower at the start of the period, and a little higher at the end of the projection period, while the gross debt of households is very close to the baseline scenario.

GDP mainland is almost unchanged in 2030 compared to the baseline, but improved competitiveness, through lower wages, increases export.

Reduced wages affect the composition of input in the product market. A reduction in the price of labour makes firms substitute capita, with labour as the relative price of capital is increased, all else equal. Hence, corresponding to the reduction in wages, demand for labour increases. Total investments are lower and employment is higher throughout the period. Figure 5 shows that investments from 2010 to 2030 are lower compared to the results in the 2013 report. Gross investments in mainland Norway is below the baseline scenario in the entire projection period, but the size of the gap is stable from 2025 to 2030. The

domestic demand also contributes to decrease investments even further. Compared to the projection in section B.3, investments are less reduced compared to Projection 2013. This is due to changes in the production level of industries. Industries which benefit from lower wage growth will increase while other industries will suffer a reduction in size. Figure 7 shows that industries with many workers with short and long educational level will expand their activity, while industries with many workers with vocational education will reduce their activity due to changes in relative wages.

In 2020, the increase in employment is about 35 000 workers relative to the baseline, and in 2030 the increase is about 50 000. However, hours worked are reduced compared to the baseline. Unemployment is somewhat lower compared to the baseline, but the unemployment rate is around 3.5 for most of the projection period in both scenarios.

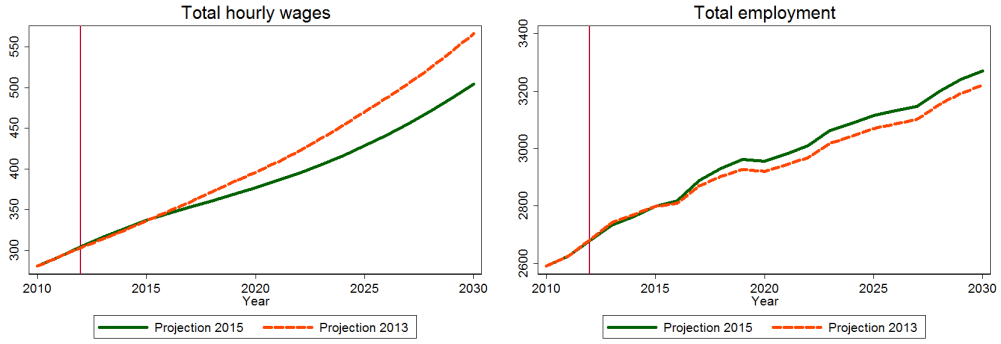

Figure 4: Hourly wages (left) and total employment in 1000 persons (right).

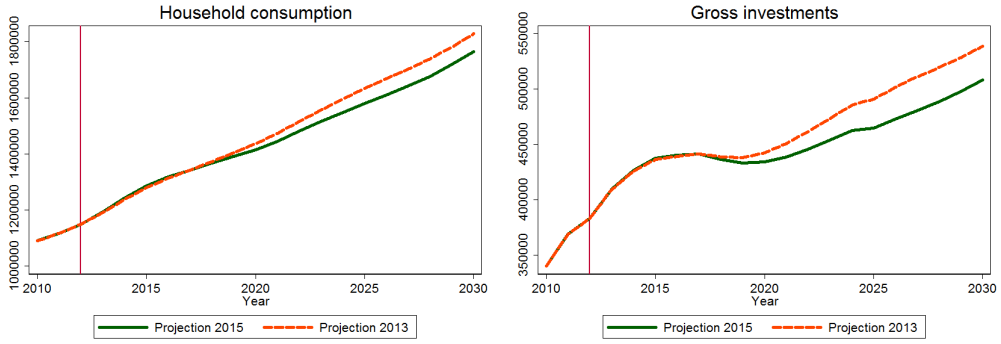

Figure 5: Household consumption (left) and gross investments, mainland (right).

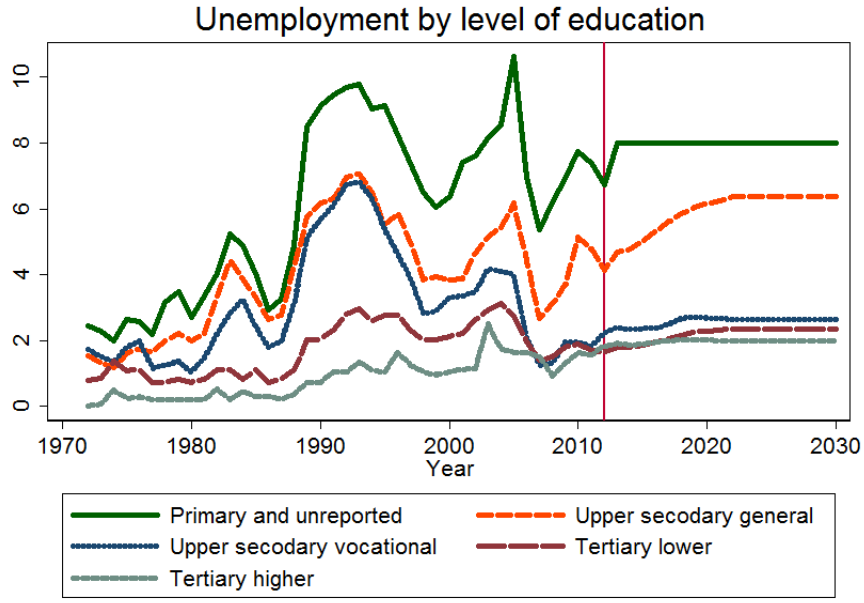

Figure 6: Unemployment rates by education.

5.2 Employment by educational groups

The macroeconomic model includes industry-specific employment for five educational groups. This is used to investigate the composition of labour and differences between educational groups. These groups are partly substitutes within each industry and the employment shares within each industry depend on relative wages and factors related to technological change such as capital stocks and deterministic trends as explained in Section 4. Exogenous assumptions regarding employment shares are used for government sector and primary industries, and these are not affected by changes in relative wages. Hourly wages are determined in each of the three main sectors of the economy; manufacturing, market oriented service activities and public services. Wage determination in Norway is quite centralized and this feature has contributed to relatively stable wage differences in past decades. The previous section showed that aggregated wage level is reduced relative to the baseline scenario. Figure 7 shows how this reduction affects the five educational groups as it displays education-specific wage rates relative to average hourly wage rate. Relative wages will converge somewhat in the coming decades, but relative wages are reduced most for workers with short and long length of education while wages for vocational education are somewhat higher than before. This leads to increased demand for workers who have lower relative wages than before. However, there is an underlying trend of decreased demand for workers with short length of education.

Figure 3 displays employment aggregated across all industries in the economy for each of the five educational groups in thousands workers. The figure shows that the negative trend in employment of persons with primary and unreported education that was very strong from the late 1980s came to a halt by the early 2000s. After 2004, this number increased due to the increase in immigration. Data on education is often missing for immigrants. This increase reflects the considerable labour immigration into Norway from new EU-members in Eastern Europe.

The growth in employment of persons with upper secondary education, general programs, ended around year 2000. Since then employment of this group has been fairly stable and is projected to stay stable in the entire projec-

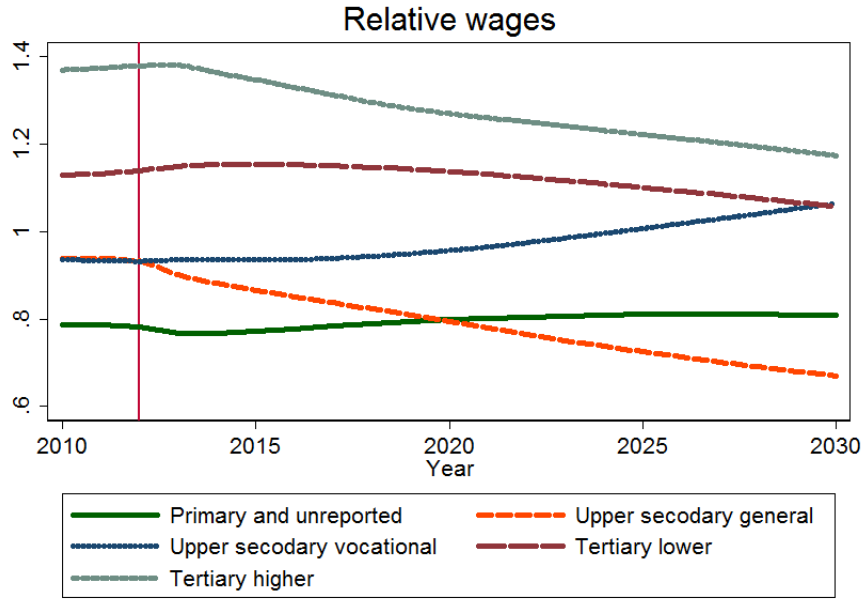

Figure 7: Hourly wage rates by educational group relative to the average hourly wage rate.

tion period. The number of employees with vocational education has continued to increase although the growth has been more moderate during the most recent decade. This is also the case for employees with tertiary education, lower degree, and these two groups are projected to be the largest groups in the future. The number of workers with tertiary education, higher degree, continue to increase, and both the number and the share of the workforce with tertiary education corresponding to a Master degree will increase strongly in the projection period. This is both due to changes in industry structure with increasing employment in service industries as well as changes within industries where technical change seems to be biased in favour of those with tertiary education.

By definition, labour supply is the sum of employment and unemployment. The education specific unemployment rates are shown in Figure 6. Historically the unemployment rates have been higher for workers with shorter education and opposite, and this is expected to continue. The unemployment rates in the projections are constant after 2025. Before this, workers with upper secondary education, general programs, will experience higher unemployment rates. For the other groups, unemployment is increasing slightly according to our projection until 2020 and then they stabilise. This is what generates the time profile for the total unemployment rate discussed in previous section. Historically, there has been a close correlation between unemployment rates for all groups, but especially for the two groups with short education.

5.3 Uncertainty and comparison of projections

Before we turn into the projection of 28 educational fields, the uncertainty and some technical comments regarding the above comparison is warranted. The simulation with new wage- and demand functions was in the previous section compared to the projection in Cappelen, Gjefsen, Gjelsvik, Holm and Stølen (2013). The projection is constructed such that the main difference between the projection and the baseline is due to new wage- and demand functions.

However, there is uncertainty about the starting point when making projections due to deviation between the model prediction and observed data. If

there is no prediction error in the starting point of the projections, the projection of wage growth will start at a representative level and the error terms can be held constant at zero through the projection period. If there are prediction errors in the starting point, the deviation between the model prediction and observed data may be due to fluctuations or structural breaks. If there is a structural break in wage growth, than the error term can be held constant at the level in the starting point to account for this shift. If there are fluctuations causing a random deviation between model prediction and observed data in the starting point, the error term may be set to zero in the projection period even though it is positive or negative in the starting point.

In the projections, the value of the error terms of the wage equations in the starting point is not zero. The non zero error terms are considered as fluctuations which might be caused by high oil prices and a booming economy in the start of the projection period, and not due to a permanent shift in wage growth. Hence, the error term is set to zero in the projection period. If on the other hand the error terms had been held constant at the level in the starting point, wage growth would be higher in the entire projection period compared to the baseline scenario. Hence, the value of the error terms in the projection period affects the level of wage growth in the entire projection period. If the error terms are negative in the starting point, setting them to zero would reduce the level of wage growth, and opposite if error terms are positive.

In the baseline scenario, the error terms of the wage equations are also non zero in the starting point. Some of the error terms are adjusted gradually to zero between 2012 and 2020 before they are set to zero in the rest of the projection period. Now, data on wage growth for 2013 an 2014 exist and therefore the first years of the projection period are compared to data. In the new projection there is no need to gradually adjust the error terms. As the wage equations in the two projections differ, the error terms in the starting point of the projections differ. The new wage equations are estimated on new data and incorporate the effect of immigration, and are thus expected to be a better and somewhat different model of wage growth. Therefore the error terms of the wage equations differ between the baseline scenario and the new projections from 2012 to 2020. From 2020 to 2030 the error terms are all set to zero and therefore the only difference between the projections are the estimated wage equations.

5.4 Employment by educational field

In this section, five educational groups are further disaggregated into 28 educational fields, see A for a complete list. The 28 fields correspond to the Norwegian education standard (NUS), and several educational programs are covered by several fields.

In the previous section, MODAG was used to project industry-specific employment by education, accounting for changes in industrial structure that may affect demand for labour. The projection of industry and educational level from MODAG are used to determine the 28 educational fields by using a sub-model, or projection procedure, in which employment by industry is disaggregated to specific educational fields.

Bjørnstad et al. (2010) presented a sub-model to match data with industry-specific employment to educational field, which was used also in Cappelen, Gjefsen, Gjelsvik, Holm and Stølen (2013). By using register data, education-specific employment shares for each educational field are calculated. Then, most of the employment shares have a continuing trend. In projections, these trends are assumed to continue. The projection method implies that if employment of persons with an educational field in a specific industry has increased strongly in

the data period, the future employment also increases, but at a slower pace.

Therefore, employment by educational fields is projected for the next fifteen years by extrapolating the historical trend of growth. Employment shares for the 28 educational fields are extrapolated using data from 1986 to 2012, and coupled with data on employment by educational groups. The projections are based on historical data and political changes might cause the actual development to be different from the projections. For some fields, the trends used in the projection in Cappelen, Gjefsen, Gjelsvik, Holm and Stølen (2013) differ from the historical pattern, due to very step trends. In what we will present no such judgments of historical trends are used.

Figure 8a displays the number of workers with primary education, unreported education, secondary general education and secondary general education with focus on business and administration. Employment of the first two groups develops as described above, while the last two groups are fairy stable throughout the period. Demand for workers with secondary general education with focus on business and administration will decrease by about 10 000 workers in the projection period while workers with secondary general education will increase by about 20 000. Relative to the labour force these groups decline.

Figure 8b displays employment of workers with upper secondary education, vocational programs. Electric and mechanic is by far the largest educational field within this category. All the educational fields will increase steadily until 2018 and have a somewhat lower growth after this. The exception is Health and care which increases steadily over the entire period and have the steepest growth of the educational fields after 2020. The average growth rate per year is 2.3 percent for workers with education in Health and care. This is in line with increased demand for workers in the health sector as the share of elderly increase in the population.

The expected development of the groups of workers with tertiary education, lower degree, are presented in Figure (9). Teachers and pedagogues that have studied Education constitute the largest group and the number will increase steadily over the period with an average growth rate of 3.2 from 2013 to 2030. The group of workers with a degree in Business and administration will increase accordingly and is the second largest group. The number of nurses will grow steadily over the period, but at a lower rate of approximately 1.9 percent per year on average. In 2030 the number of nurses will have grown by about 47 percent from the level in 2010. Workers with education in Other health and care will experience the largest growth relative to own size and increase with about 90 percent. Engineers is a group that will stay fairly constant over the period with a total increase of about 2000 workers from 2012 to 2030. However, the number of Graduate engineers will increase as displayed below. The groups of workers with bachelor degrees in Arts and humanities, Social sciences and law or Other university educations constitutes the smallest groups within this category.

The group of workers with education corresponding to a Master degree or more, is displayed in Figure 10. In 2010, workers with Other science subjects constituted the largest group, but Business and administration has increased rapidly and is expected to reach the equivalent level as Other science subjects in 2030. Employment of workers with education in Business and administration is expected to increase with an average of 1.2 percent per year over the period, while the growth of Graduate engineers, the second largest group in 2010, is only 0.3 percent per year on average. Teachers and pedagogues with master degree will increase as with approximately the same rate as Graduate engineers, while the number of dentists is expected to decrease with about 660 persons over the period. The number of workers with education in Law and Medicine will in-

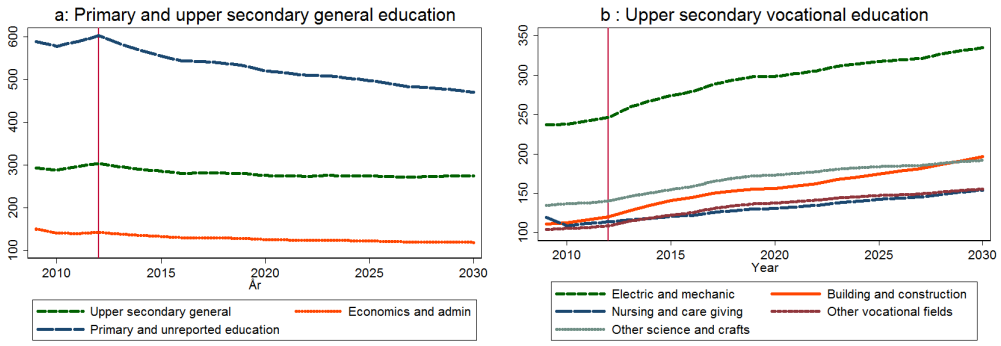

Figure 8: Number of workers with primary and secondary education in 1000 persons.

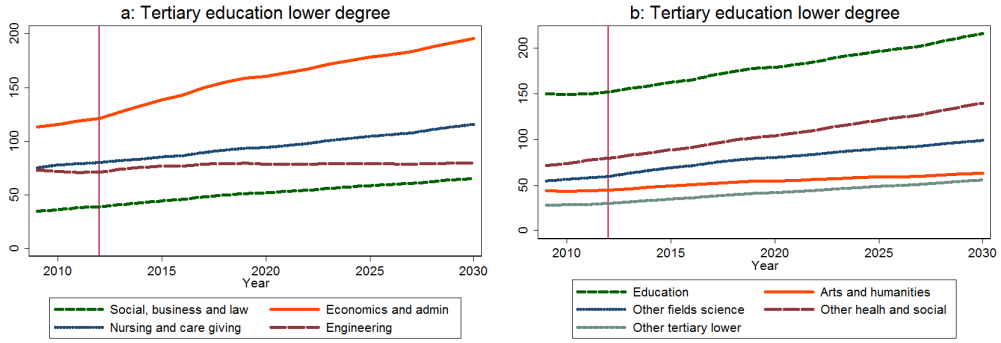

Figure 9: Number of workers with tertiary education, lower degree, in 1000 persons.

crease from about 20 000 in 2012 to about 30 000 and 27 000 respectively in 2030. Workers with education in Art and humanities, Social sciences or Other university educations will increase similarly to Law and Medicine, but the largest growth of these groups is expected in Social sciences.

Compared to the results in the report from 2013, there are some important differences. Table 3 compares the projections made in this report to those made in 2013, see Cappelen, Gjefsen, Gjelsvik, Holm and Stølen (2013). In the table, deviations in employment in 2012 and 2030 are shown together with projected employment levels in this report. The deviations from 2013 are caused by new wage relations and demand functions, as in the previous sections, but are also associated with data improvements and the fact that 2012-figures were projected and not observed in the 2013-report.

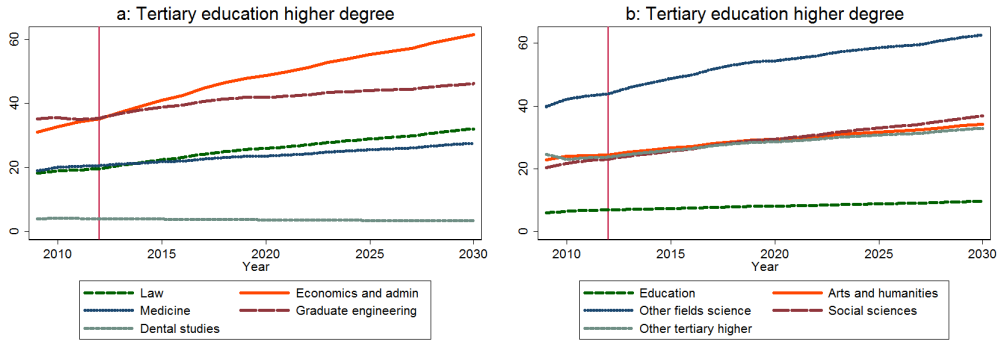

Figure 10: Number of workers with tertiary education, higher degree, in 1000 persons.

Table 3: Employment level and employment deviations between the current analysis and the 2013-report. In 1000 persons.

	Level in this study		Deviation from 2013-report*	
	2012	2030	2012	2030
Primary and unreported education	**603**	**471**	0	-46
Upper secondary education	**1175**	**1425**	**0**	**-26**
General programs	304	274	0	-23
Economics and administration	142	118	0	-13
Electronics, mechanics work and machinery	246	335	-2	8
Building and construction	120	196	-2	9
Other fields of science, technique and crafts	140	192	-4	-11
Nursing and care giving	114	154	10	4
Other fields, upper secondary education	109	155	-2	0
Tertiary education, lower degree	**675**	**1029**	**-3**	**71**
Humanities and arts	44	63	-3	6
Education	152	215	-3	-2
Social sciences, business and law	39	65	-2	7
Economics and administration	121	195	-3	27
Engineering	71	80	-2	5
Other fields of science	59	99	-2	9
Nursing and care giving	80	116	-6	-29
Other fields of health and social services	79	139	19	47
Other tertiary education, lower degree	30	56	-2	-2
Tertiary education, higher degree	**237**	**347**	**-1**	**29**
Humanities and arts	25	34	-1	3
Education	7	10	1	2
Social sciences	23	37	-1	2
Law	20	32	-1	3
Economics and administration	35	61	0	11
Graduate engineering	35	46	-1	-1
Other fields of science	44	63	-1	7
Medicine	21	28	2	-1
Dental studies	4	3	1	0
Other tertiary education, higher degree	24	33	-1	3
Total	**2690**	**3272**	**-4**	**27**

* Positive figures means that this report projects a higher number than the 2013-report.

6 Permanent increase in labour migration flow

To underpin the results in Section 5, we perform a stylized simulation to illustrate the model's properties of a permanent increase in labor supply through higher gross migration flow on the labour market. This increase in gross migration flow can also reflect increased competition in the Norwegian labour market. We assume that for the years 2015 to 2030, relative to the baseline scenario, 15 000 additional immigrants enter the population. We further assume that for the years 2016 to 2030, relative to the baseline scenario, the outflow also increases by 15 000. This increase in outflow may be due to return migration and emigration of native population, reflecting the increasingly more integrated European labour market. Relative to the baseline scenario, the net effect of these two changes is a permanent increase of the population by 15 000 inhabitants.

The increase in gross immigration flow is lower, but comparable to the increase following the EU-enlargement. Gross immigration flow in the early 2000s was about 10 000 persons per year. It increased to about 30 000 after the EU-enlargement in 2004, and is on average 34 000 in the baseline scenario with a declining trend. The extra immigrants are assumed to be men of age 25 to 45 with the same participation rate as natives in this age group. They are also perfect substitutes to natives with similar educational background. This amounts to 0.54 per cent of all persons in the age group 15 to 74 in 2015.

We use the model derived in Section 4 to simulate demand for labour, but with an increase in gross immigration flow, equal to 15 000 persons in each year in the period 2015 to 2030. The simulation with higher gross immigration flow is compared to the baseline scenario in Section 5. Although important mechanism to the wage setting such as changes in prices, productivity and demand for labour are accounted for, this is a stylized analysis. For example, it does not account for changes in other policy variables or the behavior of agents.

Considering that the analysis takes into account heterogeneity across education groups and industry classifications, effects of this supply shock may be sensitive to which part of the labor market is directly affected. Although effects may be mitigated over time as the economy finds a new equilibrium, this new equilibrium may depend on whether supply is permanently increased by 15 000 immigrants with low-level of education or with high-level of education.

We consider a number of scenarios. First, we assume that the education distribution of the 15 000 newly arrived immigrants is identical to that of the Norwegian labor force in the year 2015. This is shown as Scenario A in the graph and it suggest that 2700 of the newly arrived immigrants have the lowest level of education so that the share of workers with the lowest level of education in the Norwegian economy remains the same as in 2015, namely 18 percent (=2700/15000). Numbers for the other education groups are calculated similarly. This represents a scenario where the increase in supply does not change the skill composition that already exists in the Norwegian economy.

Another setup, represented by Scenario B1 in the graph, assumes that all the newly arrived immigrants have primary education. The same can be assumed for each of the education groups, namely that the 15000 new workers have the same education level. Clearly these education-specific positive supply shocks (there are 5 education groups in total) do change the skill composition in the Norwegian economy, unlike the first case (i.e. Scenario A).

We study four shifts in labour migration; one where the proportion of immigrants are related to the size of the labour supply of each educational group (scenario A) and three shifts where immigrants only enters the supply of one group of education at the time, primary education (B1), upper secondary vocational education (B2) and tertiary education, higher degree (B3). Note however,

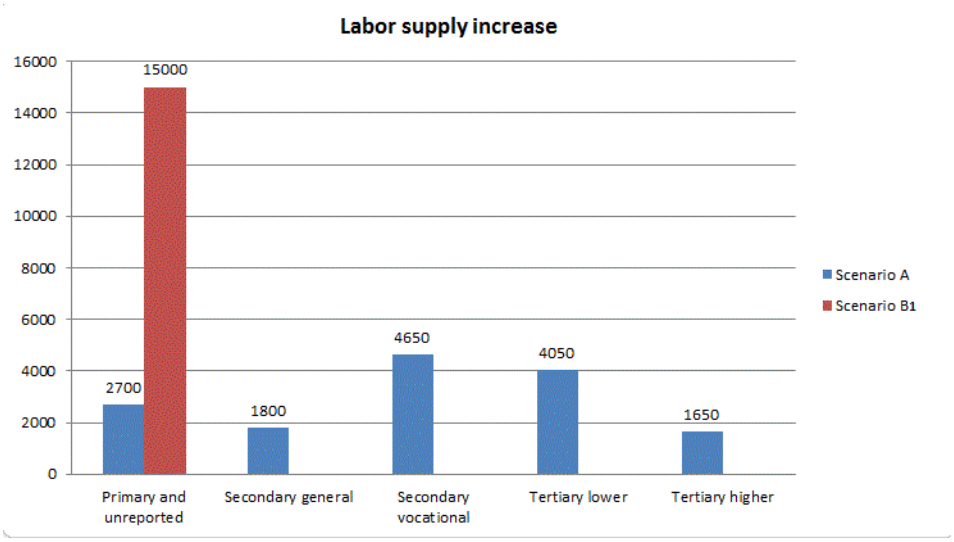

Figure 11: Education distribution of the immigration flow in scenario A and B1.

that increased immigration affects all of the estimated wage equations by education, independent of scenario A and B1-B3. In all shifts, we have assumed that interest rate and exchange rate encompasses to the new economic environment.

In the first shift, A, the increase in immigrants is spread out on all educational groups. Table 4 shows that wages are more than 8 percent lower than in the base line scenario. This effect mitigates the effect of increased labour force as some persons withdraw from the labour market. In sum, the labour force increases somewhat and is 0.2 percent higher than in the base line scenario.

The table also shows that lower wages increases the demand for labour and hence employment increases. Public employment is assumed unchanged compared to the baseline scenario. The increase in employment is so large that unemployment decreases even if the supply of labour increases. The increase in supply of labour is smaller than the increase in population, this is due to lower labour force participation rate owing to reduced wages. Reduced wages improve competitiveness and decrease the interest rate, which in isolation leads to higher investment. However lower wages increase the relative cost of capital and result in an overall decrease in the investment level compared to the base line scenario. The labour productivity is therefore reduced compared to the baseline scenario.

The households disposable income is mainly determined by changes in employment and wages. Changes in these two variables have opposing effects on households disposable income. The effect of wages is largest and decreases income compared to the baseline. Lower income level reduces aggregate consumption and imports. On the other hand, improved competitiveness increases exports. Reduced demand, decreases mainland GDP by 0.6 percent compared to the baseline. However, one should be aware that the income is shifted from wage earners to capital owners and in the model, the latter group has a very low propensity to consume. The reduction in consumption is therefore somewhat large. Public consumption is also unchanged.

There are some differences between the educational groups. The wage effect is most pronounced for the educational group with long education and lowest for the two groups with short length of education. The supply of labour increases at all educational levels, but somewhat more for the middle groups. The result might seem contra intuitive since wages respond more in the long educational group. However, labour demand in government sector is exogenous, i.e. determined outside the model, and demand from government sector

does not react to reduced wages. The number of working hours outside government sector is higher than the average effect for the highest educational level. As discussed above, reduced wages increases employment and decreases unemployment. The effect is largest for the short educational group.

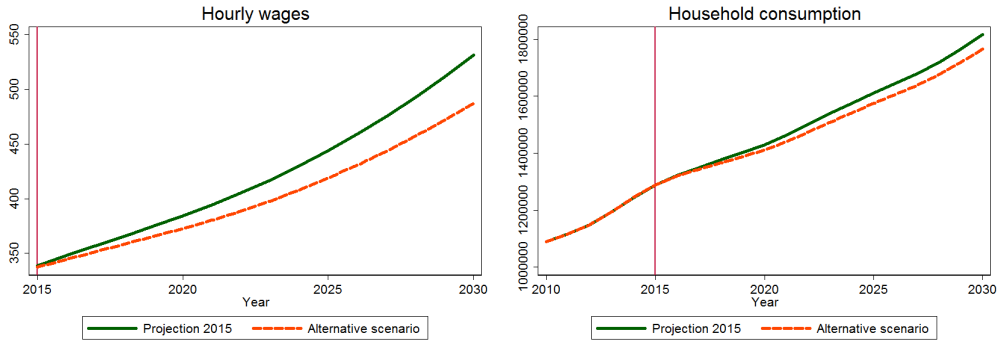

Figure 12: Effects on hourly wages and household consumption of an increase in labour immigration flow. Labour supply is distributed in all groups.

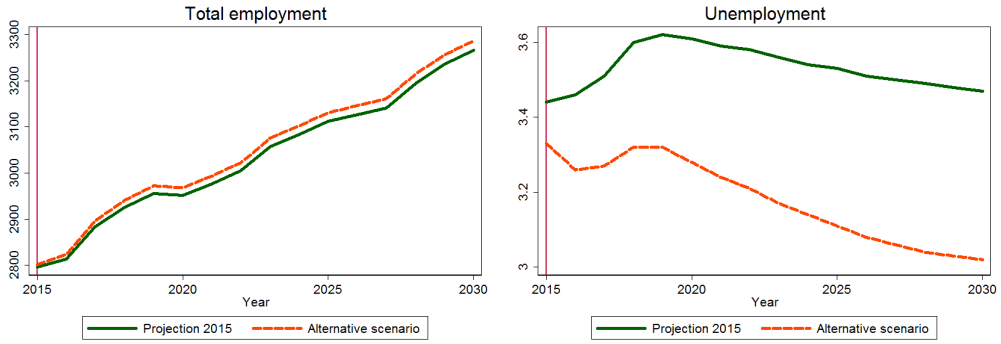

Figure 13: Effects on employment and unemployment of an increase in labour immigration flow. Labour supply is distributed in all groups.

In Table 5 we consider the macroeconomic effects due to education specific supply shocks. First it should be noticed that the effects are qualitatively similar to the effects shown in Table 4. A positive labor supply shock reduces aggregate wages and increases employment in the economy, primarily because labor becomes a less scarce resource. Aggregate unemployment decreases because the effect of lower wages counteracts the increase in labor supply. Lower wages dominate over higher employment and lead to lower disposable income and lower domestic consumption. Although the economy has become more competitive in the international labor market, as reflected by the increase in exports, lower domestic consumption dictates the decrease in GDP. In short, this suggests that the qualitative response of the aggregate economy to a labor supply shock is robust to variations in the skill distribution of the extra labor force.

Second, the effect on unemployment rate for the educational group that is directly affected by the increase in supply of labour is positive, unlike the effect on aggregate unemployment. This suggests that although lower wages for the directly affected educational group would decrease their unemployment rate, the effect of a supply increase dominates and leads to a higher unemployment rate for this educational group.

And finally, the reduction in GDP is smaller in the first scenario (Table 4) than in the last three (Table 5, columns 1 to 3). This suggests that the economy is less negatively affected when the increase in supply has a skill distribution

Table 4: The effect of increased gross immigration flow measured in percentage change from baseline scenario in 2030. Labour supply is distributed in all educational groups.[1]

	Total	Primary	Sec. general	Sec. vocational.	Tertiary lower	Tertiary higher
National accounts data						
Household consumption	-2.71					
General government consumption	0.00					
Gross fixed investment mainland	-3.23					
Exports, traditional goods	1.26					
Imports	-2.76					
GDP mainland	-0.61					
Labour market						
Hours worked, wage earners	0.68	1.10	0.79	0.69	0.50	0.59
Employment	0.63	0.92	0.68	0.66	0.46	0.55
Supply of labour	0.21	0.35	0.52	0.41	0.44	0.35
Unemployment rate, percentage points	-0.45	-0.75	-0.44	-0.24	-0.12	-0.08
Prices and wages						
Wage per hour	-8.26	-7.11	-5.50	-8.19	-7.98	-11.23
Real disposable income	-3.25					
Real public transfers	-5.88					
Consumer price index (CPI)	-4.35					

[1] Corrected 1. December 2015.

that is similar to the hosting country. One potential explanation is related to the degree of mismatch in the labor market, as reflected by the effect on unemployment. When the supply shock has the same skill composition as the host country each education-group experiences a reduction in unemployment. In contrast, when the supply shock has a skewed skill composition the education-group that is directly affected experiences an increase in unemployment. Furthermore, the aggregate wage decreases less in the first scenario, which has a less detrimental effect on domestic consumption and consequently on GDP mainland.

It should be noted that it is difficult to assess the likelihood of these scenarios. The education distribution of newly arrived immigrants may change for reasons that most likely are exogenous to the Norwegian economy. For example, negative aggregate shocks in some of the source countries may change the distribution of source countries and consequently the education distribution of newly arrived immigrants in Norway. These scenarios reflect extreme cases in terms of the skill composition of newly arrived migrants.

The results presented here rely on a number of simplifying assumptions. We abstract away from challenges that newly arrived labour immigrants may have in the host labour market. In addition, immigrants are perfect substitutes to natives of comparable education and they have the same labor force participation rate as native men of same age- and education-group. Furthermore, we assume absence of labour market policy changes, such as extensions of general agreements, that may mitigate the negative effects of increased migration on wages.

Table 5: Percentage change in 2030 of increased gross immigration flow. Immigration only enters in one educational group.[1]

	Primary B1	Vocational B2	Tertiary higher B3
National accounts data			
Household consumption	-3.38	-2.86	-3.21
General government consumption	0.00	0.00	0.00
Gross fixed investment mainland	-3.96	-3.4	-3.58
Exports, traditional goods	1.46	1.28	1.31
Imports	-3.37	-2.92	-3.16
GDP mainland	-0.77	-0.64	-0.75
Labour market			
Hours worked, wage earners	0.87	0.74	0.69
Employment	0.82	0.67	0.64
Employment, own group	1.38	0.85	0.71
Supply of labour	0.29	0.23	0.20
Supply of labour, own group	2.35	1.19	3.13
Unemployment rate, percentage points	-0.58	-0.48	-0.48
Unemployment rate, own group	0.55	0.33	2.45
Prices and wages			
Wage per hour	-9.73	-8.62	-9.44
Wage per hour, own group	-6.46	-8.89	-13.43
Real disposable income	-4.06	-3.42	-3.84
Real public transfers	-7.25	-6.20	-6.64
Consumer price index (CPI)	-4.87	-4.49	-4.92

[1] Corrected 1. December 2015.

7 Recent macroeconomic changes and implications for labour demand

Analysis in the previous sections does not take into account the latest macroeconomic developments in the Norwegian economy. This section presents some of the latest national and international changes and incidents and discusses how these changes affect the projections towards 2030. The model MODAG[5] is used with updated assumptions about oil prices, unemployment and other essential variables.

7.1 How to incorporate new information into MODAG

MODAG is a model of the Norwegian economy, and a simplification of the economy. This means that many economic circumstances are not built into the model (even if MODAG consists of many relationships). For instance, global economic development is not determined within the model. Changes in the global economy will for instance affect the export and in turn the level of GDP. Therefore, changes in such variables will affect our projections.

Since 2013, new economic information is available and have changed many economic figures. These variables are input to the model, and output is a projection of important economic variables. Assumptions are made based on historical data and beliefs about the future. The projection presented in this section is based on National Accounts data until 2014 and the focus is on medium and long-term development, not on short term cyclical features of the Norwegian economy. The latest changes in the Norwegian economy are presented before the macroeconomic effects of these changes are discussed.

7.2 Latest developments in the Norwegian economy

Low oil prices, reduced investments in petroleum sector and increased unemployment are affecting the Norwegian economy. The development in these variables the next years will have implications for the projections. Likewise, development of other economic variables affects the Norwegian economy. As Norway is a small open economy where natural resources such as oil, natural gas and fishing are the basis of the largest industries, the development in prices of these goods on the world market is important for the economic situation. In order to evaluate the effects of recent changes in the economy, the model is updated with a number of assumptions regarding the development in the world economy, Norwegian policy changes, the development of the petroleum sector and other economic variables that are not projected by the model. As an example, public purchases account for about 14 percent of GDP, and hence the assumptions about fiscal policy are important for the model's projection of the Norwegian economy.

It is assumed that the inflation rate will equal roughly 2 per cent annually in the euro area from 2018 in line with inflation targets of the European Central Bank. World markets prices on manufactures are assumed to increase only by half a percent. The money market interest rate in the euro area is assumed to increase from the currently very low level to 4 per cent in 2018 and be constant thereafter.

The crude oil price (Brent Blend) is currently (November 2015) roughly 50 USD per barrel. The oil price is expected to stay at this low level during 2016 and 2017. After this it is expected to increase slowly to about 90 USD per barrel in 2030. Hence, it is not expected to reach the high levels of 2011 to 2013 when

[5]The version of MODAG in this section is documented in Cappelen, Eika and Prestmo (2013).

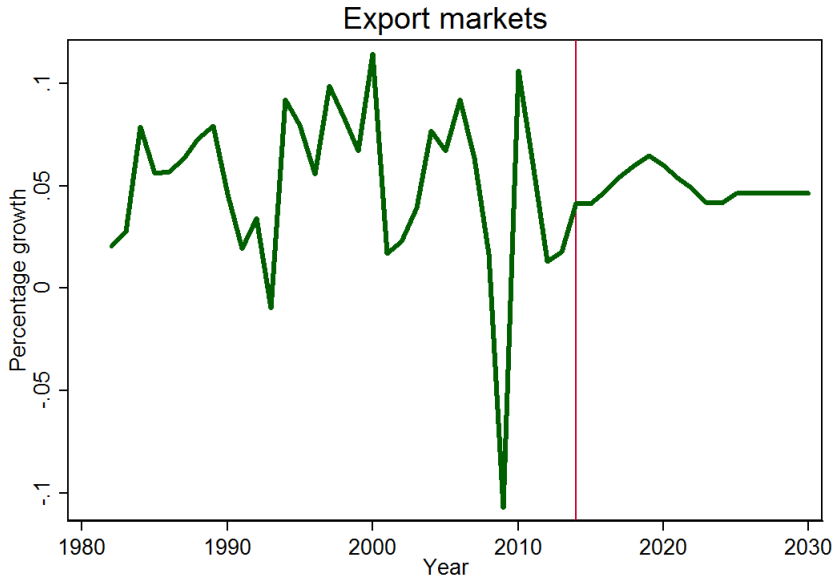

Figure 14: Growth in exports markets, in per cent.

the price was above 110 USD per barrel. The average export price on natural gas is held constant in nominal terms which implies a reduction in the real price of gas by almost 50 per cent from 2010 to 2030.

Figure (14) shows historical growth rates of imports for Norway's trading partners. Norwegian exports depend on demand from the largest trading partners, especially Sweden, Germany and Great Britain. According to the Armington-approach, demand from export markets and relative prices are important determinants of the demand for Norwegian products abroad. This approach specifies that products traded internationally are differentiated by country of origin and not treated as homogenous, see Armington (1969). The level of import of Norway's trading partners is important in explaining the level of Norwegian exports. The current growth in export markets is low reflecting poor growth in the OECD economies and in Europe in particular. However, the growth is expected to increase. During the 2020s annual growth rates are assumed to be somewhat higher than the historical average from 1982 till the financial crisis.

Fiscal policy is specified in accordance with the fiscal policy rule that was introduced in Norway in March 2001, St.meld. (2001). Further it is assumed a nominal return on the government pension fund of 5.5 per cent annually implying a real return of 3.5 per cent using international consumer price inflation (CPI) as deflator. In 2015 the structural oil adjusted deficit is slightly less than this return and the adjusted deficit is assumed to follow the rule over time, but not every year. Public consumption is assumed to grow by 2-2.5 per cent annually until 2020 and 1.5-1.7 per cent annually thereafter. Public investment in infrastructures increases by 2 per cent annually from 2016 to 2030. Total investment in the public sector is also affected by purchases of new fighter aircrafts during the period 2015-2024, amounting to more than 60 billion kroner during these years. From 2017 to 2024 military investments in aircrafts are 7 billion kroner annually. Tax rates are reduced slightly from 2015 to 2017 and are then held constant until 2030. Social transfers grow in line with entitlements and are mainly driven by demographic trends following the population forecast. Nominal growth in the National Insurance basic amount (grunnbeløpet) follows wage growth.

Figure (15) presents the main features of the most recent population forecast. Due to high immigration the Norwegian population is forecasted to in-

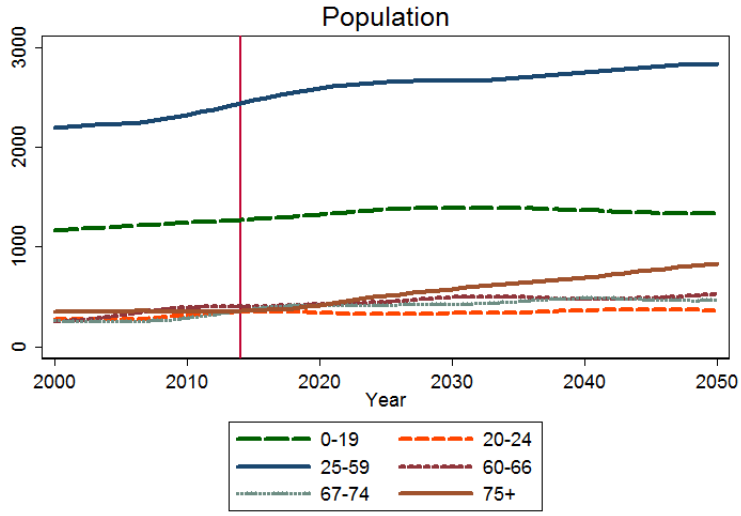

Figure 15: Population based on register data 2000-2011 and forecasted 2012-2030. In thousands.

crease quite rapidly during the coming decade. The ageing of the Norwegian population takes place in particular after 2020 when the population of 75 years and older increases markedly. The number of young people (0-19 years) is increasing somewhat while the potential student population (20-24 years of age) is quite stable. The population in the core working age group (25-59 years) increases rapidly at the moment but this growth rate is forecasted to decline somewhat due to lower immigration during 2020-2030. In our scenario the number of elderly people largely determines pensions and government transfers as well as spending on social care while the number of young people is important for government expenditures on education.

Finally, some details on expected developments for the Norwegian petroleum extraction industry are presented. A lasting significant decline in oil prices, will most likely lead to major adjustments in the development of new capacity offshore. The size of the adjustments are difficult to estimate as lower oil prices may initiate research and development activities providing new solutions and opportunities. The baseline scenario is based on historical data and petroleum production (volume) is expected to be around 50 billion 2010-kroner lower every year than in the projections in the 2013 report. In 2030, petroleum production is expected to be nearly half of the level in 2013. The decline is primarily due to the effect of more resources remaining in the ground as they are not profitable to extract with low oil prices. In addition, exploration intensity falls and hence fewer resources will be discovered, which will also help to reduce production in the baseline scenario further.

7.3 The Norwegian economy towards 2030

The assumptions above are input to the model and once they are incorporated, the model is used to project the development of the Norwegian economy towards 2030. Table (6) summarizes the projections from 2013 to 2030. The focus is not on providing a projection that tries to capture the details of current business cycle movements, but on medium to long run features of the economy that are important for industry developments and demand for labour with different levels and fields of education. Thus the key macroeconomic variables move close to their expected long-term trend and demand for labour by education result mainly from structural rather than cyclical factors.

Table 6: Macroeconomic projections (annual growth rates if not stated otherwise)

	2011-15	2016-20	2021-25	2026-30
National accounts data				
Household consumption	2.2	2,7	3.0	2.3
General government consumption	2.2	2.2	1.6	1.5
Gross fixed investment	1.8	4.0	0.7	0.7
Exports	0.3	2.3	2.3	0.9
Exports, traditional goods	2.6	3.8	2.3	2.6
Imports	3.1	2.6	2.6	2.4
GDP	1.3	2.6	1.9	1.1
GDP, mainland	1.9	3.2	2.0	1.7
Labour market				
Hours worked, total	0.7	1.2	0.6	0.4
Labour force	0.7	1.0	0.8	0.5
Unemployment rate, level in percent	3.7	4.0	3.5	3.4
Prices and wages				
Wage per hour	3.1	2.7	2.8	3.3
Consumer price index (CPI)	2.1	1.4	1.3	1.3

The Norwegian economy is now in a moderate recession, where petroleum investments has fallen from a peak in 2013, and the oil price dropped during the summer of 2014. Unemployment increased from 3,6 percent in 2014 to 4.5 percent in the summer of 2015. Unemployment is expected to increase further before it is reduced from 2017 and vary between 3.2 and 3.9 percent through the rest of the projection period, with an average of 3.66 per cent. Supply of labour is expected to increase by an average of about 0.8 percent each year over the period. The supply of labour and employment follow each other quite closely.

The growth in yearly wages of 2.95 per cent in 2014 was the lowest in two decades, and the wage settlement of 2015 is expected to provide even lower wage growth of 2.6 per cent. Growth in yearly wages is expected to increase in 2016, but to stay under 4 percent for the rest of the period. Real consumer wages grow by 1.5 per cent annually on average.

Inflation is expected to be low and stable over the period, and the growth of the consumer price index seems to stay under 2 percent from 2016 with an average growth of 1.45 percent annually.

Total GDP is expected to grow less than GDP in the mainland economy due to the decline in petroleum extraction. Average growth in GDP is 1.78 per cent over the period while it is 2.26 per cent for mainland GDP. This also explains why total exports grow less than exports of traditional goods. The small decline in the GDP mainland growth rate is mainly caused by lower growth in labour supply due to demographic factors and lower immigration. The growth rate in labour productivity (approximated by the growth rate in mainland GDP minus total number of hours worked), shows that the baseline scenario projects a fairly stable productivity growth of approximately 1.5 percent annually.

Declining production of oil and gas also causes total exports to grow less than imports over the period. Average growth in total exports is expected to be 1.5 per cent per year while imports are expected to increase by 2.6 percent annually. Terms of trade is expected to decline in 2015 and 2016 because of changes in real oil price, but will stay fairly stable at around 1.3 for the rest of the period. Nominal wage growth, combined with a relatively stable exchange rate at approximately 8.4 against the Euro, lead to a fairly constant terms of trade for the exposed sector. From 1996 and onwards the government has been investing its budget surplus abroad in a pension fund leading to a close relation between the current account surplus and net financial investment by government. This is also seen in the baseline scenario in the years ahead and is shown in Figure (16).

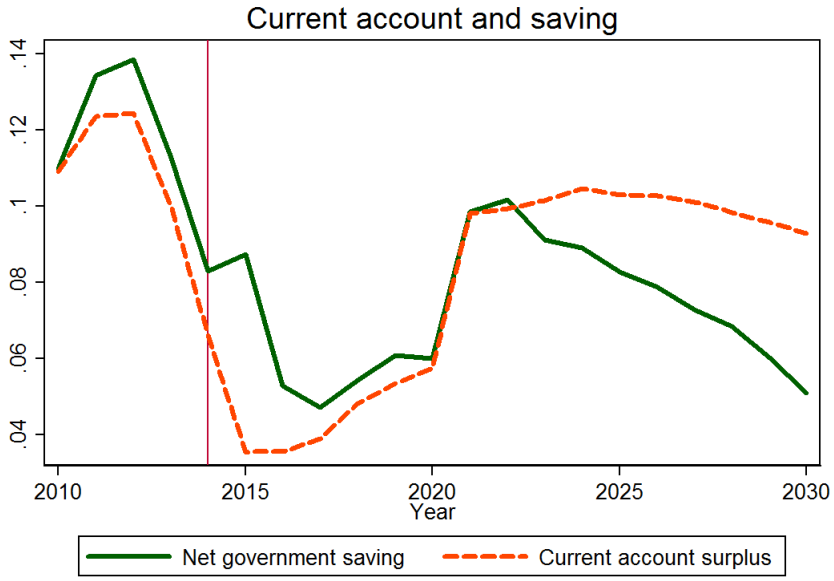

Figure 16: Current account and net government saving as share of nominal GDP.

Public consumption is expected to increase steadily with an average growth rate of 1.8. The growth in government investments drops from about 9 percent 2014 to about 3.7 in 2015. Disregarding military investments, government investments will increase at about 4.5 percent per year the next years, and grow at a lower rate of 2.7 percent after 2020. The growth in defense investments peak in 2017 because of the aircraft investments.

Mainland investments increase more than total investments the next years because of the decline in petroleum investments. Petroleum investments seems to increase from 2018 to about 2024 before the growth steadily declines at a rate of about 2.7 percent per year.

Household consumption grows in line with growth in households real disposable income. Household consumption is expected to grow by 2.6 percent per year on average over the period, while the expected growth of households real disposable income is 2.8 on average. In line with the difference between increase in income and consumption, the households savings ratio is expected to increase. Higher average growth in consumption relative to mainland GDP is partly due to increased pension payments and demographic changes but also because of slightly lower taxes. The room for fiscal stimulus according to the fiscal policy rule is partly used for higher military expenditures on investments and growth in public consumption related to the ageing of the population.

The labour participation rate fell during the years of the financial crisis and has not yet fully recovered. The labour participation is expected to be reduced by one percentage point in 2016 to 70 per cent and then increase slowly to 73 per cent by 2030. The fairly stable participation rate implies that labour supply in Norway tracks labour demand quite closely as unemployment is relatively stable in the period. The declining growth of the supply of labour is therefore due to demographic factors and lower immigration in particular. Immigration is expected to decline markedly from 2017. There are at least two arguments for a somewhat higher participation rate in the future. First, labour force participation is higher for those with a tertiary education compared to those with a primary or secondary education. Since the number of tertiary educated persons increases while the number of persons with less education decreases in our projections, the average participation rate is expected to increase as well. Secondly, higher real wages lead to higher labour supply in particular in terms of hours

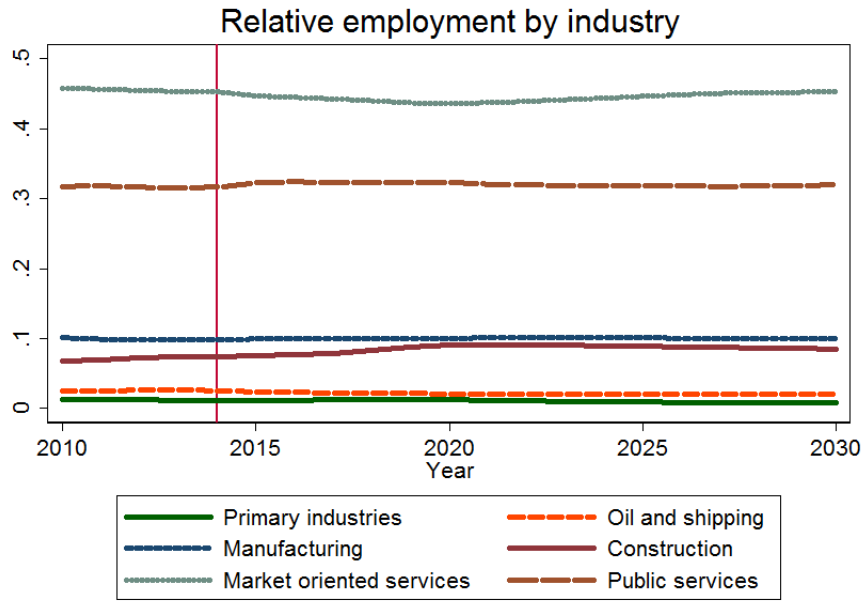

Figure 17: Employment by industry as share of total employment.

per employee. On the other hand labour participation rates for some immigrants are quite low and this will lower aggregate participation rates. An ageing population will do the same, but participation rates for those 62 years and older has been increasing for some time and this counteracts some of the ageing effect.

The structure of employment by industry is important for the demand for labour by education. Figure (17) shows the relative composition of employment by some industry aggregates. Employment in primary industries is expected to decline slowly but steadily over the estimation period. Employment in fish farming is expected to increase and reach a top in 2020 before it declines back to approximately the level of today in 2030. In Manufacturing, total employment is fairly constant in the years ahead. Construction and Electricity production is also quite stable with some moderate increase. Employment in services in both market oriented and public industries are expected to increase considerably. The increase in public sector is mainly driven by demographic factors leading to higher demand for social services such as health and social care for elderly people. This is a fairly standard feature of all projections of the structure of employment in Norway.

The relative shares of employment by industry seems to be fairly stable in the estimation period. There is a small decline in shares of employment in primary industries and in oil and shipping, while construction and services share of employment is increasing. Consequently changes in the education structure are mainly driven by a relative increase in employment in services in general. In addition there will be changes in labour demand due to changes in the education structure within industries.

Compared to previous projections to 2030 our current projection differs from Cappelen, Gjefsen, Gjelsvik, Holm and Stølen (2013) as the drop in oil prices has increased unemployment and further reduced investments in petroleum. Our study is based on the middle alternative according to the most recent population forecasts by Statistics Norway where immigration is projected to be higher in the coming years.

8 Concluding remarks

Statistics Norway has a long tradition in constructing model-based projections of labor demand and supply that take into account heterogeneity in educational levels. The theoretical models and the estimated relations, which provide the foundations of the labor market projections, are improved and updated over time.

This report presents new research on the demand side of the model. New wage relations and demand functions are estimated using new knowledge and latest available data. These relations are the basis for new projections of demand for labour till 2030, and the results are compared to the previous report on employment by education by Cappelen, Gjefsen, Gjelsvik, Holm and Stølen (2013).

To account for recent incidents, such as the introduction of inflation targeting in 2001 and a surge in immigration since the expansion of EU in 2004, new equations are estimated to describe wage growth. Compared to the previous results, wages are found to move towards equilibrium faster than before for four educational groups in manufacturing, implying that wages above or below equilibrium will be counteracted more rapidly through reduced or increased wage growth. For the group with education corresponding to a Master degree in manufacturing, wages adjusts more slowly which implies that wages can deviate from equilibrium for a longer time period. Gross immigration flow is found to have a negative effect on wages.

Firms' demand for different types of labour varies across industries, and therefore changes in industry structure affect the relative demand for different types of labour at the aggregate level. The aggregate level of industries have changed since the previous estimations were constructed. To account for such changes, new cost shares representing demand for labour are estimated for three educational groups. The estimation gives support to the hypothesis of skill biased technology change as demand for labour with vocational education and tertiary education increases relative to demand for labour with shorter education.

The projections show that the past trends with increasing demand for highly educated labour and lower demand for those with shorter education will continue in the next two decades. The increase seems to be most pronounced for labour with upper secondary education, vocational programs and tertiary education. Furthermore, when studying the labour demand projections by educational fields, demand increases for all fields within tertiary education, and particularly for candidates in economics and administration, as well as in nursing and social care. This is mainly in line with previous projections of education specific employment.

To highlight our findings of gross immigration flow on the wage formation, four alternative scenarios of changes in immigration are investigated. An alternative scenario of a 15 000 persons increase in gross labour migration flow in 2015 to 2030 and an equivalent increase in outflow from 2016 to 2030 leads to a 4.1 per cent decrease in real wages in 2030 relative to the baseline scenario. Lower wages decrease households' disposable income and they lower consumption. On the other hand, lower wages contribute to higher employment, lower unemployment and improved competitiveness. The former effect dominates, and therefore GDP is lower. Note that in the calculations, income is shifted from wage earners to capital owners, and the latter has a very low propensity to consume. The reduction in consumption is therefore somewhat large. Public consumption is also unchanged.

We also find that the effect on the economy depends on the skill composition of the immigrants. The effect on the economy, i.e. the effect on GDP, is

less negative when the increase in supply has a skill distribution that is similar to the hosting country. One potential explanation is related to the degree of mismatch in the labor market, as reflected by the effect on unemployment. When the supply shock has the same skill composition as the host country each education-group experiences a reduction in unemployment. In contrast, when the supply shock has a skewed skill composition, the educational group that is directly affected experiences an increase in unemployment.

Recently, the flow of refugees has increased substantially. This has raised several questions on how refugees are integrated and affect the labour market. These questions are not discussed in this report.

Information on the educational background of immigrants has improved recently but the skills of future immigrants are a particular problem for this study. This is an issue where more research is needed.

References

Armington, P. S.: 1969, A Theory of Demand for Products Distinguished by Place of Production, *International Monetary Fund Staff Papers* **16**(1), 159–178.

Barrabes, N. and Ostli, G. K.: 2015, Norwegian standard for educational grouping (in Norwegian: Norsk standard for utdanningsgruppering Revidert 2000 Dokumentsajon), *Statistics Norway Notat* **37**.

Bjørnstad, R., Gjelsvik, M. L., Godøy, A., Holm, I. and Stølen, N. M.: 2010, Demand and supply of labor by education towards 2030 Linking demographic and macroeconomic models for Norway, *Reports Statistics Norway* **39/2010**.

Bjørnstad, R. and Skjerpen, T.: 2006, Trade and inequality in wages and unemployment, *Economic Modelling* **23**(1), 20–44.

Boug, P. and Dyvi, Y.: 2008, *MODAG - en makroøkonomisk modell for norsk økonomi*, Vol. 111, Statistics Norway, Oslo - Kongsvinger, Norway.

Bratsberg, B., Raaum, O., Røed, M. and Schøne, P.: 2014, Immigration wage effects by origin, *Scandinavian Journal of Economics* **116**(2), 356–393.

Calmfors, L. and Larsson Seim, A.: 2013, Pattern Bargaining and Wage Leadership in a Small Open Economy, *Scandinavian Journal of Economics* **115**(1), 109–140.

Cappelen, ., Gjefsen, H., Gjelsvik, M., Holm, I. and Stølen, N. M.: 2013, Forecasting demand and supply of labour by education, *Statistics Norway Reports* **48/2013**.

Cappelen, A., Eika, T. and Prestmo, J. B.: 2013, Petroleumsvirksomhetens virkning pånorsk økonomi og lønnsdannelse. Framtidig nedbygging og følsomhet for oljeprissjokk, *Reports Statistics Norway* **59**.

Cuaresma, C.: 2003, Okun ' s Law Revisited, *Oxford Bulletin of Economics and Statistics* **4**, 439–451.

Gjefsen, H. M.: 2015, Projections of employment divided by education. Definitions and assumptions (in Norwegian: Framskrivinger av arbeidstilbud fordelt etter utdanning. Definisjoner og forutsetninger), *Statistics Norway Notat* **36**.

Gjelsvik, M. L.: 2013, The Demand for Labour by Education. A Sectoral Model of the Norwegian Economy, *Reports Statistics Norway* **41/2013**.

Gjelsvik, M. L., Nymoen, R. and Sparrman, V.: 2015, Resilience and adaptation. An Econometric Study of Pattern Wage Bargaining in Norway, *Discussion paper Statistics Norway* .

Haraldsen, K. W.: 2015, Coordination in Norwegian Wage Setting Estimation of wage relations with heterogeneous labour, *Master thesis* .

Harris, A., McAvinchey, D. and Yannopoulos, A.: 1993, The demand for Labour, Capital, Fuels and Electricity: a sectorial Model of the United Kingdom Economy, *Journal of Economic Studies* **20**(3), 24–35.

Kremer, M. and Maskin, E.: 2006, Globalization and inequality, *Harvard University* .

Machin, S.: 2001, The changing nature of labour demand in the new economy and skill-biased technology change, *Oxford Bulletin of Economics and Statistics* **63**(SUPPL.), 753–776.

Okun, A. M.: 1962, Potential GNP: Its Measurement and Significance, *Proceedings of the Business and Economic Statistics Section of the American Statistical Association* .

Sparrman, V.: 2012, Arbeidsledighet som konjunkturindikator og forklaringsfaktor i makromodeller, (in Norwegain. Unemployment as economic indicator and explanatory variable in macroeconomic models), *Økonomiske analyser* **5**, 21–25.

St.meld.: 2001, Guidelines for economic policy (Retningslinjer for den økonomiske politikken), *Det Kongelige Finansdepartement* **29**(29).

von Brasch, T.: 2012, Technical change: Norway is the odd country out, unpublished note, *Unpublished work* .

Wilson, R., Homenidou, K. and Dickerson, A.: 2004, Working Futures: New Projections of Occupational Employment by Sector and Region , 2002-2012, *Sector Skills Development Agency* .

A Data and definitions

All data used in the report are collected from Statistics Norway. Time series for the number of unemployed, the unemployment rate and the labour market participation rate is from the labour force survey. Time series for wages, employment, normal working hours, kapital, value added, productivity and price developments are taken from the National Accounts (NA). Also, the discount rate and the number of children per woman is from NA.

Lower case letters refer to the logarithm of the original variables listed below. For example, $u_t = \log(U_t)$ denotes the log of the unemployment rate. Variables in first differences are denoted by Δ. Subscripts denote time period. For example, p_{t-4} refer to the (log of) the price level 4 periods back.

Variables

$WW-$Index for hourly wage
$WC-$Wage costs, includes pay roll tax rate
$N-$ Employment, hours worked by wage earners
$L-$ Labour supply
$U-$ Unemployment rate
$K-$ Kapital
$Q-$ Value added
$A(t)-$ Deterministic trend, defined as
$S-$ Cost share, see
$P-$ Consumer price index
$H-$ Normal working hours
$Q-$ Price product deflator in manufacturing
$YP-$ Labour market participation rate (share of total population participating in the labour market)
$DR-$ Discount rate
$CPW-$ Number of children per woman
$Z-$ Productivity
$C-$ Consumption
$WA-$ Alternative wage
$KWA-$ Reference wage

Definitions

Cost shares (S), defined for a skill group i as $S_i = (WC_i N_i) / \sum_i WC_i N_i$
Skill intensity, defined as N_H / N_L
Skill premium, defined as W_H / W_L

Key industries

Primary industries (Primærnæringer - næring 10A, 13 og 14)
Manufacturing (Industri - næring 15, 25, 30, 40 og 45)
Market oriented service activities (Privat tjenesteyting - næring 63, 74, 81, 83, 84, 85 og 86)
Public sector (Offentlig sektor - næring 92S, 91S og 90K)
Oil and shipping (Sjøfart og utvinning av råolje og naturgass - næring 65 og 66)
Construction (Bygg og anlegg - næring 55)

Industries with estimated cost shares

15 Consumption goods
25 Misc. manufacturing
30 Energy intensive manufacturing
45 Engineering products
55 Construction
63 Financial intermediates
64 Oil and gas exploration
71 Electricity
74 Domestic transportation
81 Wholesale and retail trade
84 Information and communication
85 Other market oriented services
86 Real estate activities

The disaggregated data on wages and employment classified by educational groups are taken from the Labour Accounts. We aggregate these into skill groups listed below.

Five educational groups

$GRK-$ Primary and lower secondary education (Level 0 and 1)
$VA-$ Upper secondary general education (Level 2a)
$VF-$ Upper secondary vocational education (Level 2b)
$HO-$ Short tertiary education (Level 3)
$UN-$ Long tertiary education (Level 4)

Three educational groups

$L-$ Short education (GRK *and* VA)
$M-$ Medium education (VF)
$H-$ Long education (HO *and* UN)

28 educational fields

The fields of education is taken from register data. Aggregated educational groups, based on the Norwegian Educational Standard (NUS), highest completed level of education[6]:

Level 0: Unreported (Uoppgitt)
9: Unreported education (Uoppgitt utdanning)
Level 1: Primary education (ISCED 0-2) (Grunnutdanning)
1 Primary education (Grunnskole)
Level 2: Upper secondary education (ISCED 3 and 4)
(Videregående opplæring, inkluderer fagskole/påbygging/forkurs)
Level 2a
2.1 General programs (Studieforberedende)
2.2 Economics and administration (Økonomiske og administrative fag, inkluderer også handel og markedsføring, kontorfag og hotell- og reiselivsfag)
Level 2b
2.3 Electronics, mechanics work and machinery (Elektrofag, mekaniske fag og maskinfag)
2.4 Building and construction (Bygg og anleggsfag)
2.5 Other fields of science, technique and crafts (Naturvitenskaplige fagog ulike håndverksfag)
2.6 Nursing and care giving (Helse- og sosialfag)
2.7 Other fields, upper secondary education (Andre utdanninger, blant annet transport og tjenesteyting)
Level 3 Tertiary education, lower degree (ISCED 5, lower degree)[7]
(Kort høyere utdanning, minst 120 studiepoeng)
3.1 Humanities and arts, lower degree (Humanistiske og estetiske fag)
3.2 Education, lower degree (Lærerutdanning og pedagogikk)
3.3 Social sciences, business and law, lower degree (Samfunnsfag og juridiske fag)
3.5 Economics and administration, lower degree (Økonomiske og administrative fag)
3.6 Engineering, lower degree (Ingeniør)
3.7 Other fields of science, lower degree (Naturvitenskaplige fag, tekniske fagog håndverksfag)
3.8 Nursing and care giving (Pleie- og omsorgsfag)
3.9 Other fields of health and social services (Andre helse- og sosialfag)
3.10 Other tertiary education, lower degree (Andre utdanninger, blant annet primærnæringsfag)
4 Tertiary education, higher degree (ISCED 5, higher degree and ISCED 6)
(Lang høyere utdanning, femåring utdanning samt forskerutdanning)
4.1 Humanities and arts, higher degree (Humanistiske og estetiske fag)
4.2 Education, higher degree (Lærerutdanning og pedagogikk)
4.3 Social sciences, higher degree (Samfunnsfag)
4.4 Law, higher degree (Juridiske fag)
4.5 Economics and administration, higher degree (Økonomiske og administrative fag)
4.6 Graduate engineering (Sivilingeniør)
4.7 Other fields of science, higher degree (Naturvitenskaplige fag, tekniske fagog håndverksfag)
4.8 Medicine (Medisin)
4.9 Dental studies (Tannlege)
4.10 Other tertiary education, higher degree (Andre utdanninger, blant annet primærnæringsfag)

[6] Note that there is a new Norwegian standard for educational grouping, see Barrabes and Ostli (2015).

[7] A group numbered 3.4 is skipped to obtain the same sub-number for corresponding groups with a lower and higher degree in tertiary education

B Additional results

B.1 Wage relations with full heterogeneity

The estimated results of wage equations in Section 4, table 1, are restricted. However, none of the restrictions are outside the confidence interval of the unrestricted estimates. This appendix display the unrestricted results.

Table 7: Wage relations with full heterogeneity, SUR-estimation.

Manufacturing	Primary		Secondary		Vocational		Low univ.		High univ.	
	Estimate	Std	Estimate	Std	Estimate	Std	Estimate	Std	Estimate	Std
Wage share$_{i,t-1}$	-0.12	0.05	-0.15	0.05	-0.14	0.05	-0.13	0.04	-0.04	0.06
u_{t-1}	0.02	0.02	0.02	0.03	-0.04	0.03	0.01	0.01	-0.00	0.02
$u_{i,t-1}$	-0.04	0.02	-0.03	0.02	0.03	0.02	-0.00	0.01	-0.00	0.01
diffun									-0.21	0.15
$\Delta wc_{m,i,t-1}$	0.26	0.09	0.32	0.07	0.34	0.10	0.34	0.08	0.54	0.19
Δz_t	0.05	0.07	0.14	0.07	0.20	0.10	0.17	0.08	0.35	0.08
Δh_t	-0.45	0.16	-0.31	0.15	-0.45	0.19	-0.23	0.16	-0.05	0.18
Δp_t	0.41	0.16	0.76	0.13	0.86	0.18	0.82	0.16	0.90	0.18
$D_{wage\ freeze}$	-0.02	0.01	-0.01	0.01	-0.01	0.01	-0.02	0.01	0.01	0.01
Δu_t	-0.01	0.03	0.01	0.03	-0.04	0.04	-0.02	0.02	-0.05	0.02
$\Delta u_{i,t-1}$	-0.01	0.02	-0.03	0.02	0.00	0.02	-0.00	0.01	-0.01	0.01
Immigration	-0.01	0.01	0.00	0.01	0.01	0.02	-0.01	0.01	-0.02	0.01
D_{1975}	0.02	0.01	0.02	0.01						
D_{1978}					0.05	0.02				
$D_{1988-1997}$									-0.01	0.01
D_{1991}			0.03	0.01						
D_{1992}			-0.04	0.01						
D_{1993}	-0.02	0.01	0.00	0.01	-0.01	0.02	-0.01	0.01	0.00	0.02
D_{2003}					-0.01	0.01				
D_{2008}	-0.03	0.01	-0.07	0.01						
Constant	0.86	0.33	1.02	0.31	0.96	0.34	0.90	0.31	0.45	0.37
Years	39.00									
F-test	25.04		26.07		18.10		21.99		18.39	
RSS	0.00		0.00		0.01		0.01		0.01	
MSS	0.05		0.05		0.06		0.04		0.05	
RMSE	0.01		0.01		0.02		0.01		0.01	
R^2	0.92		0.94		0.90		0.89		0.90	
Durbin Watson	1.46									
Breusch-Pagan	136.95(10.00)									

Table 8: Wage relations with full heterogeneity, SUR-estimation.

Public sector	Primary		General		Vocational		Low univ.		High univ.	
	Estimate	Std	Estimate	Std	Estimate	Std	Estimate	Std	Estimate	Std
$(ww_{g,i} - kwa_{g,i})_{t-1}$	0.02	0.17	-0.36	0.11	-0.00	0.07	-0.09	0.25	-0.16	0.10
$u_{i,t-1}$	-0.05	0.02	0.00	0.01	0.01	0.01	0.00	0.01	0.01	0.01
$\Delta ww_{g,i,t-1}$	-0.29	0.20	-0.31	0.08	-0.15	0.14	-0.06	0.23	-0.49	0.13
$\Delta kwa_{g,i,t-1}$	0.17	0.23	0.50	0.11	0.41	0.16	0.39	0.22	0.79	0.17
Δp_t	0.16	0.20	0.79	0.12	0.65	0.12	0.51	0.18	0.61	0.19
Δu_{it}	-0.04	0.01	-0.03	0.01	-0.01	0.01	-0.01	0.01	0.01	0.01
Immigration	-0.01	0.02	0.00	0.01	0.02	0.01	0.01	0.01	-0.01	0.01
1975	0.03	0.02	0.03	0.01	0.03	0.01	0.04	0.02	0.05	0.02
1976	0.05	0.02	0.04	0.01	0.05	0.01				
1979	-0.05	0.02							-0.02	0.02
1982					0.04	0.01	0.05	0.02		
1988			-0.03	0.01	-0.04	0.01	-0.02	0.01		
1988-1997									-0.01	0.01
2001	0.01	0.02	-0.00	0.01	0.01	0.01	0.03	0.01		
2008			0.08	0.01	0.02	0.01			-0.07	0.02
2009									0.03	0.01
Constant	0.16	0.05	-0.04	0.03	-0.00	0.02	-0.01	0.06	-0.02	0.03
Years	38.00									
F-test	15.33		36.28		28.70		17.32		18.70	
RSS	0.01		0.00		0.00		0.01		0.00	
MSS	0.04		0.05		0.04		0.03		0.04	
RMSE	0.02		0.01		0.01		0.01		0.01	
R^2	0.86		0.93		0.93		0.87		0.90	
Durbin Watson	2.10									
Breusch-Pagan	30.86(10.00)									

Market oriented	Primary		Secondary		Vocational		Low univ.		High univ.	
	Estimate	Std	Estimate	Std	Estimate	Std	Estimate	Std	Estimate	Std
$(ww_{s,i} - kwa_{s,i})_{t-1}$	-0.33	0.12	-0.10	0.08	-0.12	0.06	-0.16	0.08	-0.21	0.06
$u_{i,t-1}$	0.01	0.01	0.00	0.01	-0.00	0.01	0.00	0.00	0.01	0.00
$\Delta ww_{s,i,t-1}$	0.04	0.07	0.11	0.10	0.30	0.10	0.24	0.08	0.44	0.10
$\Delta kwa_{s,i,t}$	0.81	0.05	0.81	0.08	0.76	0.12	0.73	0.07	0.55	0.08
$\Delta^2 p_t$	0.17	0.08	0.11	0.12	0.22	0.13	0.16	0.09	0.14	0.12
Δu_t	-0.05	0.02	-0.03	0.02	-0.05	0.03	-0.02	0.01	-0.03	0.01
Δu_{it}	0.07	0.01	0.04	0.02	0.03	0.02	-0.01	0.01	0.00	0.00
Immigration	-0.02	0.00	0.00	0.01	-0.01	0.01	-0.01	0.01	-0.01	0.01
D_{1978}	0.02	0.01								
D_{1982}	0.02	0.01								
D_{1987}					0.02	0.01				
D_{1993}			0.00	0.01	-0.00	0.01	-0.00	0.01	-0.02	0.01
D_{2007}									0.02	0.01
D_{2008}			-0.08	0.01	-0.03	0.01	-0.03	0.01		
D_{2009}			0.04	0.01						
Constant	-0.01	0.02	0.01	0.01	0.00	0.01	0.02	0.01	0.02	0.01
Years	39.00									
F-test	132.53		56.35		41.15		71.17		32.77	
RSS	0.00		0.00		0.00		0.00		0.00	
MSS	0.05		0.04		0.05		0.04		0.04	
RMSE	0.01		0.01		0.01		0.01		0.01	
R^2	0.98		0.96		0.94		0.96		0.92	
Durbin Watson	1.91									
Breusch-Pagan	24.43(10.00)									

B.2 Changes in hourly wages and error terms

This appendix display plots of percentage change in hourly wages and error terms for the model with new wage equations (straight line) compared to the baseline scenario (dotted line) with old wage equations. The figures display plots for five educational groups in manufacturing with changes in hourly wages to the left and error terms to the right. The large drop in error terms in 2007 and 2008 are due to the financial crisis.

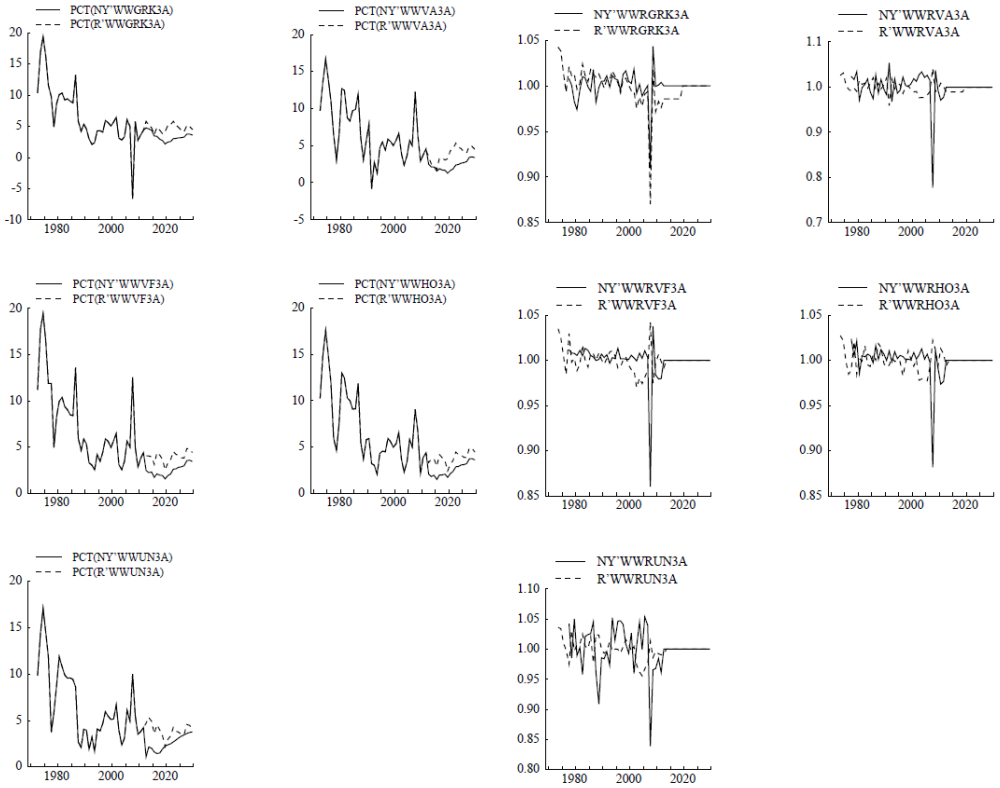

Figure 18: Percentage change in hourly wages (left) and error terms (right) in manufacturing

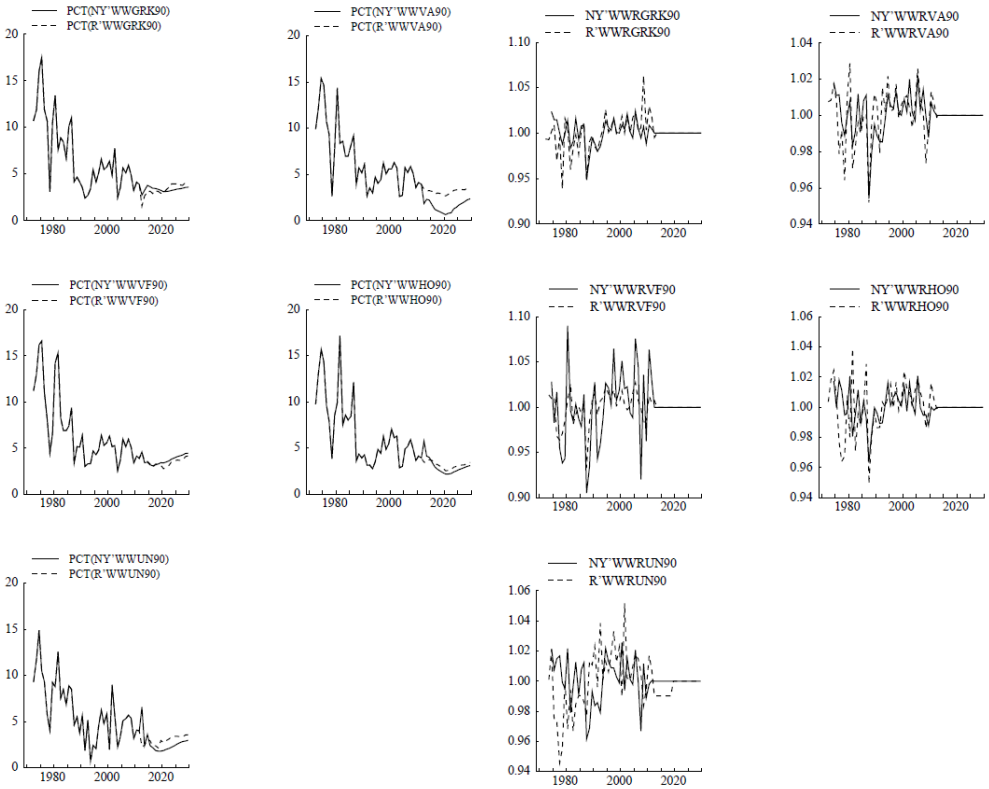

Figure 19: Percentage change in hourly wages (left) and error terms (right) in public sector

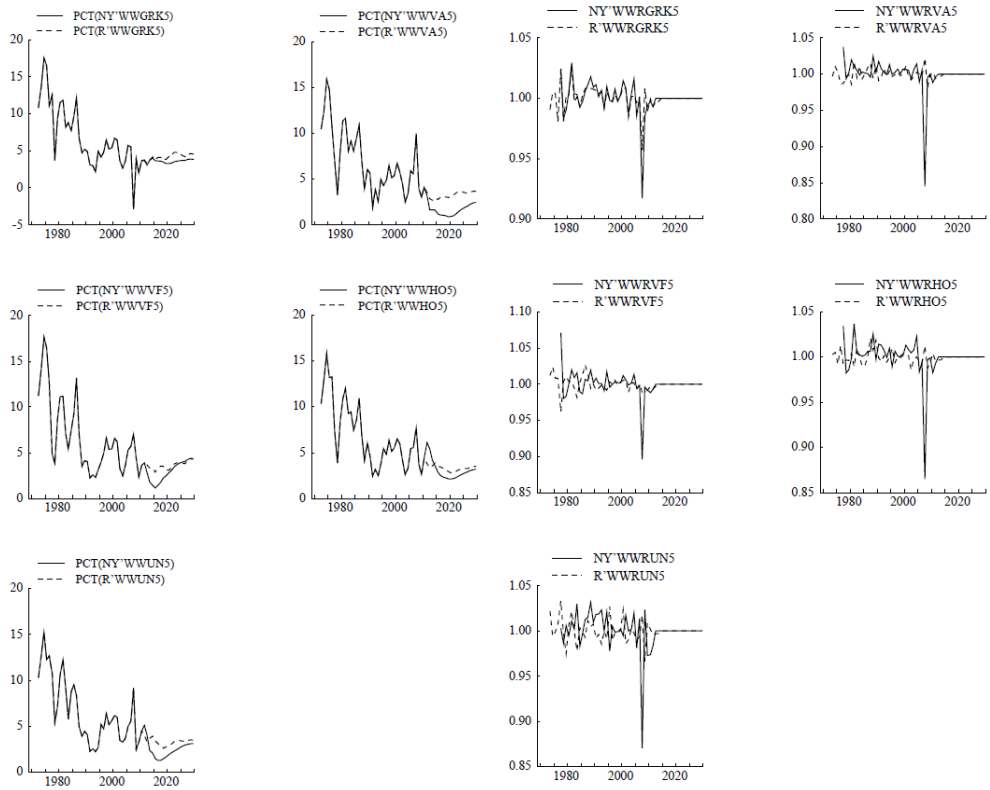

Figure 20: Percentage change in hourly wages (left) and error terms (right) in market oriented service activities.

Table 9: Changes in macroeconomic projections, in percentage points.

	2020	2030
National accounts data		
Household consumption	-1.39	-2.50
Gross fixed investment mainland	-2.20	-4.83
Exports, traditional goods	1.28	4.19
Imports	-1.89	-3.41
GDP mainland	0.18	1.14
Labour market		
Hours worked, wage earners	1.97	2.76
Total employment	1.82	2.75
Labour force	-0.15	-0.27
Unemployment rate, level in percent	-0.00	0.29
Prices and wages		
Wage per hour	-5.08	-10.68
Real disposable income	-1.77	-2.46
Real public transfers	-3.58	-5.24
Consumer price index (CPI)	-1.36	-5.68

B.3 Projected effects of new wage relations

Small changes in estimated wage relations implies that the differences between the baseline scenario and the new projection, are small. The main macroeconomic variables are presented in Table 9. The noteworthy effects are highlighted in this section, while Section 5 presents a complete projection and comparison of labour supply to the 2013-report where also the new demand functions described i the next section are implemented.

Figure 21 displays employment and hourly wages. Growth in aggregate wages is lower at the start of the projection period from 2013 to 2018, and hourly wages will therefore be at a lower level compared to the baseline scenario. However, the growth will be higher, and converge with the baseline scenario over time. This is in line with a more rapid adjustment towards equilibrium wage share and reference wage. It may also be due to larger estimated effects of changes in consumer prices, which ensures that small changes in inflation is met with small changes in wages.

Lower wages affects household's real disposable income and therefore their consumption. Lower consumption implies that firms producing consumer goods face lower demand. In line with reduced consumption, total imports are reduced in the projection period. Figure 22, left panel, shows the small reduction in consumption from 2010 to 2030 compared to the results in the 2013 report.

The lower wage growth implies a lower price growth. The consumer price index is at a lower level through the entire projection period and ensures that the change in real disposable income is small between the projections. Also housing prices are expected to be a little lower at the start of the period, and a little higher at the end of the period, while the gross debt of households is very close to the baseline scenario. This corresponds with the changes in wages.

Reduced wages affects the composition of input in the product market. A reduction in the price of labour makes firm's substitute capital with labour as the relative price of capital is increased, all else equal. Hence, corresponding to the reduction in wages, demand for labour increases. Total investments are lower and employment is higher throughout the period.

Gross investments in mainland Norway is about 3 billions below the baseline scenario around 2020, but this is a relatively small change. Figure 22, right panel, shows the small reduction in investments from 2010 to 2030 compared to the Projection 2013. Although there are some changes in gross investments,

there is no significant change in GDP for mainland Norway. This is mainly due to increased exports. There is no change in public consumption in fixed prices.

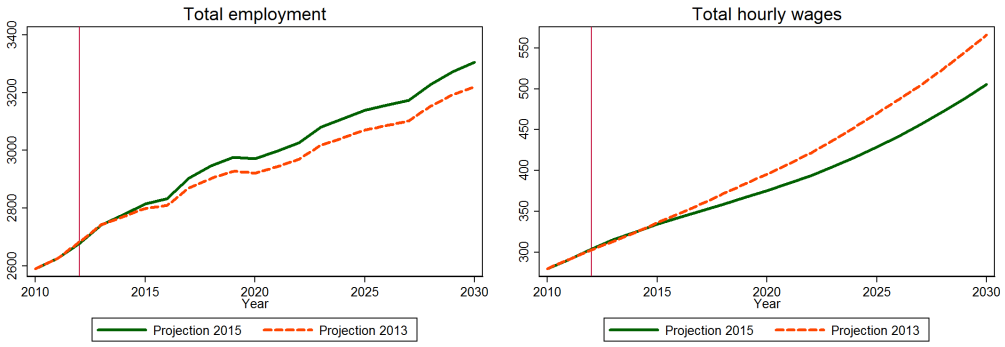

Figure 21: Total employment in 1000 persons (left) and average hourly wage rate (right).

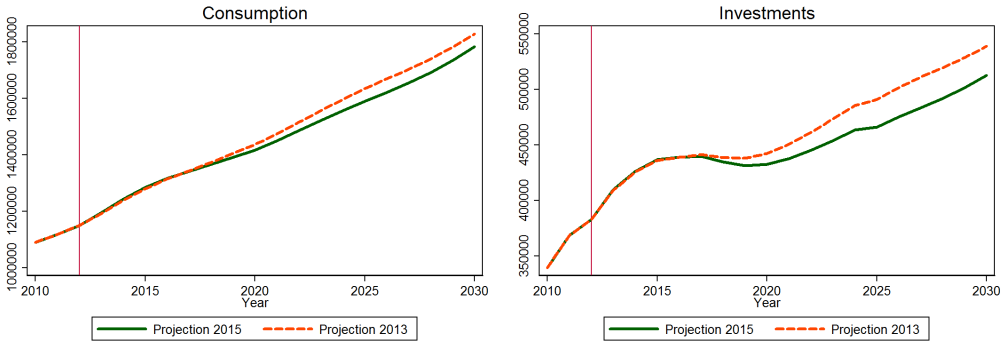

Figure 22: Household consumption (left) and gross investments, mainland (right).

In spite of relatively small macro economic changes, the education specific changes are somewhat larger. Figure 23 to 27 display changes in employment and wages for the five educational groups. The largest deviations in wages from the baseline are present in the projections for workers with upper secondary education, general and vocational programs. In both public sector and market oriented service activities, growth in hourly wages are higher for workers with upper secondary vocational education and lower for those with upper secondary general education.

The largest deviations in employment are in the groups of workers with short education. The group with primary or unreported education in Figure 23 have higher employment, but almost no difference in hourly wages. This may be due to immigration as this is a new variable in the projections. The group with upper secondary education, general programs, has a larger difference in wages, and the lower level of wages increases the employment massively in this group.

For workers with tertiary education, the changes in wages and unemployment are small. Wages are at a somewhat lower level and employment higher for workers with tertiary education, higher degree, while the development for workers with tertiary education, lower degree, are almost identical to the projections from 2013. B.2 displays plots of changes in hourly wages for all three sectors and five educational groups.

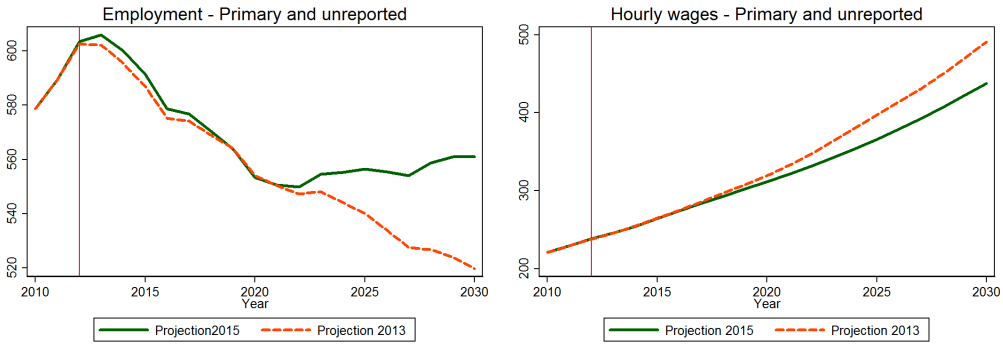

Figure 23: Employment in 1000 (left) and hourly wages (right).

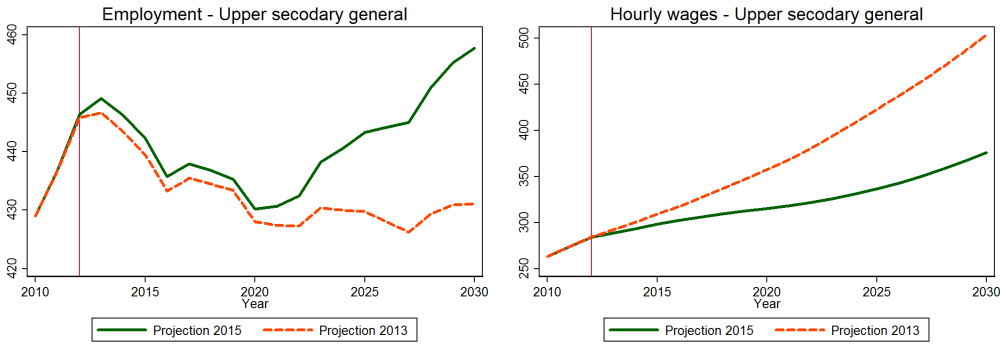

Figure 24: Employment in 1000 (left) and hourly wages (right).

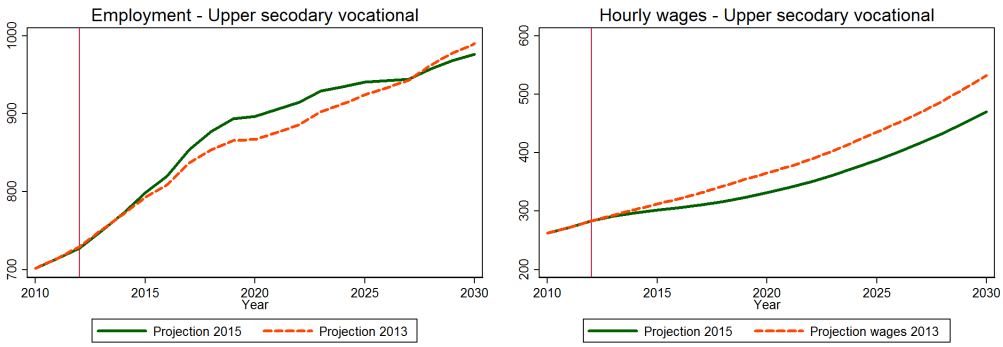

Figure 25: Employment in 1000 (left) and hourly wages (right).

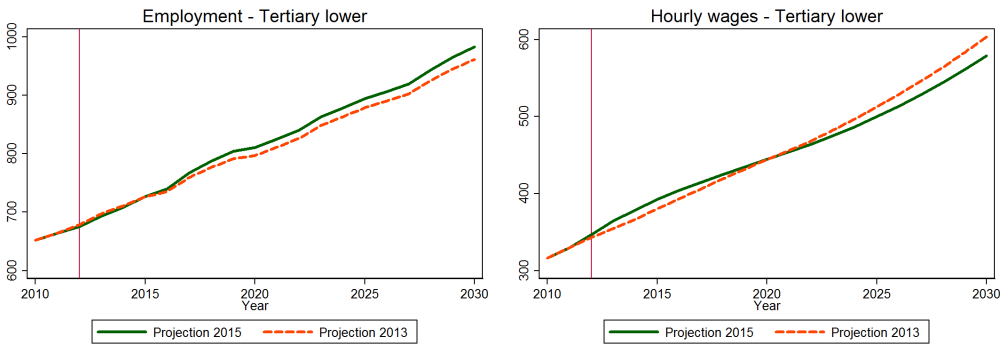

Figure 26: Employment in 1000 (left) and hourly wages (right).

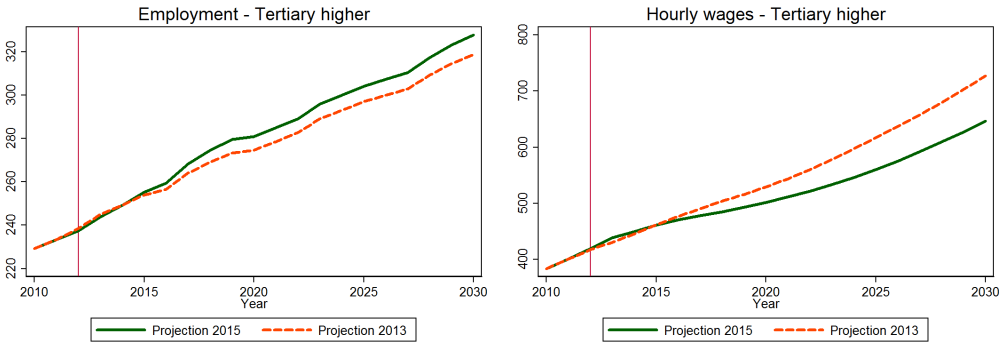

Figure 27: Employment in 1000 (left) and hourly wages (right).

Figure 28: Number of engineers in 1000 with bachelor (left) and master (right).

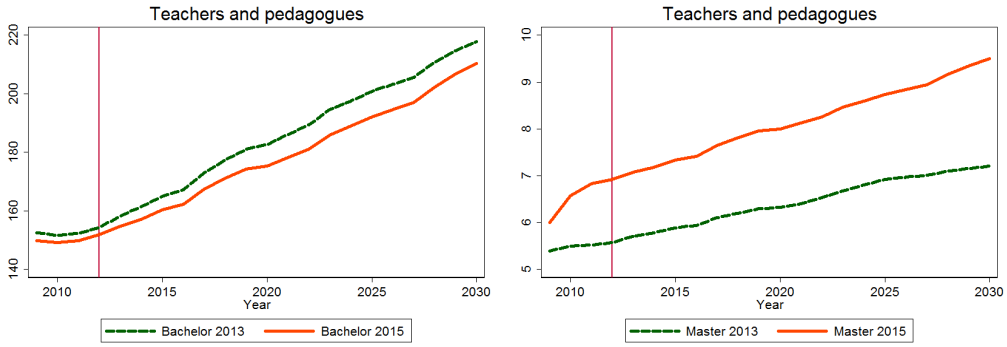

Figure 29: Number of teachers and pedagogues in 1000 with bachelor (left) and master (right).

The changes in employment affects employment by educational field. The changes are small in most fields, but there are some noteworthy changes in employment of workers with education in engineering and the education field. Compared to the 2013 report, employment of graduate engineers is at a lower level in the beginning of the projection period, but at a higher level in some years. This is may be due to reduced demand from the petroleum sector in the beginning of the projection period. Employment of teachers and pedagogues with a bachelor degree is at a somewhat lower level, but the number of workers with a master degree is much higher than previously projected.

B.4 Demand for labour by educational level

The demand for different educational length is determined in two steps. First, the long run relationship of educational specific demand is determined. Second, the dynamic demand for educational specific labour is determined. The demand for each educational group is in the long run determined by minimizing the translog cost function with respect to educational specific wage levels, given the production level and aggregate demand for labour. We distinguish between three educational groups: short education (S), medium education (M) and long education (L). The group of labour with short education covers workers with primary and lower secondary education as well as workers with upper secondary education, general programs. The group of labour with medium education covers workers with upper secondary vocational education, while the group of labour with long education covers the two groups with tertiary education. The tree-part scale represents the demand side in a convenient manner, see Cappelen, Gjefsen, Gjelsvik, Holm and Stølen (2013). A technical and complete description of the cost functions and demand for educational specific inputs are given in Gjelsvik (2013).

The cost function is given by $C(W_S, W_M, W_L, K, Y, A(t))$, where W_i represents the wage rate of workers with short (S), medium (M) and long (L) educational level, capital K is treated as a quasi-fixed factor of production, Y represents value added and $A(t)$ is an unobserved time trend (i.e. SBTC). Assuming constant returns to scale and a translog form of the cost function, the linear economic system of cost share(s) can be written as:

$$S_S = \beta_{SO} + \beta_{LS} \ln(W_L/W_M) + \beta_{SS} \ln(W_S/W_M) + \beta_{SK} \ln(K/Y) + \beta_{SA} A(t) + e_S \tag{4}$$

$$S_L = \beta_{L0} + \beta_{LL} \ln(W_L/W_M) + \beta_{LS} \ln(W_L/W_M) + \beta_{LK} \ln(K/Y) + \beta_{LA} A(t) + e_L. \tag{5}$$

where the cost shares depend in general on relative wages (W_i/W_M) where (i = S, H), the stock of capital divided by gross output (K/Y) and a trend A(t), which in the absence of observable variables increases demand for labour with tertiary education relative to other educational groups. This trend may represent skill biased technological change (SBTC). To ensure that the cost shares are bound between zero and unity, the technology variable are represented by $A(t) = t(t+30)^{-1}$, where t is a deterministic time trend taking the value 0 in 1972, 1 in 1973 etc. Since the cost shares sum to unity, the cost share for labour with vocational upper secondary education is estimated implicitly as $S_M = 1 - S_L - S_S$.

Table 10: Estimated coefficients in the unrestricted translog system of cost shares by industry, 1972-2012

Industry	β_{LL}	β_{LS}	β_{SS}	β_{LK}	β_{SK}	β_{LA}	β_{SA}
15	-0.38771	0.53053	-0.67383	-0.07209	0.18852	0.148867	-0.789524*
25	-0.34504*	0.242443	0.70528*	-0.082497	0.13659	0.232090*	-0.754657*
30	0.19792*	-0.19975*	0.839097*	0.014908	-0.023613	0.211292*	-1.016340*
40	0.422656*	-0.145824	0.177342	0.000132	9.00E-05	0.006692	-0.638271*
45	0.361775	-0.441649	0.443119	0.006137	-0.035866	0.182672*	-0.860912*
55	0.099158	-0.199570	-0.428425	0.013991	-0.006594	0.058954	-0.810018*
63	0.825173*	-0.781552*	0.78141*	-0.217545*	0.201600*	0.933011*	-0.943142*
64	-0.221514	-0.180137	0.448256*	0.068629*	-0.007955	-0.012153	-0.533824
71	-0.921471	0.107497	-0.007497	-0.204150*	-0.009368	0.001228	-0.673988*
74	0.382894	-0.060264	0.338757	0.005107	-0.017357	0.265558*	-0.668416*
81	-0.048443	-0.043030	0.017774	-0.012094	0.012400	0.180815*	-0.512513
84	0.428845	-0.299019	0.227542	-0.039977	0.027773	0.148401	-0.276178
85	1.122252*	-1.062032*	0.936709*	0.157820	-0.205928	0.514628*	-0.643641*

*The coefficient is significant at 5 per cent level
[1]The translog functions are estimated by FIML using annual data from 1972 to 2012.

Table 10 shows the estimated coefficients in the system of cost share equations for various industries together with an indication of whether the coefficient is significant. The coefficients relating to the effect of capital to value added (β_{LK} and β_{SK}) are required to be significant to be included in the cost share function, while the other coefficients are included independent of the significance level.[8]

The table shows that the estimated coefficients relating to the effects of relative wages are large, but statistically insignificant with some notable exceptions, i.e. industry number 25, 30, 63 and 85 in particular. This might be due to the fact that relative wages have been fairly constant over the estimation period.

According to Table 10, the effect of capital to value added is significant in the cost share functions for three industries; banking and insurance (63), extraction and service activities in petroleum and natural gas (64) and electricity generation (71). This implies that increased capital intensity does affect the demand for educational specific labour in these industries. However, the effect is not significant in all of the educational specific cost share equations. It is significant in the cost share equations of labour with long education, but only significant in industry 63 for short educational level. The sign of the effect of capital to value added on the cost share is positive for workers with short and long length of education in industry 63 and 64, while it is negative for workers with long length of education of in both industry 63 and 71. Increased capital intensity in these industries can therefore both lead to a reduction and an increase in demand for labour, depending on the industry as well as the type of labour.

Furthermore, the trend coefficients are large and highly significant in most industries. There is a tendency for this effect being negative and larger in absolute value in the cost share equation for workers with short level of education than in the corresponding equations related to labour with long education. The trend is not significant for the equations related to labour with long education levels in industries 40, 64 and 71. The results provide support for a substitution away from the use of low skilled workers in favour of increased demand for labour with both long- and medium education.

[8]The translog functions are estimated by FIML using annual data for the period 1972-2012.

Table 11: Estimated coefficients in the restricted translog system of cost shares by industry, 1972-2007

Industry	β_{LL}	β_{LS}	β_{SS}	β_{LK}	β_{SK}	β_{LA}	β_{SA}
15	-0.33289	0.480609	-0.768553	-	-	0.091597	-0.597038*
25	0.08561[a]	-0.08145[a]	0.11929[a]	-	-	0.254512*	-0.823161*
30	0.13851[a]	-0.13833[a]	0.1392[a]	-	-	0.202133*	-1.00286*
40	0.185702 [a]	-0.06678[a]	0.10595[a]	-	-	0.025265	-0.655530*
45	0.176959a	-0.251053*	0.18973[a]	-	-	0.145590*	-0.815615*
55	0.076954	-0.221127	-0.36176	-	-	0.109787	-0.815051*
63	0.167876[a]	-0.159925[a]	0.18868[a]	-0.213365*	0.198129*	1.016324*	-1.020676*
64	-0.193128	-0.096256	0.12576[a]	0.059120*	-	-0.010191	-0.520134*
71	-0.965594	0.074138	-0.01003	-0.185152*	-	0.012761	-0.672541*
74	0.0773298[a]	-0.077588[a]	0.120041[a]	-	-	0.203591*	-0.656794*
81	-0.064668	-0.052197	0.036243	-	-	0.201288*	-0.540782*
84	0.2404491[a]	-0.199168*	0.201705[a]	-	-	0.172873*	-0.326259*
85	0.2170107 [a]	-0.237660*	0.2316509[a]	-	-	0.291121*	-0.522687*

[a]The coefficient is restricted
*The coefficient is significant at least a level of 5 per cent
[1]The translog functions are estimated in Eviews by FIML using annual data from 1972 to 2012.

Together with the value of the cost shares, the relative wage coefficients determine the own and cross price elasticities. As a consequence, the own and cross price elasticities differ at every data point. To ensure that the estimated values of equations 4 are the solution to the minimization problem of the cost function, the functional form of the translog cost function must be concave. 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. the β_{LL}, β_{LS} and β_{SS}, is negative semidefinite. Following Harris et al. (1993), a less severe test is employed, where concavity is assumed when the own price elasticities are non-positive. The concavity is secured at every data point in the estimation period. This implies that the parameters are restricted in all cases where unrestricted estimation of equation 4 results in positive own price elasticities.

Table 11 shows the estimated system of cost shares where the parameters have been restricted so that all own price elasticities are negative. The table shows that in a majority of the industries, the parameters β_{LL} and β_{SS} are restricted while for β_{LS} this is the case in four industries. With the exception of industries 25 and 63, the parameters are restricted to values that lie in the confidence interval of the estimated coefficients of the unrestricted system, defined by 2 standard deviations.

As in the unrestricted system, few of the estimated effects of relative wages are statistically significant, with the cross wage elasticities of industries 45, 84 and 85 representing notable exceptions. Normally, the coefficients, β_{LK} and β_{SK}, are insignificant in the restricted system and excluded from the cost share function. This implies that increased capital intensity does not affect the demand for educational specific labour. In industries 63, 64 and 71, however, the effect of capital to value added is significant for at least one of the two education categories. The effect is positive for workers with short and long education length in industries 63 and 64, and negative in industries 63 and 71 for labour with long education. Increased capital intensity in these industries can therefore both lead to a reduction and an increase in the cost share of labour, depending on the industry as well as the type of labour.

Even though there is limited support in the data for the hypothesis that relative wages can explain the use of labour by education across industries, the

results show that the estimated coefficients are more precisely estimated in the extended data set compared to the results in Gjelsvik (2013). The failure to estimate precise effects could be a result of little variation in relative wages in the data period. Theory also suggests that relative wages are important in explaining demand for educational specific labour. This could also be the reason why the effect of capital to value added is statistically insignificant in most industries.

The static relationship between cost shares, relative wages and capital to value added and the trend, in equations (4) and (5), cannot be expected to hold in the short run. The ideal way to impose dynamics in this system is to add variables that make part of the long run solution on difference form. However, with a yearly data set spanning from 1972 to 2012, there are too few observations to estimate the entire system simultaneously and we do not in general obtain precise estimates. Consequently, the dynamic system of translog equations is a system consisting of individually designed and estimated error correction equations, i.e. one equation for each industry and level of education. The general equation explaining the change in the cost shares for labour with respectively long- and short education in an industry is:

$$\begin{aligned}\Delta S_{Lk,t} = \; & \alpha_{L0,k} + \alpha_{LL,k} * ecm_{Lk,t-1} + \alpha_{LS,k} * ecm_{Sk,t-1} + \gamma_{LL,k}\Delta \ln(W_{Lk,t}/W_{Lk,t}) \\ & + \gamma_{LS,k}\Delta \ln(W_{Sk,t}/W_{Lk,t}) + \gamma_{LK,k}\Delta \ln(K_{k,t-1}/Y_{k,t}) \\ & + \gamma_{LL1,k}\Delta \ln(W_{Lk,t-1}/W_{Lk,t-1}) + \gamma_{LS1,k}\Delta \ln(W_{Sk,t-1}/W_{Lk,t-1}) \\ & + \gamma_{LK,k}\Delta \ln(K_{k,t-2}/Y_{k,t-1}) + \theta_{LL,k}\Delta S_{Lk,t-1}\end{aligned}$$

$$\begin{aligned}\Delta S_{Sk,t} = \; & \alpha_{S0,k} + \alpha_{SL,k} * ecm_{Lk,t-1} + \alpha_{SS,k} * ecm_{Sk,t-1} + \gamma_{SL,k}\Delta \ln(W_{Lk,t}/W_{Lk,t}) \\ & + \gamma_{SS,k}\Delta \ln(W_{Sk,t}/W_{Lk,t}) + \gamma_{SK,k}\Delta \ln(K_{k,t-1}/Y_{k,t}) \\ & + \gamma_{SL1,k}\Delta \ln(W_{Lk,t-1}/W_{Lk,t-1}) + \gamma_{SS1,k}\Delta \ln(W_{Sk,t-1}/W_{Lk,t-1}) \\ & + \gamma_{SK,k}\Delta \ln(K_{k,t-2}/Y_{k,t-1}) + \theta_{SS,k}\Delta S_{Sk,t-1},\end{aligned}$$

where the error correction term is $ecm_{it} = s_{it} - \hat{s}_{it}$ and $\hat{s}_{it}$ is the equilibrium cost share for educational groups $i = L, S$. The equations are estimated by OLS and are reduced to specific equations with only significant coefficients, see Gjelsvik (2013). The coefficients α_{LL} and α_{SS} are negative in all dynamic specifications, supporting that there is error correction in the cost shares of labour with long and short education.

B.5 The elasticity of substitution

For the translog cost function, the own and cross price elasticities are computed as

$$\eta_{ii} = (\beta_{ii} + S_{i,t}^2 - S_{i,t})/S_{i,t} \tag{6}$$

and

$$\eta_{ij} = (\beta_{ij} + S_{i,t}S_{j,t})/S_{i,t} \tag{7}$$

Table 12 shows the implied own- and cross price elasticities across industries calculated for the year 2010. The own price elasticities are all restricted to be negative or zero, implying that an increase in the relative wage of one educational group will not lead to an increase in the use of that type of labour in that group.

Table 12: Implied own and cross price elasticities calculated for the year 2010

Industry	η_{LM}	η_{ML}	η_{LS}	η_{SL}	η_{MS}	η_{SM}	η_{LL}	η_{MM}	η_{SS}
15	-0.44	-0.23	3.06	1.23	1.28	0.98	-2.61	-1.04	-2.21
25	0.39	0.20	-0.01	-0.00	0.29	0.31	-0.38	-0.49	-0.31
30	0.46	0.27	-0.24	-0.25	0.26	0.46	-0.22	-0.53	-0.21
40	0.18	0.14	-0.04	-0.14	0.05	0.18	-0.13	-0.19	-0.04
45	0.67	0.48	-0.55	-0.67	0.40	0.68	-0.12	-0.88	-0.00
55	1.63	0.40	-1.34	-0.56	1.38	2.37	-0.29	-1.78	-1.81
63	0.03	0.43	0.09	0.15	-0.30	-0.04	-0.12	-0.13	-0.11
64	0.94	1.31	-0.04	-0.15	0.07	0.16	-0.89	-1.38	-0.01
71	2.21	2.96	0.31	0.95	-0.02	-0.04	-2.53	-2.94	-0.90
74	0.34	0.17	0.04	0.01	0.37	0.25	-0.37	-0.54	-0.26
81	0.83	0.63	0.26	0.11	0.57	0.31	-1.10	-1.20	-0.42
84	0.05	0.27	-0.06	-0.16	0.23	0.11	0.00	-0.50	0.00
85	0.23	0.58	-0.16	-0.23	0.37	0.21	- 0.07	-0.95	0.00
Total	0.58	0.59	0.10	0.02	0.38	0.46	-0.68	-0.97	-0.48

For most industries, the price sensitivity is larger for labour with medium education than for labour with short and long education. However, for a couple of industries, it is the other way around, with labour with long and/or short education having the highest price sensitivity.

For our analysis, the cross price elasticities are of interest. Table 12 shows that with some notable exceptions, the cross price elasticities between labour with short and medium education have a tendency to be higher than the other cross price elasticities. Compared with former results based on data till 2007 this tendency though is much less discernible after having extended the data set to 2012. In most industries, the numeric value of η_{MS} is larger than η_{LS}, implying that a change in the wage of labour with short education will have a larger effect on the demand for labour with medium education than on the demand for labour with long education. However, there are a couple of important deviations from such a tendency, industry 15 (consumption goods) being a particular case in point.

The possibilities for substitution between labour with short- and medium education are quite profound in a couple of industries like consumption goods (industry 15) and construction (industry 55). Labour with medium education and labour with long education are otherwise found to be complements in only one industry, the consumption goods industry (15). As far as industry 15 is concerned the numeric values of η_{ML} is larger than η_{LM}, implying that an increase in the wages of labour with medium education will lead to a stronger decrease in the demand for labour with long education than a similar increase in the wages of labour with long education will lead to with respect to demand for labour with medium education.

In many industries labour with short and long education are found to be complements. This is quite profound in construction (industry 55). Complementarity between these two educational groups implies that if the wage is increased for one of the groups, the uses of both education groups are reduced. To maintain the total number of working hours, the use of labour with medium education must increase.

In two industries complementarity between labour with short education and labour with medium educations are identified; financial services (industry 63) and electricity generation (71).

The cost share equations can be linked to the change in relative demand between two educational levels of production through the Morishima elasticity. The Morishima elasticity of substitution is defined by

$$\sigma_{ij,t} = \frac{\partial \ln(N_{it}/N_{jt})}{\partial \ln(W_{jt}/W_{it})} = \eta_{ij,t} - \eta_{jj,t} \qquad i,j = L,M,S.$$

where $\eta_{ij,t} = \partial \ln N_{it} / \partial \ln W_{jt}$ represents the price elasticity of demand. The Morishima elasticity of substitution measures the percentage change in relative demand with respect to a percentage change in one wage rate. In particular, it is defined under the assumption that a change in W_{jt}/W_{it} is due solely to a change in W_{jt}. The educational levels are substitutes if $\sigma_{ij} > 0$, i.e., if the price of j causes N_i/N_j to increase, and conversely, they are complements if $\sigma_{ij} < 0$.

Table 13: Morishima elastistites of substitution calculated for the year 2010

Industry	σ_{LM}	σ_{ML}	σ_{LS}	σ_{SL}	σ_{MS}	σ_{SM}
15	0.60	2.38	5.26	3.84	3.48	2.02
25	0.88	0.58	0.30	0.38	0.60	0.80
30	1.00	0.49	-0.04	-0.03	0.47	0.99
40	0.37	0.28	-0.00	-0.00	0.09	0.37
45	1.55	0.60	-0.55	-0.55	0.40	1.55
55	3.41	0.68	0.47	-0.27	3.20	4.15
63	0.16	0.54	0.20	0.27	-0.18	0.09
64	2.32	2.21	-0.03	0.74	0.08	1.54
71	5.15	5.48	1.22	3.47	0.89	2.89
74	0.88	0.54	0.30	0.39	0.63	0.79
81	2.03	1.73	0.68	1.21	0.99	1.51
84	0.55	0.26	-0.12	-0.17	0.18	0.61
85	1.19	0.65	-0.19	-0.16	0.35	1.16
Total	1.54	1.26	0.58	0.70	0.86	1.42

B.6 Labour by educational field

Table 14: Wage relations with full heterogeneity, SUR-estimation.

Year	Primary and unreported	Upper secondary general	Upper secondary business
2009	589	294	150
2010	578	288	141
2011	590	297	140
2012	603	304	142
2013	585	296	139
2014	568	290	135
2015	556	286	133
2016	543	281	130
2017	544	282	130
2018	539	281	129
2019	532	280	128
2020	521	276	126
2021	515	275	125
2022	511	274	124
2023	509	276	124
2024	504	275	123
2025	498	275	122
2026	491	273	121
2027	483	272	120
2028	481	274	120
2029	477	274	120
2030	470	274	119

Table 15: Labour by educational field. Upper secondary education, vocational programs. In 1000 persons.

Year	Electric, mechanic etc	Construction	Other science	Nursing and care	Other vocational
2009	237	111	135	119	104
2010	238	112	137	109	106
2011	242	117	138	112	106
2012	246	120	140	114	109
2013	259	128	146	116	115
2014	267	134	150	118	119
2015	274	141	155	121	122
2016	279	145	158	122	125
2017	288	150	165	126	130
2018	294	153	169	128	134
2019	298	155	172	130	137
2020	299	156	173	131	138
2021	302	159	175	133	139
2022	306	163	177	135	141
2023	311	167	181	138	144
2024	314	171	182	140	146
2025	318	175	184	142	147
2026	319	178	185	144	148
2027	321	181	185	145	149
2028	327	187	188	149	152
2029	331	192	190	152	154
2030	335	196	192	154	155

Table 16: Labour by educational field. Tertiary education, lower degree. In 1000 persons.

Year	Social and law	Nursing	Economics and admin	Engineering	Education	Other science subjects	Other univ.	Arts and humanities	Other healh and social
2009	35	75	113	73	150	55	28	44	72
2010	36	78	116	72	149	56	28	43	74
2011	38	79	119	71	150	58	29	44	77
2012	39	80	121	71	152	59	30	44	79
2013	41	82	127	74	156	63	32	46	82
2014	43	83	133	76	159	66	33	47	85
2015	44	85	139	77	163	69	35	49	89
2016	46	87	143	77	165	71	36	50	91
2017	48	89	150	79	170	74	38	52	95
2018	50	92	155	79	174	77	39	53	99
2019	51	93	159	79	178	79	41	54	102
2020	52	94	161	79	179	80	42	54	104
2021	53	96	164	79	182	82	43	55	107
2022	54	98	167	79	185	84	44	56	110
2023	56	101	172	79	190	86	46	57	114
2024	57	102	175	79	193	88	47	58	118
2025	59	105	178	79	197	90	48	59	121
2026	60	106	181	79	199	91	50	59	124
2027	61	108	183	79	202	92	51	60	127
2028	62	111	188	79	207	95	53	61	131
2029	64	113	192	80	212	97	54	62	136
2030	65	116	195	80	215	99	56	63	139

Table 17: Labour by educational field. Tertiary education, higher degree. In 1000 persons.

Year	Law	Medicine	Dental studies	Economics and admin	Graduate engineering	Education	Other science subjects	Other univ.	Arts and humanities	Social sciences
2009	18	19	4	31	35	6	40	25	23	20
2010	19	20	4	33	36	7	42	23	24	22
2011	19	20	4	34	35	7	43	24	24	23
2012	20	21	4	35	35	7	44	24	25	23
2013	21	21	4	37	37	7	46	25	25	24
2014	22	21	4	39	38	7	47	25	26	25
2015	22	22	4	41	39	7	49	26	27	26
2016	23	22	4	42	39	8	50	26	27	26
2017	24	23	4	45	41	8	52	27	28	27
2018	25	23	4	46	41	8	53	28	29	28
2019	26	24	4	48	42	8	54	28	29	29
2020	26	24	4	49	42	8	54	29	29	29
2021	27	24	4	50	42	8	55	29	30	30
2022	27	24	4	51	43	8	56	29	30	31
2023	28	25	4	53	43	9	57	30	31	32
2024	28	25	4	54	44	9	58	30	31	32
2025	29	26	4	55	44	9	59	31	32	33
2026	29	26	3	56	44	9	59	31	32	34
2027	30	26	3	57	44	9	60	31	32	34
2028	31	27	3	59	45	9	61	32	33	35
2029	31	27	3	60	46	10	62	33	34	36
2030	32	28	3	61	46	10	63	33	34	37

C Previous results

C.1 Main structure of the model system

This section presents the main structure of the model system used for projecting supply and demand for different kinds of labour. The model system has a recursive structure as shown by Bjørnstad et al. (2010). We base our study on the regular population forecasts of Statistics Norway. These projections give us the Norwegian population by age and gender and are used both in the macroeconomic projection using MODAG as well as in projections of the labour force by education using the MOSART model.

The standard version of the macroeconometric model MODAG, documented in Norwegian in Boug and Dyvi (2008), has only one type of labour. A version of the model where labour is divided into five educational groups is developed, see Cappelen, Gjefsen, Gjelsvik, Holm and Stølen (2013). Gjelsvik (2013) presents how this labour module is specified and estimated. The version of MODAG containing this labour module is presented in some more detail in Section 4, and supply of labour is described in Cappelen, Gjefsen, Gjelsvik, Holm and Stølen (2013). Here it suffices to say that total demand for labour by industry depends on technological progress and factor substitution with other inputs. Thus relative factor prices play an important role for labour demand in the long run. In addition there are substitution possibilities between the various categories of labour where relative wages for the different groups matter for demand within industry. Demand for these five educational groups by industry is further divided into 28 educational fields. The employment shares within each main educational group within an industry are exogenous and here relative wages do not play any role in the model. These assumptions imply that there is substitution between employees with different educational levels but not between employees at similar levels. You can not substitute a plumber with a carpenter but you can substitute a carpenter with an engineer. Historical trends in these shares observed from past decades are generally prolonged in order to forecast the composition of labour by industry.

C.2 Education specific wage curves

The wage equations represents the labour supply in our model. In the following, the subscripts m, s, and g refer to sectors, i.e. manufacturing, market oriented services and public sector, respectively. The subscript i runs across educational groups, i.e. $i = GRK, VA, VF, HO$ and UN.

Manufacturing:

$$\begin{aligned}\Delta ww_{mt} &= \gamma_{m0} + \gamma_{m1}(ww - q - z)_{mt-1} + \gamma_{m2i}u_{t-1} + \gamma_{m3i}u_{it-1} \\ &\quad + \gamma_{m4i}(wc_{mit-1} - wc_{git-2}) + \gamma_{m5i}D_{88-02} + \gamma_{m6}\Delta wc_{mit-1} + \gamma_{m7}\Delta z_{mt} \\ &+ \gamma_{m8}\Delta h_t + \gamma_{m9i}\Delta p_t + \gamma_{m10i}\Delta u_t + \gamma_{m11i}\Delta u_{it} + \gamma_{m12}D_{wf} + \gamma_{m13}D_{93} + \epsilon_{mit}, \quad (8)\end{aligned}$$

where $wc = \ln W + \ln(1 + TF)$ is the log of hourly wage costs in manufacturing, q is the log of the producer price index in manufacturing, z is the log of labour productivity in manufacturing, u is the log of the average rate of unemployment, u_i are logs of education-specific unemployment rates, h is the log of normal working hours and p is the log of the consumer price index. There are three dummy variables in manufacturing; D_{88-02} is 1 in the period 1988-2002 (for an apparent regime-switch in the wage equation for workers with long tertiary education), D_{93}, which is 1993 and 0 otherwise (for changes in payroll taxes in 1993) and D_{wf} is a dummy for wages freezes, which is 1 in 1979, 1988 and 1989 and 0 otherwise.

For market oriented industries:

$$\begin{aligned}\Delta ww_{st} &= \gamma_{s0} + \gamma_{s1}(ww - wa)_{sit-1} + \gamma_{s2}\Delta ww_{sit-1} \\ &\quad + \gamma_{s3}\Delta wa_{sit} + \gamma_{s4}\Delta^2 p_t + \gamma_{s5}\Delta u_t + \gamma_{s6i}\Delta u_{it} + \epsilon_{mit} \quad (9)\end{aligned}$$

For public sector:

$$\begin{aligned}\Delta ww_{gt} &= \gamma_{g0} - \gamma_{g1}(ww - wa)_{git-1} + \gamma_{g2i}u_{it-1} + \gamma_{g3}D_{88-02} \\ &\quad + \gamma_{g4}\Delta ww_{git-1} + \gamma_{g5}\Delta wa_{git-1} + \gamma_{g6}\Delta p_t - \gamma_{g6i}\Delta u_{it} + \epsilon_{mit} \quad (10)\end{aligned}$$

Wages in market oriented industries and in public sector are also modeled on error correction form. The reference wage, wa is calculated as the wage level in the other sectors weighted by their representative employment shares. There is long-run homogeneity between wages and reference wages.

Table 18: Estimated coefficients in the wage equations by educational group in manufacturing:

	Primary and unreported	Secondary general	Secondary vocational	Tertiary lower	Tertiary higher
γ_{m1}	-0.160	-0.160	-0.160	-0.160	-0.160
γ_{m2}	-0.023	-0.023	-0.023	-	-
γ_{m3}	-	-	-	-	-0.009
γ_{m4}	-	-	-	-	-0.091
γ_{m5}	-	-	-	-	-0.022
γ_{m6}	0.324	0.324	0.324	0.324	0.324
γ_{m7}	0.116	0.116	0.116	0.116	0.116
γ_{m8}	-0.691	-0.691	-0.691	-0.691	-0.691
γ_{m9}	0.470	0.470	0.470	0.813	0.564
γ_{m10}	-0.011	-0.011	-0.011	-0.022	-0.022
γ_{m11}	-	-	-	-0.010	-0.010
γ_{m12}	-0.024	-0.024	-0.024	-0.024	-0.024
γ_{m13}	-0.012	-0.012	-0.012	-0.012	-0.012

Table 19: Estimated coefficients in the wage equations by educational group in market oriented service activities

	Primary and unreported	Secondary general	Secondary vocational	Tertiary lower	Tertiary higher
γ_{s1}	-0.057	-0.057	-0.057	-0.057	-0.057
γ_{s2}	0.241	0.241	0.241	0.241	0.241
γ_{s3}	0.720	0.720	0.720	0.720	0.720
γ_{s4}	0.201	0.201	0.201	0.201	0.201
γ_{s5}	-0.014	-0.014	-0.014	-0.014	-0.014
γ_{s6}	-	-	-	-0.012	-0.012

Table 20: Estimated coefficients in the wage equations by educational group in public sector

	Primary and unreported	Secondary general	Secondary vocational	Tertiary lower	Tertiary higher
γ_{g1}	-0.085	-0.085	-0.085	-0.085	-0.085
γ_{g2}	-0.016	-0.009	-0.009	-0.009	-0.009
γ_{g3}	-	-	-	-	-0.015
γ_{g4}	-0.035	-0.035	-0.035	-0.035	-0.035
γ_{g5}	0.572	0.572	0.572	0.572	0.572
γ_{g6}	0.496	0.496	0.496	0.496	0.496
γ_{g7}	-0.018	-	-	-	-
γ_{g8}	-	-	-	-	-0.015

C.3 Demand for labour

The production level is determined by cost minimizing the production function given technology, the factor prices and a monopolistic product price setting. The production technology is assumed to be Cobb Douglas, which implies that the factors of production are used in fixed shares and that the elasticity of substitution is 1. This determines the factor demand of nine inputs; labour (wage earners and self employed), electricity, fuels, transportation oil and other materials and four real capital stocks in 16 industries. All industries have constant return to scale except construction and domestic transportation, which experience decreasing and increasing return to scale, respectively. There is a change in notation from previous report so that high education is now referred to as long education and low education is now short education.

C.3.1 Demand for labour by educational group

Given the production level and aggregate demand for labour, the demand for each educational group is determined by a translog cost function in the labour market. In the translog structure, the factor shares depend in general on relative wages, the stock of capital divided by gross output and a trend, which in the absence of observable variables, is assumed to represent SBTC (but possibly also other factors). A technical and complete description of the cost function and demand for various labour inputs is given in Gjelsvik (2013).

The cost function is given by $C(W_H, W_M, W_S, K, Y, A(t))$, where W_i represents the wage rate of factor i, capital K is treated as a quasi fixed factor of production, Y represents value added and $A(t)$ is an unobserved time trend (i.e. SBTC). Assuming constant returns to scale and that the cost function takes the translog form, we can write the linear economic system of cost shares (s) as

$$S_L = \beta_{LO,k} + \beta_{LL}\ln(W_L/W_M) + \beta_{LS}\ln(W_L/W_M) + \beta_{LK}\ln(K/Y) + \beta_{LA}A(t) + e_L \tag{11}$$

$$S_S = \beta_{S0} + \beta_{LS}\ln(W_L/W_M) + \beta_{SS}\ln(W_S/W_M) + \beta_{SK}\ln(K/Y) + \beta_{SA}A(t) + e_S. \tag{12}$$

To ensure that the cost shares are bounded between zero and unity, we let the technology variable be represented by $A(t) = (t+30)^{-1}$, where t is a deterministic time trend. Since the cost shares sum to unity, the cost share for labour with medium education are estimated implicitly as $S_M = 1 - S_L - S_S$.

Table 21: Estimated coefficients in the unrestricted translog system of cost shares by industry, 1972-2007

Industry	β_{L0}	β_{LL}	β_{LS}	β_{LK}	β_{LA}	β_{S0}	β_{SS}	β_{SK}	β_{SA}
15	-0.048	0.116	-0.184		0.227	1.073	0.334	0.072	-0.864
	(0.103)	(0.196)	(0.245)		(0.054)	(0.168)	(0.486)	(0.034)	(0.112)
25	-0.073	0.266	-0.163		0.399	0.993	-0.241		-0.962
	(0.096)	(0.216)	(0.433)		(0.032)	(0.198)	(0.928)		(0.079)
30	0.054	0.106	-0.146		0.264	0.968	0.053		-1.088
	(0.089)	(0.135)	(0.209)		(0.034)	(0.123)	(0.409)		(0.109)
45	0.089	0.215	0.007	0.051	0.212	0.815	0.367		-0.959
	(0.119)	(0.238)	(0.224)	(0.013)	(0.051)	(0.119)	(0.373)		(0.058)
55	0.020	0.122	-0.067		0.061	0.651	-0.841		-0.704
	(0.053)	(0.098)	(0.182)		(0.030)	(0.165)	(0.632)		(0.126)
63	-0.006	0.689	-0.671		0.465	0.968	0.685		-0.507
	(0.091)	(0.349)	(0.319)		(0.058)	(0.084)	(0.296)		(0.051)
64	0.301	-0.602	0.029	0.102	0.418	0.258	-0.305	0.079	-0.160
	(0.066)	(0.140)	(0.164)	(0.023)	(0.068)	(0.067)	(0.160)	(0.013)	(0.048)
71	0.336	0.467	0.338	-0.145	0.268	0.463	-0.100		-0.792
	(0.151)	(0.391)	(0.153)	(0.045)	(0.058)	(0.088)	(0.189)		(0.052)
74	-0.213	0.511	-0.440		0.412	1.057	0.630		-0.707
	(0.078)	(0.180)	(0.209)		(0.044)	(0.103)	(0.421)		(0.059)
81	0.035	-0.019	-0.009		0.286	0.866	0.051		-0.563
	(0.047)	(0.084)	(0.074)		(0.052)	(0.073)	(0.132)		(0.092)
85	0.233	0.249	-0.170	0.026	0.223	0.669	0.130		-0.428
	(0.093)	(0.155)	(0.189)	(0.014)	(0.096)	(0.136)	(0.298)		(0.150)

Table 21 shows the estimated coefficients in the system of cost share equations for various industries together with standard errors. While we require the coefficients relating to the effect of capital to value added (β_{LK} and β_{SK}) to be significant in the cost share functions, the others coefficients are freely estimated.[9]

The table shows that the estimated coefficients relating to the effects of relative wages are possibly large, but statistically insignificant. This might be due to the fact that relative wages have been fairly constant over the estimation period. The effects of capital to value added enters in four industries in the cost share equations for high educated and in two industries in the cost share equations for short educated. The effects are positive inn all equations except for in domestic transportation. Further, the trend coefficients are strongly significant in all industries, supporting the SBTC hypothesis. Increased technology thus leads to increased demand for labour with long education and to decreased demand for labour with short education.

[9]The translog functions are estimated i Eviews by FIML using annual data spanning the period 1972–2007.

Table 22: Estimated coefficients in the restricted translog system of cost shares by industry, 1972-2007

	β_{L0}	β_{LL}	β_{LS}	β_{LK}	β_{LA}	β_{S0}	β_{SS}	β_{SK}	β_{SA}
15	0.005	0.037[a]	-0.041		0.196**	0.977**	0.079[a]		-0.811**
25	0.018*	0.068[a]	0.245		0.368**	0.804**	-1.051*		-0.896**
30	0.076**	0.073[a]	-0.106		0.255**	0.942**	-0.005		-1.078**
45	0.098**	0.149[a]	-0.133[a]	0.047**	0.222**	0.848**	0.201[a]		-0.951**
55	0.050	0.046[a]	0.021		0.075**	0.602**	-0.997*		-0.951**
63	0.143**	0.158[a]	-0.152**		0.502**	0.823**	0.178[a]		-0.543**
64	0.301**	-0.602	0.029	0.102**	0.418**	0.258**	-0.305	0.079**	-0.160**
71	0.451**	0.159[a]	0.056[a]	-0.152**	0.275**	0.593**	-0.114		-0.832**
74	0.003	0.043[a]	-0.038[a]		0.301**	0.865**	0.138[a]		-0.611**
81	0.035	-0.019	-0.009		0.286**	0.866**	0.051		-0.563**
85	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 5 per cent level
**The coefficient is significant at 1 per cent level

Together with the estimated cost shares, the relative wage coefficients determine the implied own and cross price elasticities. As a consequence, the own and cross price elasticities differ at every data point. 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. the β_{LL}, β_{LS} and β_{SS}, is negative semidefinite. Following Harris et al. (1993), we employ a less severe test, where concavity is assumed when the own price elasticities are non positive. We have secured concavity at every data point in the estimation period. This implies that the parameters are restricted to the highest possible value in the cases where free estimation results in positive own price elasticities.[10]

Table 22 shows the estimated system of cost shares with the restricted parameters. The table shows that in a majority of the industries, the parameter β_{LL} is restricted. The parameter β_{LS} is restricted in three industries while for β_{SS} this is the case in four industries. With the exception of industry 74, the parameters are restricted to a value that lies in the confidence interval of the estimated coefficient in the unrestricted system.[11] As in the unrestricted system, the estimated effects of relative wages are statistically insignificant. The coefficients β_{LK} and β_{LS} are mostly insignificant in the restricted system, and hence, left out. In industry 64 (oil and gas exploration), the effect of capital to value added is positively estimated, which implies that increased capital intensity leads to a reduction in the cost share of labour with medium education.

Even though there is limited support in the data for the hypothesis that relative wages can explain the use of labour by education 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 to value added is statistically insignificant in most industries.

The static relationship which we impose on the cost shares for labour with long and short education in the translog system given by equations (11) and (12) cannot be expected to hold in the short run. The ideal way to impose dynamics in this system is to add variables that are part of the long run solution on difference form. However, with a yearly data set spanning from 1972 to 2007, there are too few observations to estimate the entire system simultaneously and we

[10]The coefficients in Table 22 are not identical to the coefficients reported in **?**, but the estimation procedure and criterions for choices of short term dynamics are the same.
[11]Defined by 2 standard deviations.

do not obtain precise estimates. Consequently, the translog system of equations are estimated as error correction equations.

The general equation explaining the change in the cost shares for labour with long and short education is:

$$\begin{aligned}\Delta S_{Lk,t} &= \alpha_{L0,k} + \alpha_{LL,k} * ecm_{Lk,t-1} + \alpha_{LS,k} * ecm_{Sk,t-1} \\ &+ \gamma_{LL,k}\Delta \ln(W_{Lk,t}/W_{LLk,t}) + \gamma_{LS,k}\Delta \ln(W_{Sk,t}/W_{Lk,t}) + \gamma_{LK,k}\Delta \ln(K_{k,t-1}/Y_{k,t}) \\ &+ \gamma_{LL1,k}\Delta \ln(W_{Lk,t-1}/W_{Lk,t-1}) + \gamma_{LS1,k}\Delta \ln(W_{Sk,t-1}/W_{Lk,t-1}) \\ &+ \gamma_{LK,k}\Delta \ln(K_{k,t-2}/Y_{k,t-1}) + \theta_{LL,k}\Delta S_{Lk,t-1} \quad (13)\end{aligned}$$

$$\begin{aligned}\Delta S_{Sk,t} &= \alpha_{S0,k} + \alpha_{SL,k} * ecm_{Lk,t-1} + \alpha_{SS,k} * ecm_{Sk,t-1} \\ &+ \gamma_{SL,k}\Delta \ln(W_{Lk,t}/W_{Lk,t}) + \gamma_{SS,k}\Delta \ln(W_{Sk,t}/W_{Lk,t}) + \gamma_{SK,k}\Delta \ln(K_{k,t-1}/Y_{k,t}) \\ &+ \gamma_{SL1,k}\Delta \ln(W_{Lk,t-1}/W_{Lk,t-1}) + \gamma_{SS1,k}\Delta \ln(W_{Sk,t-1}/W_{Lk,t-1}) \\ &+ \gamma_{SK,k}\Delta \ln(K_{k,t-2}/Y_{k,t-1}) + \theta_{SS,k}\Delta S_{Sk,t-1}, \quad (14)\end{aligned}$$

where the error correction term is $ecm_{it} = s_{it} - \hat{s}_{it}$ and $\hat{s}_{it}$ is the equlibrium cost share for educational groups $i = L, S$. The equations are estimated by OLS in Eviews and are reduced to specific equations with only significant coefficients, see Gjelsvik (2013). The coefficients α_{LL} and α_{SS} are negative in all dynamic specifications, supporting that there is error correction in the cost shares of labour with long and short education.

C.3.2 The elasticity of substitution

For the translog cost function, the own and cross price elasticities are computed as

$$\eta_{ii} = (\beta_{ii} + S_{i,t}^2 - S_{i,t})/S_{i,t} \quad (15)$$

and

$$\eta_{ij} = (\beta_{ij} + S_{i,t}S_{j,t})/S_{i,t} \quad (16)$$

Table 23: Implied own and cross price elasticities calculated for the year 2010

Industry	η_{LL}	η_{LM}	η_{LS}	η_{ML}	η_{MM}	η_{MS}	η_{SH}	η_{SM}	η_{SS}
15	-0.62	0.38	0.24	0.20	-0.55	0.36	0.10	0.27	-0.37
25	-0.47	-1.09	1.55	-0.56	-1.81	2.37	0.85	2.50	-3.35
30	-0.46	0.60	-0.14	0.34	-0.83	0.49	-0.15	0.91	-0.76
40	-0.11	0.22	-0.11	0.19	-1.63	1.45	-0.35	5.36	-5.00
45	-0.21	0.20	0.01	0.14	-0.37	0.23	0.01	0.39	-0.40
55	-0.53	0.05	0.48	0.01	-2.12	2.11	0.20	3.60	-3.80
63	-0.13	0.03	0.09	0.48	-0.24	-0.24	0.17	-0.03	-0.14
64	-1.71	1.51	0.21	2.11	-3.03	0.92	0.69	2.23	-2.92
71	-0.18	-0.10	0.29	-0.15	-0.20	0.35	0.81	0.67	-1.48
74	-0.58	0.30	0.27	0.15	-0.35	0.20	0.09	0.13	-0.23
81	-0.88	0.41	0.46	0.31	-0.67	0.36	0.19	0.20	-0.39
84	0.00	-0.04	0.04	-0.24	-0.90	1.14	0.11	0.51	-0.62
85	-0.04	-0.02	0.06	-0.06	-0.82	0.88	0.09	0.48	-0.56
86	-0.04	-0.04	0.08	-0.11	-0.84	0.95	0.10	0.44	-0.55

Table 23 shows the implied own and cross price elasticities across industries calculated for the year 2010. The own price elasticities are all restricted to be negative or zero, implying that an increase in the relative wage of one skill group will not lead to an increase in the use of this skill group. For most industries, the price sensitivity is larger for low skilled than for medium skilled persons. However, in some large industries, it is the other way around, with high skilled labour having the highest price sensitivity.

For our analysis, the cross price elasticities are of interest. Table 23 shows that the cross price elasticities are larger between low skilled and medium skilled workers. In most industries, the numeric value of η_{MS} is larger than η_{LS}, implying that change in the wages to low skilled will have a larger effect on the demand for medium skilled than on the demand for high skilled labour. The possibilities for substitution between medium and low skilled are quite profound in large industries like miscellaneous manufacturing (industry 25), construction (industry 55) and in information and communication (industry 84). Medium and high skilled labour are found to be complements in five industries, and as the numeric value of η_{ML} is larger than η_{LM}, an increase in the wages of high skilled will lead to a stronger decrease in the demand for medium skilled in these industries than a similar increase in the wages of medium skilled.

The cost share equations can be linked to the change in relative demand between two factors of production through the Morishima elasticity. The Morishima elasticity of substitution is defined by

$$\sigma_{ij,t} = \frac{\partial \ln(N_{it}/N_{jt})}{\partial \ln(W_{jt}/W_{it})} = \eta_{ij,t} - \eta_{jj,t} \qquad i,j = L,M,S.$$

where $\eta_{ij,t} = \partial \ln N_{it} / \partial \ln W_{jt}$ represents the price elasticity of demand. The Morishima elasticity of substitution measures the percentage change in relative demand with respect to a percentage change in one wage rate. In particular, it is defined under the assumption that a change in W_{jt}/W_{it} is due solely to a change in W_{jt}. The factors are substitutes if $\sigma_{ij} > 0$, i.e., if the price of j causes N_i/N_j to increase, and conversely, they are complements if $\sigma_{ij} < 0$.

C.4 Education specific labour force

The labour force results from linking the number of persons by education, age and gender and to the share of persons with these characteristics that is participating on the labour market, i.e. the participation rate for each group. The estimated equations for the participation rate by age, gender and education, YP_{ijk} are:

$$\ln(YP_{ijk}/(1-YP_{ijk}))_t = \alpha_O + \alpha_1 \ln(YP_{ijk}/(1-YP_{ijk}))_{t-1} + \alpha_2 u_{it-1} + \alpha_3 \Delta u_{it} + \alpha_4 \Delta w_{it-1} + \alpha_5 dr_{ijkt-1} + \alpha_6 cpw_{ikt-1} + \alpha_7 D_{72-04} + \epsilon_{ijk} \quad (17)$$

The subscript i runs across educational groups, j across gender and k runs across age groups (25-39, 25-61, 40-61, 62-66 and 67-74). UR_i is the education specific unemployment rate, W_i is the hourly wage rate by education, DR_{ijk} is the discount rate and CPW_{ijk} is the number of children per woman. There is one stepdummy in the equation explaining the participation rate for older persons with long tertiary education which is 1 in the years 1972-2004 and 0 otherwise.

Table 24: Estimated coefficients in the participation rate for the demographic group k2539 by education

	Primary and unreported	Secondary general	Secondary vocational	Tertiary lower	Tertiary higher
α_0	0.387849	0.387849	0.387849	0.387849	0.387849
α_1	-0.766518	-0.766518	-0.766518	-0.766518	-0.766518
α_3	-0.07708567	-	-	-	-
α_6	1.023056	2.039022	-5.057467	3.287132	2.171862

Table 25: Estimated coefficients in the participation rate for the demographic group k4061 by education

	Primary and unreported	Secondary general	Secondary vocational	Tertiary lower	Tertiary higher
α_0	0.387849	0.387849	0.387849	0.387849	0.387849
α_1	-0.766518	-0.766518	-0.766518	-0.766518	-0.766518
α_2	-0.01104677	-0.00824986	-0.04045765	-	-
α_3	-0.03840092	-	-	-	-
α_4	2.837328	2.843087	2.297228	-	-

Table 26: Estimated coefficients in the participation rate for the demographic group k6266 by education

	Primary and unreported	Secondary general	Secondary vocational	Tertiary lower	Tertiary higher
α_0	0.387849	0.387849	0.387849	0.387849	0.387849
α_1	-0.766518	-0.766518	-0.766518	-0.766518	-0.766518

Table 27: Estimated coefficients in the participation rate for the demographic group m2561 by education

	Primary and unreported	Secondary general	Secondary vocational	Tertiary lower	Tertiary higher
α_0	0.387849	0.387849	0.387849	0.387849	0.387849
α_1	-0.766518	-0.766518	-0.766518	-0.766518	-0.766518
α_3	-0.03168093	-	-	-	-
α_4	4.770476	-	-	-	-
α_5	-1.961816	-13.73984	-	-	-

Table 28: Estimated coefficients in the participation rate for the demographic group men, $62-66$ years by education

	Primary and unreported	Secondary general	Secondary vocational	Tertiary lower	Tertiary higher
α_0	0.387849	0.387849	0.387849	0.387849	0.387849
α_1	-0.766518	-0.766518	-0.766518	-0.766518	-0.766518

Table 29: Estimated coefficients in the participation rate for the demographic group $67-74$ by education

	Primary and unreported	Secondary general	Secondary vocational	Tertiary lower	Tertiary higher
α_0	0.387849	0.387849	0.387849	0.387849	0.387849
α_1	-0.766518	-0.766518	-0.766518	-0.766518	-0.766518
α_3	-0.03776949	-	-	-	-
α_7	-	-	-	-	-0.461046

List of Figures

List of Tables

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