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A counterfactual analysis of the Norwegian resource boom 2004-2013

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Abstract:

The EU-enlargement in 2004 increased labour migration and affected the Norwegian labour market in particular. We study how this modified the Dutch disease effects during the resource boom 2004-2013. In the Norwegian case the resource movement effect of the petroleum industry has historically dominated the spending effect. One reason is the introduction of the fiscal policy rule in 2001 that limited spending. We find that economic growth in Norway was roughly doubled during this period due to the resource boom while total population increased by 2 percent. Moreover, both the resource movement and spending effects on Mainland GDP were roughly unaffected by immigration while employment increased, real wages fell and so did productivity.

Keywords: Dutch disease, Immigration

JEL classification: B22, J11, Q33

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Sammendrag

EU-utvidelsen i 2004 ga økt arbeidsinnvandring til Norge og påvirket arbeidsmarkedets funksjonsmåte ved at inntekts- og arbeidsmarkedsutviklingen i Norge i større grad enn tidligere påvirket innvandringen og dermed arbeidsstyrke og lønn. Vi studerer hvordan dette modifiserte effektene av den økonomiske utviklingen i Norge som følge av høye oljeinvesteringer og oljepengebruk i perioden 2004 til 2013. I Norge har ressursflyttingseffektene som følger av aktiviteten i petroleumsnæringen dominert over effektene av bruken av oljeinntektene. En årsak til det er innføringen av handlingsregelen i 2001 som innebærer en betydelig begrensning for inntektsbruken. Vi finner at den økonomiske veksten i Norge ble omtrent fordoblet i denne perioden på grunn av ressursboomen knyttet til petroleumsvirksomheten. Den totale befolkningen i Norge ble også økt med 2 prosent som følge av høyere innvandring i kjølvannet av høyere inntekter og lavere arbeidsløshet. Vi finner videre at effekten på BNP Fastlands-Norge av ressursflyttingen og inntektsbruken ikke ble nevneverdig endret av høyere innvandring isolert sett. Vi finner derimot at sysselsettingen økte slik at reallønn og produktivitet falt som følge av at innvandringen er blitt mer fleksibel sammenliknet med tilsvarende boom hvor innvandringen er regulert og uendret.

1. Introduction

Botswana and Norway are referred to as examples of countries that have benefitted from their endowment of natural resources, cf. van der Ploeg (2011). Several hypotheses have been forwarded to help explaining the wide variation in outcomes across resource rich countries, cf. van der Ploeg (2011). The Norwegian economy seems to have benefitted a lot due to “good institutions” according to Mehlum et al. (2006), and an ability to reinvest natural wealth in other productive assets, see Gylfasson (2001) and the discussion in Cappelen and Mjøset (2013).

The Dutch disease literature as summarized by Corden (1984) put much emphasis on the distinction between the spending and resource movement effects of a resource boom. The spending effect relates to spending parts or all of the resource rent either by the factor owners and/or by the government based on taxation of the rent. The resource movement effect is related to the use of productive resources in the extraction industry. In the Norwegian case the resource movement effect has dominated so far while the spending effect has been curtailed by the introduction of a fiscal policy rule. In our simulations we illustrate quantitatively the difference between these two effects. Our results show that it may be worth considering how different results obtained in the literature concerning the effects of natural resource booms on the economy may be related to the relative importance of the two effects.

There are not many studies of Dutch disease that have focused on the role of migration and immigration in particular. One exception is the analysis by Maddock and McLean (1984) of the Australian gold rush in the 1850s. They argue that the basic model surveyed by Corden (1984) describe short-run effects well. In the Australian case the spending effect dominated the resource movement effect after the first couple of years. But they argue that the literature misses the importance of population flows as both an equilibrating device and instrument of boom management. Consequently for Australia in 1850s living standards improved little because population expanded instead as the great majority of immigrants settled permanently. This affected domestic demand and the construction activity in particular. Beine et al. (2015) study how migration modifies Dutch disease effects in Canada with a focus on Canadian provinces. They find that the disease is mitigated by interprovincial migration but find no evidence permanent international migration has had effects. One reason for this finding could be that international immigration is regulated in Canada while interprovincial mobility is unregulated.

Immigration to Norway is to a large extent unregulated due to the Norwegian membership in the European Economic Area and Schengen-agreement. International migration increased a lot in Europe following the enlargement of the EU from 2004 and 2007. East European citizens migrated westwards seeking temporary work or in order to settle more permanently. Migrants from new EU members to Norway added 0.4 percent to the population every year for a number of years due to low unemployment and high income levels and income growth in Norway compared to most other European countreis.

We find that the resource boom increased immigration which nearly halved the wage effects of the boom compared to a situation without an immigration response. A lower wage led to a stronger employment effect which lowered the labour productivity response of the boom. On the other hand both the resource movement and spending effects on GDP were the roughly unaffected by immigration by 2013 so the effects on GDP per capita turn out negative. This result echoes the findings of Maddock and McLean (1984) for the gold rush in Australia. In the Norwegian context the petroleum industry has developed “backward linkages” to parts of manufacturing so that the resource movement effect led to increased demand for domestic manufactured goods. Thus when analyzing a resource boom our results indicate that it may be well worth to separate between the resource movement and spending effects in order to understand the different industry effects of a boom depending on the relative size of these two effects.

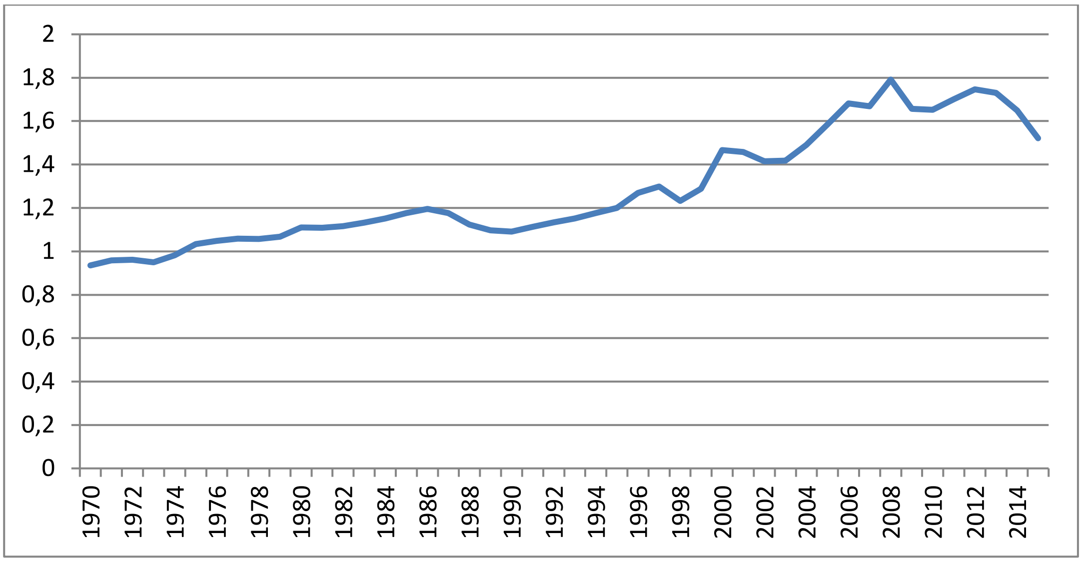
In the next section we present features of the Norwegian economy relating to the resource boom and immigration as a backdrop to our study. Next some basic qualitative predictions from an extended version of the canonical Dutch disease model in Corden (1984) are discussed. We also relate this to a few existing studies of resource booms and immigration. Section 4 presents some features of the large scale macro econometric model where immigration from three regions of the world is modelled. Details of the econometric model of immigration are presented in Appendix A. Section 5 presents our simulation results and we conclude in Section 6.

2. Resource boom and immigration – the case of Norway

Before oil extraction started in Norway in 1971, GDP per capita was slightly lower than the OECD average. By the mid 1970’s income in Norway was at par with the OECD average. From the mid 1990’s, Norwegian incomes increased significantly faster than in the OECD with relative incomes peaking in 2008 before the oil price drop in 2009. The increase in relative income is very rapid from

2003 to 2008. From 2014 Norwegian incomes have been hit by the collapse in the oil price. GDP per capita in PPPs for Norway relative to the OECD average from 1970 to 2015 is shown on Figure 1.

Figure 1 GDP per capita in current prices and PPPs Norway vs. OECD average. 1970-2015



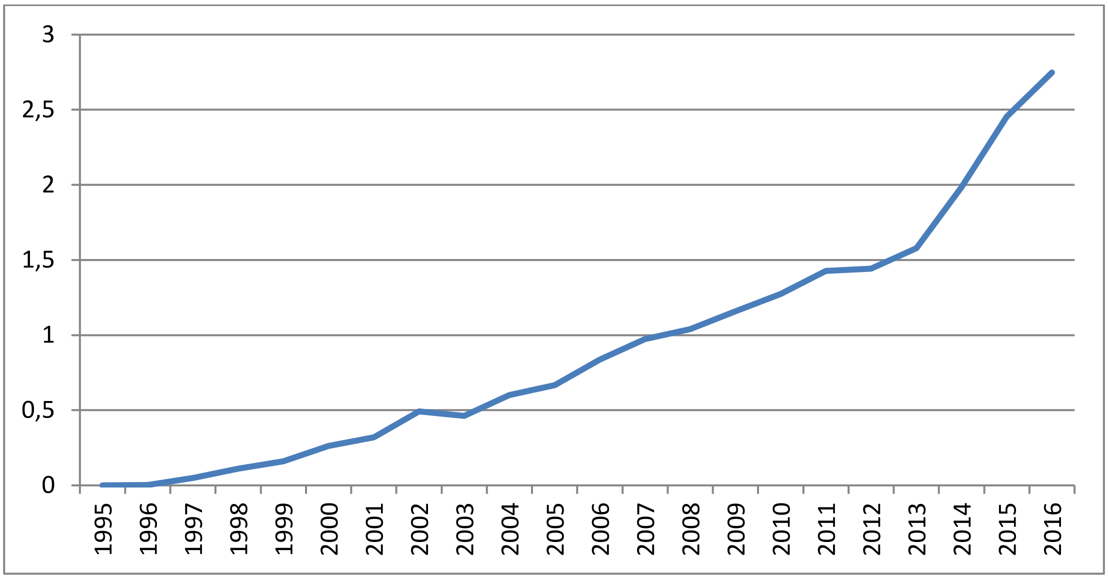
Source: OECD.

From 1996 and onwards the Norwegian government has invested a large share of its petroleum rent in foreign assets in the Government Pension Fund Global (GPFG). Figure 2 shows the value of this fund as share of nominal mainland GDP.[1] The fund is currently worth nearly three times the value of GDP (mainland). The surge in value of GPFG from 2014 is mainly due to the depreciation of the Norwegian krone and not transfers of net revenues to the fund because of the low oil price in recent years.

In March 2001 Norway introduced two new policy rules; an exchange rate target was substituted with an inflation target of 2.5 percent and a flexible exchange rate and a fiscal policy rule was introduced relating the "oil adjusted" structural budget deficit on average to 4 percent of the GPFG. Currently the structural deficit (adjusted for oil-related revenues and expenditures) is around 3 percent of the GPDG. Figure 3 shows the structural oil adjusted budget deficit as share of Mainland GDP from 1970 until 2016. This concept is normally used as an approximate measure of the spending effect in Norway. Current spending is close to 8 percent of Mainland GDP which amounts to 3 percent of GPFG.

[1] Mainland GDP is total GDP minus value added in petroleum extraction and international shipping services and is the most common GDP concept used when studying the Norwegian economy.

Figure 2 Government Pension Fund Global as share of nominal Mainland GDP. 1995-2016

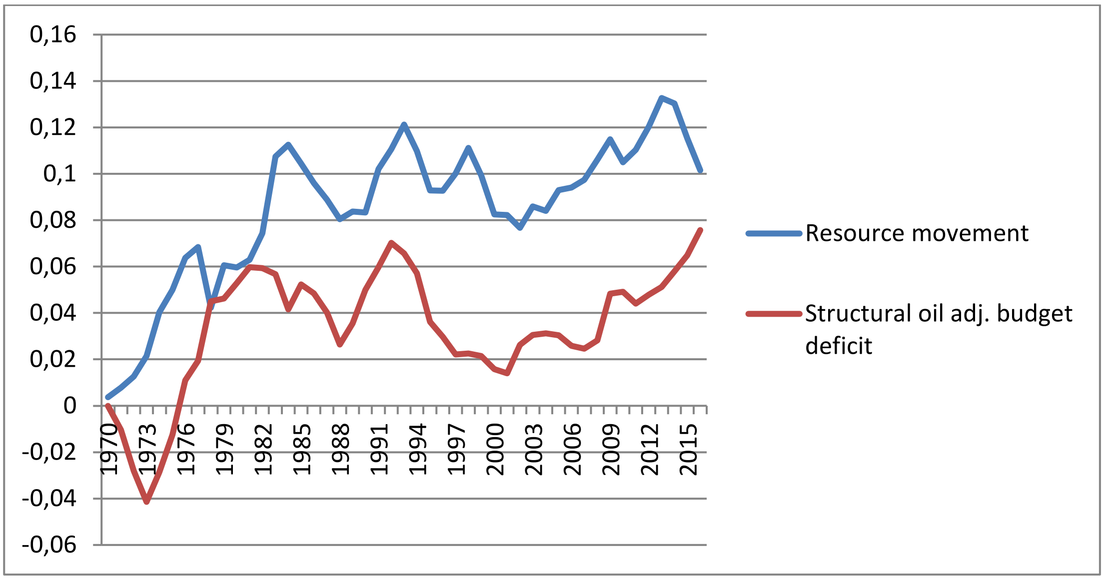


Source: Statistics Norway.

The graph in Figure 3 denoted Resource movement is a measure of what is usually thought of as the resource movement effect in the Dutch disease literature. It shows the value of current inputs used by the petroleum sector in Norway as share of Mainland GDP. Current inputs are measured as labour costs, material inputs plus gross investments. Comparing the figures for the spending and resource movement we see that in the Norwegian case the demand impulse due to resource movement has been much larger than from spending. From around 1980 the average resource movement impulse has amounted to roughly 10 percent of Mainland GDP with a peak of more than 13 percent in 2013. In 2001 when the fiscal rule was implemented, the structural oil adjusted deficit was 4.4 percent of GPFG but only around 2 percent of Mainland GDP. We see from Figure 3 that in 2004 the resource inputs in the petroleums industry were equivalent to roughly 8 percent of mainland GDP. By 2013 these resources costs had increased by close to 5 percentage points of mainland GDP. From 2004 to 2013 the increase in spending as share of mainland GDP increase from 3 to 6 percent of main land GDP.

We shall analyze the impulses from resource movement and spending separately to illustrate their relative importance but also their different macroeconomic effects as well as industry effects using a disaggregated econometric model. We take 2004 as our starting poing and begin our simulation analysis in 2005. Our choice of starting point has to do with structural changes. As mentioned already Norway introduced new policy rules in 2001 so starting our analysis in 2002 seems an obvious alternative. However, the change in labour market regulations that followed from the EU enlargement in May 2004 has dictated our choice of starting point.

Figure 3 Resource movement and spending as share of Mainland GDP. 1970-2016



Source: Statistics Norway.

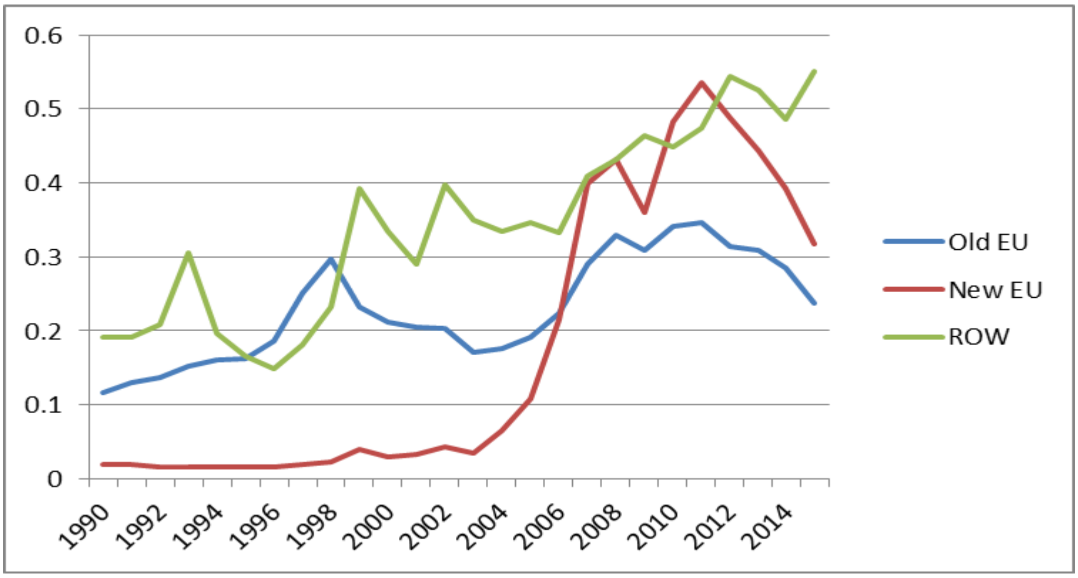
The EU-enlargement in May 2004 increased labour migration in Europe. Although Norway is not an EU country, it is a member of the European Economic Area and the Schengen agreement so Norway was affected by the EU-enlargement. The substantial increase in immigration to Norway from former and new EU-members has been found to play an important role in the development of the Norwegian economy in recent years. Not only has it affected wages for some workers in certain industries, cf. Bratsberg and Raaum (2012) but also wage formation across industry aggregates according to Gjelsvik et al. (2015). Applying standard models of migration found in the literature both Cappelen and Skjerpen (2014) and Cappelen et al. (2015) find that relative incomes and labour markets outcomes are important factors in determining immigration to Norway. Higher relative incomes (cf. Figure 1) and lower unemployment in Norway that were related to the resource boom, led to more immigration.

Figure 4 shows total gross immigration to Norway from new and former EU-members and the rest of the world.[2] We see that the EU enlargement in 2004 resulted in a surge in immigration to Norway from former East European countries. This is similar to what happened with many Western European countries. Also from the other EU countries immigration picked up from around 2005 as was the case with immigration from the rest of the world (ROW countries). In the latter case a significant share of

[2] New EU consists of 11 EU countries that joined the EU from May 2004 and onwards. Old EU is the rest of the EU countries plus EFTA countries, Australia, New Zealand, US and Canada. These groups coincide with country group 1 and 2 in the Norwegian population forecast, available at ssb.no. Other countries in the world are categorized in country group 3 and called ROW in Figure 4.

the immigrants are refugees and asylum seekers and their labour market participation is more modest compared to immigrants from the two other groups of countries. In this paper we ask in particular to what extent this surge in immigration can be traced to the increase in the resource movement and spending effects we have shown took place from the early 2000's. And more specifically we ask how the introduction of a more "liberal" regime of labour mobility in Europe has modified the way the petroleum industry affects the Norwegian economy.

Figure 4 Gross immigration in percent of the Norwegian population. 1990-2016



Source: Statistics Norway.

3. Dutch disease and immigration

The core Dutch disease model presented in Corden (1984) consists of three sectors labelled Booming, Lagging and Non-Tradeable sectors. The Booming sector corresponds to the petroleum sector in our case while the Lagging sector will be interpreted as other sectors producing tradeables. In the Dutch disease model these have usually been identified as belonging to the manufacturing sector. The two first sectors produce tradeables facing given world market prices. Output in all three sectors is produced using a sector specific variable (a natural resource or capital) and labour which is fully mobile between sectors so that the wage rate is equalized across sectors. Total labour supply is given and there is no labour mobility across borders, only between sectors.

An increase in output in the Booming sector due to say an increase in its sector specific resource will increase employment in that sector, leading to higher real product wage as measured by the nominal wage relative to the price of the Lagging sector (which is exogenous by assumption). Higher nominal wages will lead to lower employment in both the Lagging sector and the Non-Tradeable sector. This is the resource movement effect. But higher output in the Booming sector leads to higher incomes that will normally be spent by factor owners in the Booming sector and also the government if some of the higher income is taxed and spent. This spending impulse increases normally demand for all goods. For the two sectors producing tradeables output will not respond to changes in demand. Instead net exports will fall. In the Non-Tradeable sector, however, output and employment will increase, but this will happen only if the real product wage in this industry falls. The increase in employment in the Non-Tradeable sector will drive up nominal wages so that real product wages increase in the two tradeable good industries leading to lower output there. Both the spending and resource movement impulses lead to lower output in the Lagging sector while for the other two industries the effects are different. The resource movement impulse will increase output in the Booming sector but will have negative effects on the Non-Tradeable sector. The spending impulse on the other hand will stimulate the Non-Tradeable sector.

The effect of a resource boom on the consumer real wage as opposed to the various real product wages is not clear cut. If the consumption basket includes goods from all sectors we know that the real product wage in the Non-Tradeable sector has to fall in order for this sector to expand its output while the other real product wages will increase. A weighted sum like the consumer price index will increase due to higher prices on non-tradeables and consumer real wages may go both ways.

Corden (1984) generalizes the core model in a number of ways and we refer to his discussion. We shall focus on those extensions that are most relevant for the empirical model we employ in the next section to analyze the Norwegian resource boom. First, our model allows for more inputs being intersectorally mobile than only labour. We specify Cobb-Douglas production functions of the KLEM-type in nearly 20 industries in the private sector of the Norwegian economy. In such a model the resource impulse may increase output in the Lagging sector producing tradeables if this sector is more capital-intensive than the sector producing non-tradeables due to labour being more scarce when the booming sector expands. The spending impulse may change this effect but in the Norwegian case the manufacturing sector is in general not more capital intensive than “services”. This extension of the core model is therefore not important for our empirical results.

An extension of the core model to allow for international capital mobility is clearly relevant for a small open economy like Norway. It implies that the changes in return to capital due to the resource movement and spending impulses will be reduced or even eliminated over time due to capital mobility. A resource boom means that profitability is lowered in the Lagging sector and output is reduced. Over time capital will flow out of the sector in order to restore marginal profitability. This will amplify the negative output effect in the Lagging sector.

If we allow for endogenous terms of trade effects a number of new effects on the Lagging sector are possible. We keep the output price of the Booming sector (prices on crude oil and natural gas in our case) as exogenous (in foreign currency). If demand for output of the Lagging sector increases due to the resource boom (both due to resource movement and spending impulses) it is possible that output in the Lagging sector may increase instead of declining as in the core model. The reason is simply that we now consider output of the Lagging sector as an imperfect substitute or differentiated from foreign goods. There is thus an upward sloping supply curve for output of the Lagging sector and a downward sloping demand curve. We know that the resource boom increases demand for labour and drives up wages in all sectors leading to an inward shift of the supply curve of the Lagging sector. However, the boom also leads to a shift outwards in the demand curve for goods from the Lagging sector. Thus the nominal price of these goods will increase (while it was assumed constant in the core model) but it may not increase enough to compensate for higher nominal wages. So the net effect on output in the Lagging sector now depends on the slope of the demand and supply curves for L-goods. However, it is likely that a disaggregated model with many industries within the Lagging sector output may increase for some subsectors although it is not likely that this will apply to the sector as a whole.

So far we have discussed an economy without unemployment. Corden (1984) discusses how the effects change when there is "classical unemployment" or real wage resistance. If the resource boom leads to higher demand for labour and wages are rigid, unemployment would be reduced. The opposite is also true in that a resource bust will lead to unemployment with non-flexible wages. There are special cases where results may differ that are discussed by Corden (1984) cf. his Section 8, but these are less relevant for a case study of Norway in recent years. The empirical model we use is based on wage bargaining similar to the main model in Nickell et al. (2005). In this framework an increase in labour demand will result in lower unemployment as well as higher wages and not only higher wages as in the core model. This also applies to the case with Keynesian unemployment where nominal wages are "sticky" as discussed in Section 9 of Corden (1984).[3]

[3] The difference between classical and Keynesian unemployment, cf. Malinvaud (1977) was much discussed in the 1970s and early 1980s but has since more or less disappeared from the macroeconomic discourse.

Our study focuses on the role of immigration in shaping the effects of a resource boom (and bust). When there is a resource boom, wages increase and immigrants are attracted to the country. This lowers the de-industrialization effect on the Lagging sector because some of the labour demand are met by increased supply and consequently less outflow of labour from the Lagging sector is needed. However, immigration will increase the demand for non-tradeable goods and services. This will lead to higher labour demand from this sector. If the immigrants spent very little but instead transferred most of their income to the home country as remittances, this demand effect would probably be small. If the immigrants settled permanently behaving more or less as the original nationals, the demand effect on the non-tradeable sector could be significant and the effect on the Lagging sector more similar to what happens according to the core model.

With wage bargaining, which characterizes the Norwegian labour market well,[4] immigration might affect bargaining both because migrants change the "outside option" for firms and reduce the bargaining strength of unions because employers can hire foreign workers. A recent study on Norwegian data indicates that it is employers who have benefitted the most and that changes in migration rules and regulations that have led to more immigration have also reduced wages ceteris paribus, see Gjelsvik et al. (2015). The econometric wage equations of that study are included in the model we use in our study. Bratsberg and Raaum (2012) provide microeconometric evidence suggesting that immigration of workers in the construction industry has lowered wages for certain groups.

4. A short presentation of the simulation model used in our study

We use a multisectoral econometric model of the Norwegian economy when quantifying the effects of the resource boom and the role of immigration in shaping the results. The model specifies around 20 industries of which one is the petroleum sector or the Booming sector according to the core model. There are several tradeable goods industries that make up the Lagging sector as well as many industries producing mainly non-tradeables. For private industries factor demand is based on cost minimization based on Cobb-Douglas or CES production functions with constant returns to scale, cf. Hungnes (2011). Each industry produces both for the export market and the domestic market and set prices in these markets in line with standard models of imperfect competition. Both export volumes and import shares are based on the Armington hypothesis, cf. Boug and Fagereng (2010). Prices are based on a mark-up over marginal costs where the latter is derived from the production function, cf.

[4] It is estimated that more than three quarters of Norwegian employees are affected by central and local bargaining, see NOU:2016:6, Appendix 5.

Boug et al. (2013). Household consumption depends on income and wealth as well as the after tax real interest rate, cf. Jansen (2012). Household wealth depends to a large extent on housing prices which are influenced by housing stock and credit as modelled by Anundsen and Jansen (2013). Consumption by categories is modelled using a dynamic version of the Almost Ideal Demand Systemen, cf. Deaton and Muellbauer (1980) and Anderson and Blundell (1983). The model includes a standard Taylor-rule for short term money market rate relevant for capturing central bank policies after the introduction of a flexible inflation targeting regime in March 2001. The exchange rate equation for the Norwegian krone-euro rate depends on interest rate and inflation differentials compared to the euro-zone as well as the oil price, while other currencies are linked to the euro. The role of the oil price is important when explaining the strength of the krone vis a vis the Euro during 2005 to 2013 and for understanding how various industries were affected by the resource boom. For a related analysis of the Canadian economy between 2002 and 2008 cf. Beine et al. (2012).

As mentioned earlier wages are modelled in line with a bargaining approach. According to Gjelsvik et al. (2015), wage bargaining in Norway has been significantly affected by immigration. When Norway joined the European Economic Area in 1994 free movement of labour within the area was introduced. This did not change the situation much in the short run because the Nordic countries had introduced a liberal labour market regime already in the early 1960s and cross border labour migration had already become a wide spread phenomena. When the EU enlargement came into effect in May 2004, a number of relatively poorer countries that previously had little outward migration to Norway, gained access to the booming Norwegian labour market. For these countries travel costs and distance were also moderate. From 2005 and onwards immigration to Norway from the Baltic countries and Poland increased a lot, as shown in Figure 4. When Bulgaria and Rumania gained access to the EU in 2007 their citizens also could move quite freely across European borders.[5] So the “wage curve” in the model not only depends on the level of the unemployment rate but also the immigration rate in order to capture the effect that immigration might have on wage bargaining.

Immigration is endogenous in the macro model making total population endogenous as well. We model immigration from three main parts of the world as shown in Figure 4. Country group 1 includes most “western” countries such as the Nordics, original EU members etc. The second group consists of the new EU- members from 2004 and onwards. Citizens belonging to both these two country groups have easy access to the Norwegian labour market. Group 3 is the rest of the world and immigration from these countries is highly restricted and has recently been dominated by refugees. The basic

[5] There were some restrictions on mobility initially but these were dropped completely in 2009.

framework used to model immigration to Norway from each region is to model the emigration rate I_i (immigration to Norway from region i divided by the population in region i) as dependent on relative per capita incomes (Y_N/Y_i), labour markets conditions (unemployment rates in Norway and region i) and possibly regulatory features limiting immigration to Norway. The latter variables are mostly proxied by step-dummies (Dpol). The long-run equations are specified in log form

$$(1)\quad \ln(I_i) = a_0 + a_1 \ln(Y_N/Y_i) + a_2 \ln(U_i) - a_3 \ln(U_N) + a_4 \text{ Dpol}$$

Appendix A shows how we have estimated the parameters in eq. (1). Estimation results for long-run parameters for country groups 1 and 2 are shown in Table 1. For simplicity we do not report results for group 3 as the effects of economic factors are quite small.

Table 1 Elasticities of income and unemployment wrt. immigration from two groups*

	Relative income	Relative unemployment
"Western countries"/Group 1	1.2	-0.3
"Eastern Europe"/Group 2	2.6	-1.3

*The two groups "Western countries" and "Eastern Europe" correspond to country groups 1 and 2 respectively in the national population forecasts, see Cappelen et al. (2015). See Appendix A for detailed results.

We notice that the immigration rate from "Western countries" is less sensitive to relative income differences as well as unemployment differences than immigration from "Eastern Europe". However, the population of the countries included in "Eastern Europe" is only 100 million while it is almost 800 million in "Western countries". This means that a change in the migration rate for Group 1 has a noticeable effect on the Norwegian population and labour force. According to Figure 4 immigration from old and new EU members was nearly one per cent of the population and most of these immigrants came to seek employment in Norway.

In our simulation model labour supply is modelled using labour participation rates times the population disaggregated by gender and age. Labour participation rates for the non-immigrant and immigrant population from country groups 1 and 2 are quite similar but are markedly lower for countries in group 3. We assume therefore, that an increase in immigration from say Group 1 of a person in a certain age (and gender) group 15-74 leads to the same increase in the working population as a similar increase in the non-immigrant population.

5. Simulation setup

The petroleum activities in Norway affect the Norwegian economy through five main channels.

1. Demand from the petroleum industry: Resource movement

2. Use of oil revenues: Spending

3. Exports of oil-related products: Following active import substitution policies during the 1970s and 1980s a significant oil supply-industry has emerged which also gained market shares abroad.

4. Both the supply industry and petroleum extraction are sensitive to oil price fluctuations.

5. The exchange rate is affected by changes in oil prices. With a flexible inflation target the central bank will adjust its interest rate both due to changes in the exchange rate and in economic activity caused by fluctuations in petroleum related industries.

We focus on the resource movement and the spending effects related to the effects of the recent boom in the Norwegian petroleum industry. Demand from the petroleum industry increased markedly from 2003 to 2013 disregarding a short lived decline in the wake of the financial crisis, cf. Figure 3. Our study focuses on how increased labour mobility across borders has changed the effects of a resource boom. Due to the changes in immigration regulations in May 2004, we take 2004 as our starting point.

First, we calibrate the model using actual values of the econometric error terms so that the model tracks the economic development during 2004-2013 perfectly. Then several counterfactual simulations are carried out. To capture the resource movement effects all demand components in the petroleum industry, including man-hours, equals the values in 2004 in a counterfactual simulation. This simulation is then compared to the calibrated simulation showing the actual development. This means that it is only the changes in demand from the petroleum industry that generate the deviation from the actual development. We assume, in other words that neither the econometric error terms nor other exogenous variables than those we have changed are influenced by impulses from the petroleum industry.[6]

To determine the role and importance of immigration another counterfactual simulation is carried out where immigration is assumed to be exogenous and similar to what is the case in the counterfactual path without the oil boom, but where the actual values for the various demand components in the petroleum industry are fed into the simulation. In this case public service production is also adjusted so the civilian public consumption and civil public stock of physical capital per capita is similar to that

[6] Most importantly government policy and world market features are not affected by the changes in our counterfactual simulations.

of the actual development. The difference between the historical development and the counterfactual path gives our estimates of how immigration has modified the resource movement effect.

The effect of the increased spending of oil revenues is estimated based on the same type of simulation as discussed above. The methods are the same, but the construction of the counterfactual path of "unchanged oil-income spending" is different. One could imagine that we some way or another had managed to fix oil-income spending defined as the structural non-oil deficit at the 2004-level in all the years up to 2013. However, as a consequence there would have been no countercyclical policy except automatic stabilizers. In the nine-year period of our interest there have been some changes in taxation and a fairly high growth in real transfers to households due to the ageing of the Norwegian population. Some of these changes must be regarded as unrelated to variations in the petroleum industry but to identify which ones is not an easy task. We limit ourselves to adjust general government purchases including government employment i.e. variables that determine consumption and investment in the public sector. We have reduced the annual growth rate of the various components so that the level of government consumption and investment per capita would have been the same in 2013 as in 2004. Simulation with the model shows that the non-oil budget deficit divided by Mainland GDP, was quite similar to the actual 2004 deficit in 2013. This implies that also in this counterfactual scenario a countercyclical fiscal policy to combat the economic consequences of the financial crisis in 2008 would have been carried out.

To determine the importance of immigration in this case, a new counterfactual simulation is carried out the same way as in the case for the resource movement effect. Government consumption and the stock of government real capital per capita for civil purposes are changed so they become the same as in historical data.

6. Economic and population effects of the oil boom 2005 to 2013

In this section we present the main findings from our simulations. We start by outlining the main macroeconomic effects in Section 6.1. Then we move on to the industry effects which are of major interest in the Dutch disease theory before finally describing how the oil boom affected immigration and the population and how labour mobility across borders has modified the economic effects of the resource boom.

6.1. Macroeconomic effects

Our simulations show that the resource boom contributed significantly to economic growth in Norway from 2005 to 2013. The resource movement effect that amounted to a demand shock of roughly 5 per centage points of mainland GDP by 2013 led to an increase in the level of Mainland GDP by 6.5 percent in 2013 compared to a counterfactual with no resource boom while the number of employees increased by 4.4 percent during the same period. The spending effect which amounted to close to 6 percentage points of mainland GDP in 2013, increased Mainland GDP by 4.8 per cent and employment by 3.4 percent during the same period. The actual increase in Mainland GDP from 2004 to 2013 was 28 percent according to the national accounts. Consequently, we estimate that without these two oil-related impulses, economic growth in Norway would have been halved. Actual employment rose by 16.7 percent over all, and without the oil boom employment growth would also have been nearly halved. The effects on Mainland GDP and employment are shown in Figure 5.a and 5.b respectively and more detailed results in Tables C.1 and C.2 in Appendix C.

The resource boom had positive effects on employment and unemployment was reduced. Overall, the unemployment rate in 2013 would have been close to 6 percent without the oil boom and not 3.5 percent as the actual figure was. This means, however, that unemployment has fallen much less than the employment has increased. In 2013, the decline in the number of unemployed has been one-third of the increase in employment. The reason is threefold. First there was a "discouraged worker" effect in reverse meaning that labour participation has increased due to low unemployment as search costs have been reduced. Second, labour supply has been stimulated by higher after tax real wages. Finally, there has been an increase in the working population as a result of increased immigration as shown on Figure 6. Taken together, the resource boom plus the spending effects have increased the Norwegian population by nearly 100 000 persons or 2 percent in 2013.[7] Because immigrants from country Groups 1 and 2 are typically in their working age, the increase in the population aged 15-74 is somewhat higher than 2 per cent.

[7] A close inspection of the numbers in Figure 6 reveals that accumulated immigration is much larger than the change in population. This is mainly because some immigrants emigrate after a period of residence. Emigration rates by country group, age and gender is exogenous in the model making total emigration endogenous.

Figure 5 Resource movement (RM) and spending (S) effects on (a) Mainland GDP, (b) total employment, (c) hourly wages in per cent and (d) unemployment in percentage points

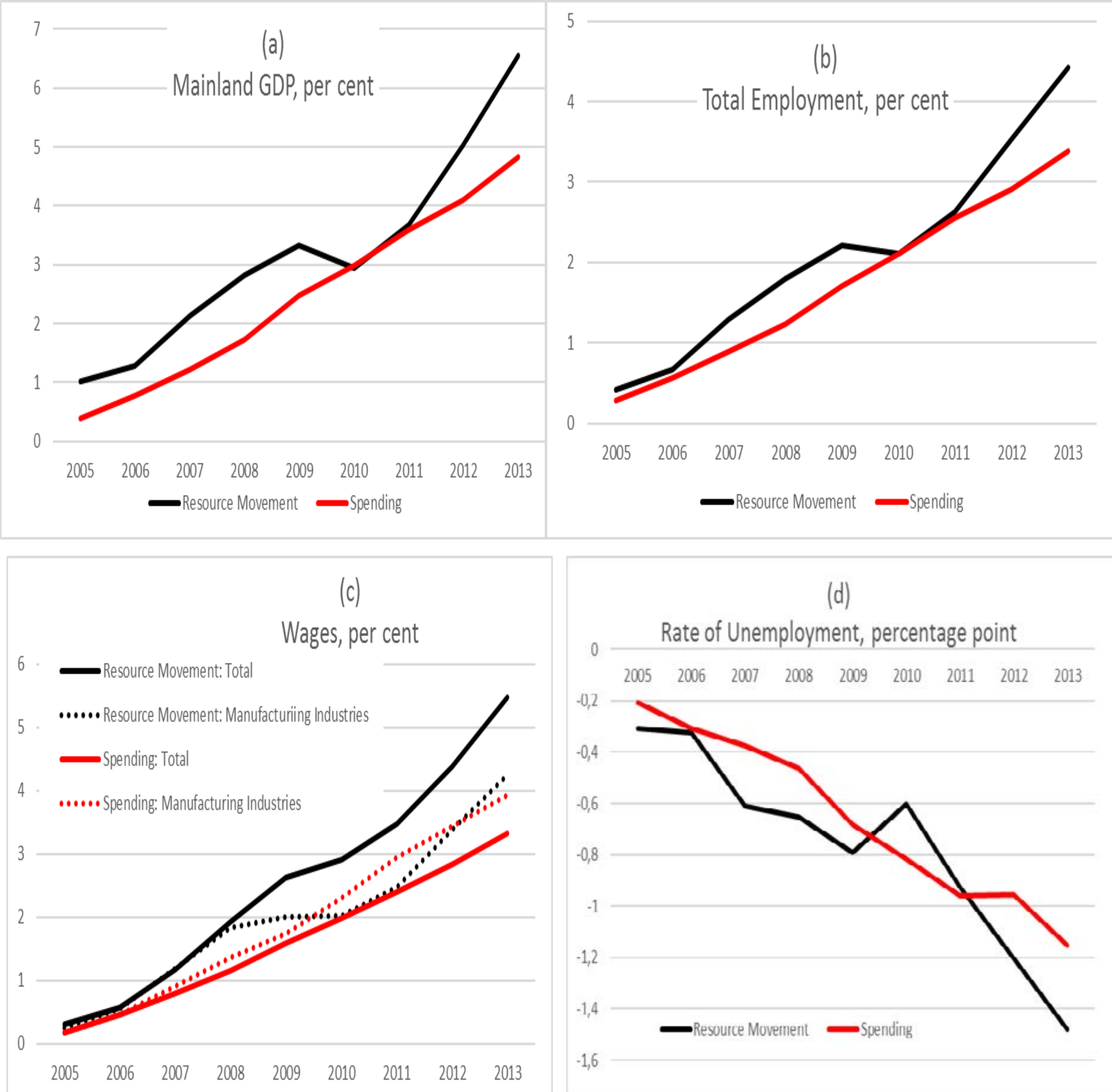
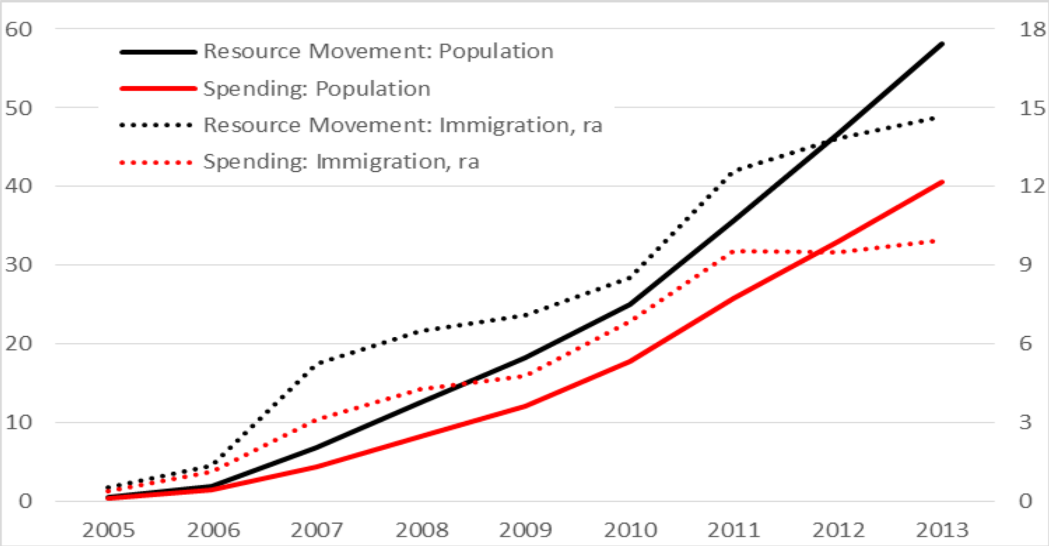


Figure 6 Resource movement and spending effects on immigration (ra=right axis) and population in 1000 persons (left axis)



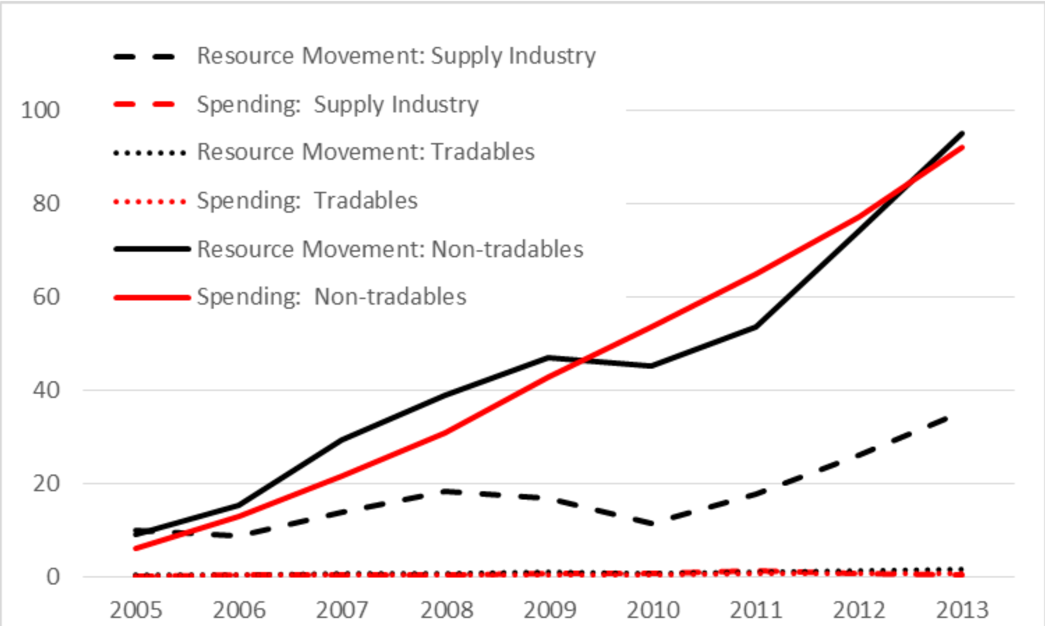
As Figure 5 and Figure 6 show the effects of resource movement have generally been higher than the spending effects although for many variables the numbers are quite similar. For the average wage rate and immigration the resource movement effect is clearly larger than the spending effect. The impact on wages from the resource movement is 5.5 percent according to Figure 5.c while only 3 percent is due to the spending effect. Notice that for wages in manufacturing the effects are much more similar. Higher immigration reduces wages primarily outside the manufacturing industry with construction being one typical example of such an industry, cf. Bratsberg and Raaum (2012) on wage effects for construction in particular. In most industries it is possible to pass increased costs in terms of increased wages on to the buyers through higher prices according to standard mark-up pricing. In manufacturing which is more exposed to international competition, the wage formation ensures the long term operating profit as a share of factor income is stable. In the model there is a direct effect on wages in industries outside manufacturing from the activity in the petroleum sector. Wages in the petroleum industry are roughly twice as high as in the rest of the economy. There are more favourable outside options for the employed people when jobs in the petroleum industry increase due to resource movement. In manufacturing however, these effects on wages are less due to profit considerations. When activity in the petroleum industry increases the direct effect from the petroleum sector and the effect of immigration are close to canceling each other out. There are no such offsetting effects in the case of an increase in spending. Our simulations show that immigration increased more due to the resource movement effect than due to the spending effect because both the income effect is higher and the unemployment effect larger in the resource movement scenario.

Another reason for the somewhat different effect on wages and immigration is that the increased use of inputs in the petroleum sector also results in higher production in the petroleum industry than would otherwise have been the case. Because of the high oil price and thus resource rent in this period, the effect on total GDP is significant and this affects realtive GDP per capita and immigration according to the model cf. Section 3.

6.2. Industry effects

Next we aggregate the 20 industries in the model economy into three major industries in line with Corden (1984). We find that our results only partially are in accordance with the standard Dutch disease hypothesis, cf. Figure 7. Non-tradable industries are positively affected by both the resource movement and spending effect as expected. However, the Tradable industries or Lagging sectors are hardly affected at all. This is due to the endogenous terms of trade mechanism discussed in Corden (1984) as an extension to the basic model. In addition, in the specific Norwegian context, manufacturing has developed a number of important linkages to the petroleum industry allowing for important demand effects of a resource boom.

Figure 7 Resource movement and spending effects on value added in billion 2013-NOK



However, industry effects are also to some degree affected by a classification problem. The boundaries between Non-tradable and Tradable industries are not clear cut. Most industries in a small open economy like the Norwegian are more or less exposed to international competition, so there are few that can be considered as completely Non-tradable industries. Tourism is an international industry, but the service produced in Norway composes of domestic transport, hotels and restaurants, museums and so forth. When the exchange rate appreciates, fewer tourists come to Norway and hotels experience more vacancies. Export of services which is endogenous in our simulation will convert some of the booming effects on the economy into negative demand effects to the service industry. Something similar can be said of the petroleum supplier industry. Most Norwegian industries are directly or indirectly supplying the petroleum industry, and for some industries this supply constitutes a large part of value added, see Hungnes et al. (2016) for quantification of these linkages. We only define industry services related to mining and engineering industries as supplier industries. In 2013 these industries produced just over 7 percent of Mainland GDP.

In line with the Dutch disease hypothesis, we see from Figure 7 that it is primarily industries usually classified as producers of Non-tradables that expanded due to the resource movement and spending impulses. The resource movement effect entails a substantial increase in the supply industry, which comes in addition to the effects on the extraction industry itself. Together they might be considered as the booming sector. The supplier industry is clearly exposed, so the resource movement actually contributes to the expansion of the producers of Tradables, albeit not the traditional exposed sector. The effects on the Tradable goods sector are also positive, but here the effects are close to zero. The latter is a result of the expansion in household and government demand which is directed primarily towards Tradables, and also some of the demand from the petroleum industry is affecting industries we have defined as sheltered. This more than offsets the negative effects through deteriorated cost competitiveness and appreciation of the exchange rate that usually lead to de-industrialization in the classical Dutch disease model.

6.3. The role of immigration

So far we have found that the resource boom from 2004 to 2013 has had large effect on the Norwegian economy. We now address the role of immigration in shaping these results. Figure 8 illustrates some of the effects on the response due to immigration. Figure 8.c shows that the impact on real wages has been roughly halved as a result of the immigration response while Figure 8.b shows that the impact on employment has almost been increased by as much as 40-45 per cent in 2013. Qualitatively, these results do not come as a surprise according to standard economic theory. The resource boom has increased incomes and immigration. This has led to a moderation of claims in wage bargaining and firms have moved down their labour demand schedule so that employment has increased. Thus nominal wage growth, prices as well as interest rates and the exchange rate have not been so much affected by the resource boom due to the response of immigration as would have been the case without this response.

Simply put, the supply curve of the economy has become less steep due to immigration. This is easy to see by comparing the nominal effects in Table C.1 with C.2 as well as Table C.3 with C.4 in Appendix C. Mainland GDP has on the other hand not been much affected. Our simulation therefore shows (implicitly) that the effect on labour productivity has been quite negative as a result of the response from immigration. Lower wages because of increased immigration leads to a substitution of labour for capital compared with what would have been the result without the immigration response. A perhaps surprising result is that immigration, according to our calculations, has increased the effects of the resource boom on unemployment, albeit not by much, cf. Figure 8.d. The wage response of immigration is so strong that the reduction in real wages reduces labour participation rates that more than offset the increase in the working population that immigration lead to. In this sense lower real wages have "crowded out" labour supply of existing residents to make room for more immigrants in the labour market.

Figure 8 The impact of the oil boom with and without immigration response

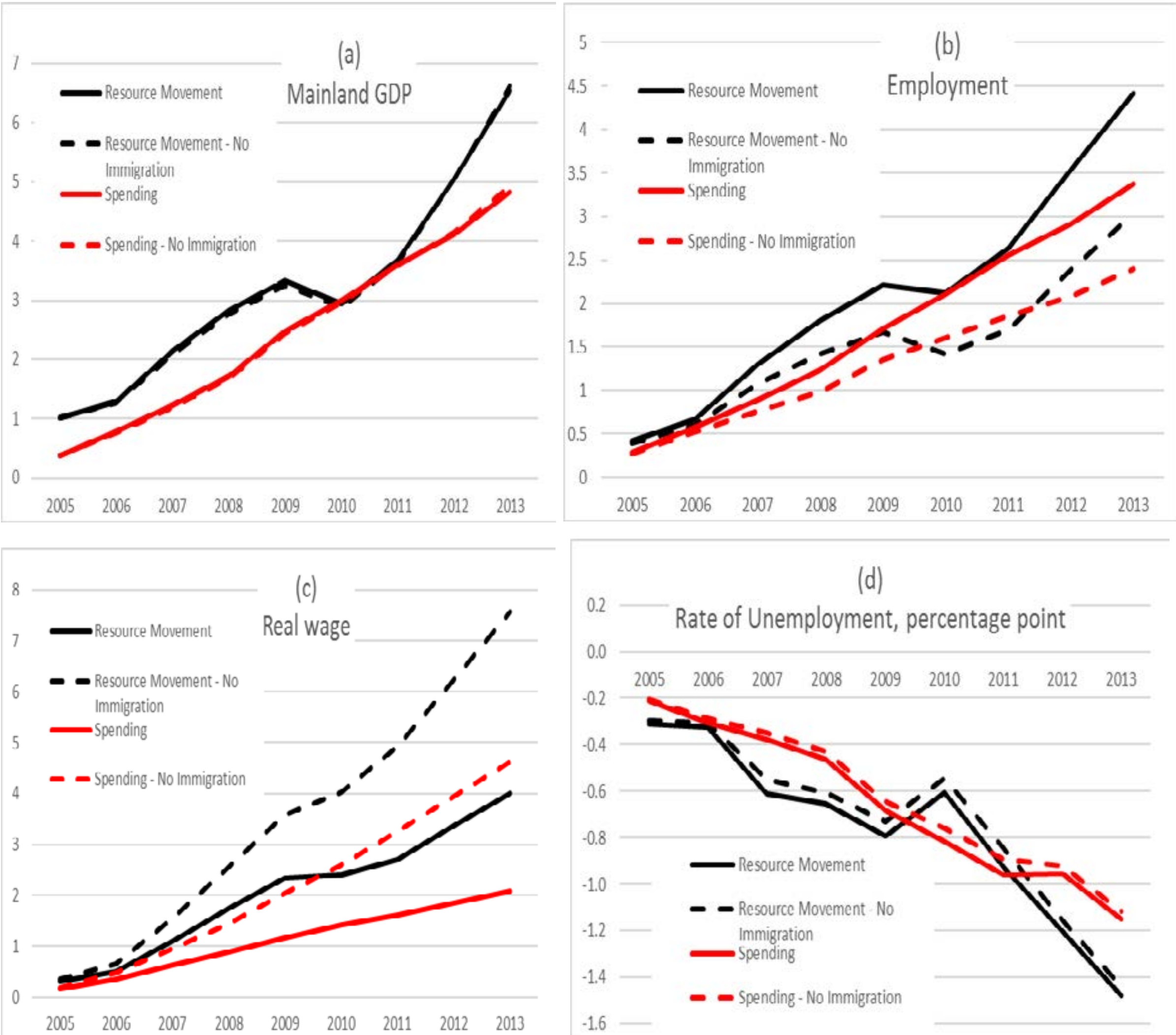
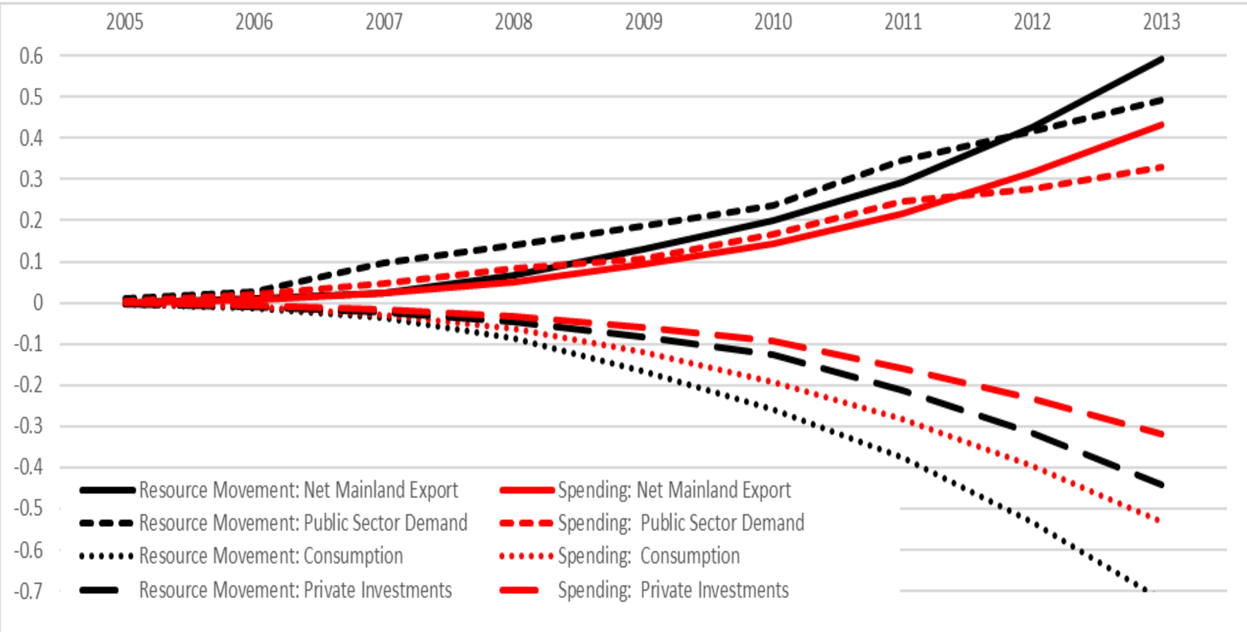


Figure 9 shows the importance of the immigration response for some main demand components of GDP. The significance of the various components is shown as shares of Mainland GDP in percentage points to make them more easily comparable. The boom led to higher immigration and this increased the effect on net exports. This export boost has contributed to an increase in the effects of the boom on Mainland GDP. The same goes for the effects via higher government spending. In the opposite direction we have the negative effect on private consumption and investments that have lowered the GDP effect of the resource boom. The small total effect of the immigration on Mainland GDP can to a large extent be explained by the finding that immigration reduces the effect of the resource boom on household consumption. The relative decline in real wages is less than the relative increase in employment and thus wage incomes decline. The substitution of labour for other inputs due to lower wages, leads to a reduction in investments which have a negative effect on GDP. The effects of the improvement in cost competitiveness and lower wages resulting from higher immigration lead to higher net exports.

Figure 9 The importance of immigration for macroeconomic effects of the oil boom. Effects as shares of Mainland GDP in percentage points



7. Conclusions

We have illustrated quantitatively how the resource boom that took place during 2004 to 2013 affected the Norwegian economy and to what extent a more liberal regime for immigration modifies the results. We found that economic growth in Norway was roughly doubled during this period due to the resource boom. The resource movement effect was estimated to have been somewhat more important than the spending effect of oil revenues in increasing Mainland GDP. Total employment growth would have been much lower without the resource boom and therefore unemployment has been much reduced because of the resource boom.

A novel feature of our study that has not received much attention in the Dutch disease literature so far is how immigration affects a resource boom. We found that the Norwegian population increased by 2 per cent in 2013 due to immigration as a consequence of the resource boom. A more liberal migration regime following the May 2004 EU-enlargement has increased labour mobility within Europe and this change explains some of the increase in immigration to Norway from 2004 to 2013. Higher immigration reduced the effect on unemployment but also affected wages by modifying wage bargaining. A moderation of wages due to immigration increased labour demand and lowered labour productivity thereby reducing the effect on the unemployment rate.

In line with the generalized model surveyed by Corden (1984) where we allow for an endogenous terms of trade effect, we found that the Lagging sector was not negatively affected by the resource boom, in fact hardly affected at all. This result is due to the positive demand effect that follows from both the resource movement and spending effects associated with a resource boom. Loss of competitiveness leads to lower export volumes and more import penetration, but these effects are counteracted by the positive domestic demand effect. Looking at the effects on manufacturing as a whole and not only the Lagging sector, another interesting result appeared. In the Norwegian context parts the petroleum industry has developed “backward linkages” to parts of manufacturing so that the resource movement effect led to increased demand for domestic manufactured goods. Thus when analyzing a resource boom it may be well worth to separate between the resource movement and spending effects in order to understand the different industry effects of a boom depending on the relative size of these two effects.

Finally, we found that immigration affected our results in a number of ways. The resource boom increased immigration and in itself this change nearly halved the wage effects of the boom compared to a situation without the immigration response. A lower wage led to a stronger employment effect lowering the labour productivity response of the boom. In fact we found that immigration increased the effect on unemployment slightly because the wage response of immigration was so large that existing residents lowered their labour supply so that immigration completely crowded out the extra labour supply that would have followed a boom that led to higher real wages. On the other hand both the resource movement and spending effects on Mainland GDP were roughly unaffected by immigration in 2013 so immigration made the effect of the resource boom on Mainland GDP per capita turn out negative. This result echoes the findings of Maddock and McLean (1984) for the gold rush in Australia. However, in the Norwegian context total GDP per capita increased a lot relative to the OECD average during the resource boom as shown in Figure 1. This was partly due to the fact that most of the resource rent associated with the boom was collected by the government through taxation of petroleum extraction and invested abroad through the Government Pension Fund Global.

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Appendix A: Modelling immigration

Our starting point for modelling immigration to Norway is

(1) $\log (I_1) = a_0 + a_1 \ln(Y_N/Y_1) + a_2 \ln(U_N) + a_3 \ln(U_1) + a_4$ Dpol.

Here I_1 is immigration from region or country group 1 to Norway divided by total population in region 1. The Y's are GDP per capita in PPPs in Norway and region 1 and the U's are unemployment rates in Norway and region 1. Dpol is a set of step-dummies that are included in order to capture possible policy regime changes related to immigration. For region 1 "Western countries" the only relevant dummy is a step dummy from 1994 and onwards when Norway joined the European Economic Area. This dummy was not significant in any specification so we drop it here for simplicity.[8] Data on population are taken from the UN while income data and unemployment rates are readily available from the OECD web page cf. Cappelen et al. (2015).

Because multiple long-run relationships may exist among the variables included in the model of immigration, we employ the Johansen (1995, p. 167) trace test for cointegration rank determination. We thus start with an unrestricted p-dimensional VAR of order k having the form

(2) $Y_t = \sum_i \Pi_i Y_{t-i} + \delta t + \mu + \varepsilon_t, \qquad t = k + 1, ..., T$

where Y_t is a (p x 1) vector of modelled variables at time t, μ is a vector of intercepts, $\Pi_1, ..., \Pi_k$ are (p x p) coefficient matrices of lagged level variables, t captures a trend and $\varepsilon_{k+1}, ..., \varepsilon_T$ are independent Gaussian errors with expectation zero and (unrestricted) (p x p) covariance matrix Ω. The initial observations $Y_1, ..., Y_k$ are kept fixed.

The question now is how (2) can be reparameterised to a cointegrated VAR (henceforth CVAR) in which immigration behaviour can be formulated as a reduced rank restriction on the impact matrix $\Pi = -(I - \Pi_1 - ... - \Pi_k)$. The way the CVAR is formulated in our context depends on the exogeneity status of the unemployment series.

If Y_t is I(1), then the first difference ΔY_t is I(0), implying either $\Pi = 0$ or Π has reduced rank such that $\Pi = \alpha\beta'$, where α and β are (p x r) matrices and $0 < r < 4$. Here r denotes the rank order of Π. Assuming for notational simplicity that k =2, the CVAR becomes

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[8] Results including this dummy are available upon request.

(3) $\Delta Y_t = \Gamma_1 \Delta Y_{t-1} + \alpha\beta' Y_{t-1} + \delta t + \mu + \varepsilon_t$,

where $\beta' Y_{t-1}$ is a (r x 1) vector of stationary cointegration relations among $\ln(I_1)_t$, $\ln(Y_N/Y_1)_t$, $\ln(U_N)_t$ and $\ln(U_1)_t$ and $\Gamma_1 = -\Pi_2$ is the (4 X 4) coefficient matrix of the lagged differenced variables.

We present the case where the two unemployment rates (the U's in (1)) enter in relative form similar to relative incomes and are weakly exogenous for the long run parameters. If this is the case, valid inference on β can be obtained by considering the two-dimensional system of $\ln(I_1)_t$ and $\ln(Y_N/Y_1)_t$ conditional on log of relative unemployment (U) without loss of information, see Johansen (1992). Following Harbo et al. (1998), we may formulate the partial CVAR equivalent to (3) as (again assuming k = 2)

(4) $\Delta Y_t = \omega \Delta \ln(U)_t + \gamma_1 \Delta Y_{t-1} + \alpha\beta' Y_{t-1} + \delta t + \mu + \varepsilon_t$

where ω and γ_1 are (2 x 1) and (2 x 2) matrices, respectively. The corresponding marginal model is $\Delta U_t = \gamma_2 \Delta Y_{t-1} + \delta_2 t + \mu_2 + \varepsilon_{2,t}$ where γ_2 is a (1 x 2) vector. It follows that relative U_t is included in the long-run part of (4) as a non-modelled variable. As noted by Harbo et al. (1998), the asymptotic distribution of the trace test statistic is influenced by conditioning on weakly exogenous variables and standard critical values are thus not valid. We therefore use the critical values in Table 2 in Harbo et al. (1998). The constants enter the partial system unrestrictedly.

We find that using k = 2 produces a model which pass all single-equation and vector diagnostics according to standard tests. Table A.1 reports trace test statistics for the partial CVAR assuming k = 2.

Table A.1: Tests for cointegration rank for the partial CVAR

r	λ_i	λ_{trace}	5 %-Harbo
r = 0	0.29	21.8	30.5
r ≤ 1	0.13	6.4	15.2

Notes: Sample period: 1972 - 2016. The underlying VAR is of order 2. The partial CVAR consists of two Y's as modelled variables and relative U's as an exogenous variable. r denotes the cointegration rank, λ_i are the eigenvalues from the reduced rank regressions, λ_{trace} are the trace test statistics, and 5% Harbo are the critical values (5 per cent significance level) from Table 2 in Harbo et al. (1998).

The null hypothesis of no cointegration cannot be rejected according to the test in Harbo et al. (1998) at 5 %. However, we show below that a single equation tests for cointegration based on Banerjee et al. (1998) as well as Pesaran et al. (2001) lend some support for a cointegrating relationship between the immigration rate, relative incomes and relative unemployment.

Assuming the rank to be one, we may specify one restricted cointegrating vector normalized on the immigration rate (I_1) as depending on relative incomes (Y_N/Y_1) and relative unemployment rates as shown in (5) below. Given that the rank equals one, we test if relative income is weakly exogenous for the cointegrating relationship and that the trend is not significant. With χ^2 (2) = 0.41 (p-value = 0.52) we find that this joint hypothesis cannot be rejected. Thus we proceed to single equation estimation based on the following cointegrating relationship

$$(5)\ \ln(I_1)_t = \text{const.} + \underset{(0.139)}{1.1975} \ln(Y_N/Y_1)_t - \underset{(0.121)}{0.2896} \ln(U_N/U_1)_t$$

The estimate of the corresponding adjustment coefficient is -0.436 with an estimated standard error of 0.115 so the corresponding t-value equals -3.79. We thus define an equilibrium correction term (eqcm)

$$(6)\ eqcm_t = \ln(I_1)_t - 1.1975 \ln(Y_N/Y_1)_t + 0.2896 \ln(U_N/U_1)_t.$$

Using a general-to-specific modelling strategy we find the following well-specified parsimonious model using a sample from 1972-2016

$$(7)\ \Delta\ln(I_1)_t = \underset{(0.220)}{0.933} - \underset{(0.084)}{0.425} \Delta\ln(U_N/U_1)_t - \underset{(0.082)}{0.302}\Delta\ln(U_N/U_1)_{t-1} - \underset{(0.099)}{0.416}\, eqcm_{t-1}$$

$\sigma = 0.077$, $AR_{1\text{-}2}$: F(2,38) = 1.93 [0.16], $ARCH_{1\text{-}1}$: F(1.42)= 2.35 [0.13], NORM: $\chi^2(2)$ = 1.40 [0.50]
HET: F(6,38) = 1.28 [0.29], HET-X: F(9,34) = 1.17 [0.35], RESET23: F(2,38) = 0.27 [0.76]

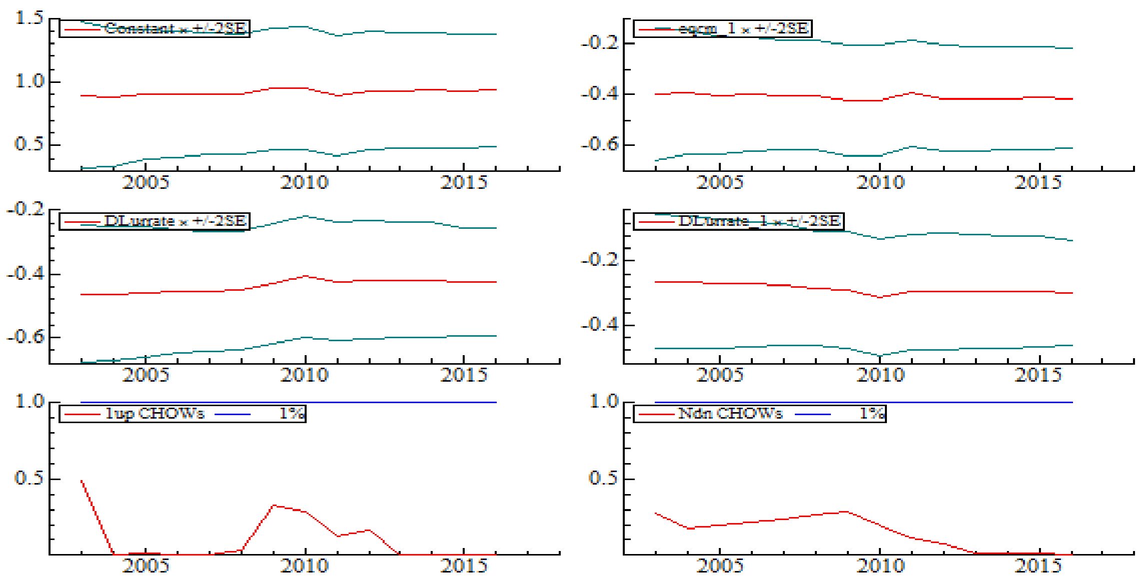
The specification tests show no sign of any residual autocorrelation or heteroscedasticity and the error term is well proxied by Gaussian errors.[9] Note that the model includes no dummies at all. The parameter estimates are highly significant. The highly significant parameter estimate for the eqcm-term (t-value of - 4.2) supports cointegration. According to Table 1 in Banerjee et al. (1998) the critical value is – 3.28 supporting the existence of a cointegrating relationship. A generalization of this approach within a single equation framework is found in Pesaran et al. (2001) for both I(0) and I(1) regressors. This method consists of estimating an error correction form of an autoregressive dirstributed lag model and testing whether variables in levels could be deleted from the model or not. The maintained model is one in levels and we test if cointegration could be rejected or not. If H_0 is not rejected there is support for cointegration. In our case we do not impose the results in eq. (6) but let lagged levels of the immigration rate, relative incomes and unemployment enter a model in first

[9] AR is a test for up to 2nd order residual autocorrelation used by Harvey (1981), ARCH is the Engle (1982) test for first order autoregressive conditional heteroskedasticity, NORM is the normality test described in Doornik and Hansen (2008), HET are tests for residual heteroskedasticity due to White (1980) and RESET is a test for functional form misspecification based on Ramsey (1969).

differences and lagged differences in line with our cointegration analyses earlier where we found that a VAR in levels with two lags provided a parsimonious representation with desirable statistical properties and in particular no autocorrelation. The resulting F-test has as a non-standard distribution and in our case the F-value from comparing a model with and without regressors in levels is 4.63. At 5 % and in the case with no trend and unrestricted intercept the upper limit is 4.85 (cf. Table CI(iii) in Persaran et al. (2001) for I(1)-variables). At 5 % our test is in the inconclusive regions while if we look at the 10 % level the F-statistics is 4.14 supporting cointegration. A test of whether or not the coefficient of the lagged dependent variable is zero is -3.45 while the critical value at 5 % (cf. Table CII(iii)) is – 3.53 while at 10 % the critical value is 3.21 again lending support for cointegration.

Recursive estimates show that (7) has very stable parameters from 2003 and onwards and Chow tests do not indicate any breaks. Eq (7) is included in the multisector macromodel used in the simulations in this study.

Figure A.1. Recursive estimates of the parameters in model (7).



Immigration from Eastern Europe (new member countries in the EU in 2004 and 2007) is modelled in the same way as in (7). In this case we have not carried out a cointegration analysis because we have too few observations. The breakdown of the Soviet-block in 1989 changed both economic and political conditions in these countries and comparable data from 1970 are not available. Thus we use a sample from 1990 to 2015. Due to changes in immigration rules affecting countries in this region we include step dummies from 2004 and 2007 to capture the new policy regimes for immigration.

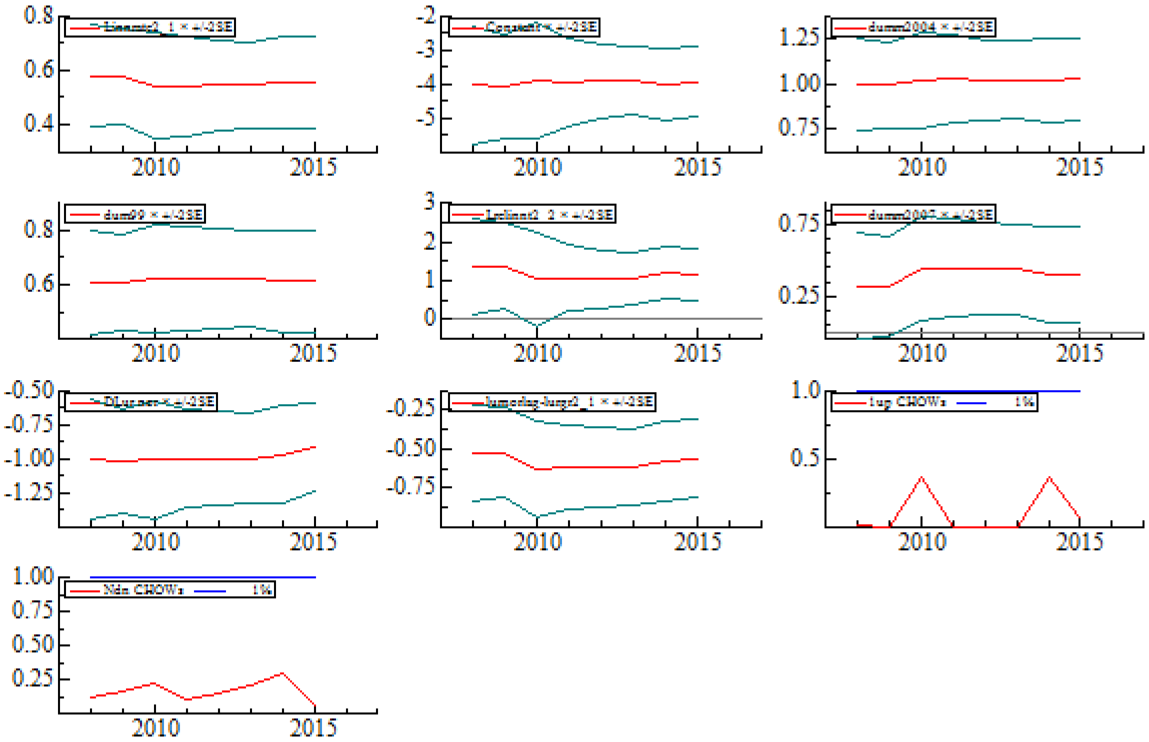
(8) $\Delta\log(I_{2,})_t$ = - 3.944 – 0.611 DUM1999 + 1.024 DUMSTEP2004 + 0.400 DUMSTEP2007
(0.519) (0.093) (0.114) (0.165)

- 0.911 $\Delta\log(U_N)_t$ - 0.559 $(\log(U_N)_{t-2} – \log(U_2)_{t-1})$ – 0.446 $\log(I_2)_{t-1}$ + 1.152 $\log(Y_N/Y_2)_{t-2}$
(0.162) (0.127) (0.068) (0.331)

σ = 0.087, AR_{1-2} : F(2,13) = 1.52 [0.26], $ARCH_{1-1}$: F(1,21)= 0.048 [0.83], NORM: $\chi^2(2)$ = 0.252 [0.88]
HET: F(11,10) = 0.393 [0.93]

The model for immigration from Eastern Europe has much larger marginal effects of relative unemployment and relative incomes compared to the model for “Western countries”. The long-run relative income elasticity is roughly twice as high and the unemployment term four times as high. Note again that in the long run only relative unemployment rates affect the immigration rate. Thus the populations of the new EU member countries are much more inclined to migrate than the population in the Western countries which includes North America and Oceania. Intuitively this seems reasonable due to differences in geographical location. On the other hand the differences in language skills and probably also culture are more pronounced. The estimates show that the immigration rate increased a lot due to the EU enlargements of 2004 and 2007. We have experimented with the possibility that not only the constant term shifted due the EU enlargements but also slope parameters. However, these attempts did not produce reasonable results or a well specified statistical model. As we can see from eq. (8) the t-value for the coefficient of the lagged dependent variable is -6.56 which according to the cointegration tests in Pesaran et al. (2001) clearly rejects that variables in levels should be excluded from our model thus supporting cointegration. This equation is thus included in our simulation model used in this paper.

Below we show the recursive parameter estimates of model (8) from 2008 and onwards when both Bulgaria and Rumania had become members of the EU (from 2007). The estimates are quite stable during these recent years.


dum99 × +/-2SE
1up CHOWs 1%
Ndn CHOWs 1%
2010
2015

Appendix B: The model used in the simulations

The model used in our study is a disaggregated econometric model (MODAG) using annual data with an input-output core based on the National Accounts system. Products are in general assumed to be imperfect substitutes, hence Norwegian product prices can differ from prices set by foreign competitors. Foreign prices are taken into account by Norwegian producers in their price setting in line with theories of monopolistic competition. Norwegian prices on exports and home markets are set as a mark-up on firms' marginal costs. The mark-ups usually increase if prices of competing goods produced abroad increase. Foreign prices also affect the firms' costs through imported intermediate inputs which are taken into account in the input-output core of the model. Hence, changes in demand can lead to adjustments in both product prices and production levels.

In each industry producer prices on home goods (H) and exports (A) (excl. taxes) are the product of a mark-up (MU) and marginal costs (MC). Industry-specific marginal costs follow from the specification of the technology which we discuss later.

$$P_{ij} = MU_{ij} \; MC_{j\,;} \qquad i = H, A, \; j = \text{industry}$$

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

$$MU_{ij} = m_{0i} \, (P_{Fi}/P_i)^{mi} \, ; \quad i = H, A.$$

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

$$P_{ij} = m_{0i}^{\;1/(1+mi)} \, P_{Fi}^{\;mi/(1+mi)} \, MC_j^{\;1/(1+mi)} \, ; \quad i = H, A, \; j = \text{industry}$$

If $m_i = 0$ the mark-up is constant. In this case price equals marginal costs multiplied by m_0. If on the other hand the export price or the price in domestic markets for each industry/good equals the competitors price P_F, there is price-taking behaviour and output (gross production) is supply determined (small open economy case). This is the case in the petroleum industry where the crude oil price is exogenous in the model and all prices are equal (except for some short-run differences). In the standard case with mark-up pricing, output in each industry is determined by a weighted sum of demand categories in the model.

For each component of demand there is a purchasing price index determined in line with national accounts definitions. Below the price index for other material inputs (PM) for each industry is used as an example of how purchasing prices are determined. The price indices for various consumer goods as well as investment categories are determined in exactly the same way. Each price index is basically a weighted sum of domestic (P_H) and foreign (P_F) basic prices, a trade margin (P_{TM}) and indirect taxes where the weights (denoted by small letters in the equation below) are calibrated constants based on the national accounts. IS_i are indices of changes in import shares compared to the base year import share (is_{0i}).

$$PM_j = \sum_i c_{ij} (1+VAT_{ij})[(1-is_0 IS_i)P_{Hi} + is_{0i}\, IS_i\, P_{Fi}) + b_{ji}\, ET_{ji} + c_{tmj}\, P_{TM}]$$

VAT is the value added tax which varies between uses. Consumption of food has a low rate (15 per cent). Some services have a lower rate while some services even have a rate equal to zero while the standard VAT-rate is 0.25. Excise taxes rates (ET) vary a lot between various products, where fuels, electricity, alcohol and tobacco as well as most cars are heavily taxed while most goods and consumer categories are hardly taxed at all. Both the VAT rates and ET rates are exogenous variables in the model and are not changed in any of the simulations in our study compared to actual historical values. The P_H variables are determined according to the mark-up pricing model above. Import prices are mostly exogenous in foreign currency although for some goods there is pricing-to-market effects in line with an up-dated version of Naug and Nymoen (1996).

The trade margin P_{TM} plays an important role as a buffer between import prices in foreign currencies and domestic prices when the exchange rate changes, cf. Boug et al. (2013) for discussion and analyses of exchange rate pass-through in the model. So except for the tax rates and input-output coefficients in the PM equation, all other variables are endogenous in the model.

The import shares IS are endogenous.[10] Assuming that there is weak separability in demand between imported and home goods of the same variety using a CES aggregate, we can specify IS as a function of relative prices P_H/P_F for each product in the model.

[10] IS_i are indices that indicate deviations from the base year import share is_0.

For each product there is a supply and use equation which slightly simplified[11] looks like

$$I_i + X_i = \sum_j d_{Mij} M_j + \sum_k d_{Cik} C_k + \sum_r d_{Jir} J_r + A_i + DS_i$$

Here X is gross production, M is other material inputs, C is various consumer categories and J gross investment categories. A is exports and DS changes in total stocks. The index i runs over 38 goods while j refers to 18 industries. There are 18 consumer categories and 8 investment categories.

The import equation is quite similar to the supply and use equation

$$I_i = IS_i \left[\sum_j d_{MIij} M_j + \sum_k d_{CIik} C_k + \sum_r d_{JIir} J_r + DSI_i \right]$$

Here DSI is changes in stocks of imported goods (so DS = DSI + DSH where the latter is changes in stock of domestically produced goods). The base year of the model which normally is the year for which the most recent final national accounts data are available, is used for calibrating the d's. The import share IS refers to changes in the average import share compared to the base year and is commodity specific but not "use-specific".

Exports of goods and services are in general modelled using the Armington-approach so the volume of exports of each product is determined by relative prices and a weighted average of real incomes for Norwegian trading partners.

In the Cobb-Douglas case cost minimization implies log-linear factor demand equations. We illustrate the approach by showing demand for Other material inputs

$$M_j = \lambda_{tj}(PU_j/PM_j)^{\alpha} (W_j/PM_j)^{\beta} X_j^{\,1/(\alpha+\beta)} K_j^{\,-1/(\alpha+\beta)+1}$$

Here PU is the input price for the energy aggregate (E and F), W is labour costs per hour and PM is the price index for other material inputs shown earlier. These variables are industry specific. We have simplified the equation by using the aggregate industry capital stock which is lagged one year due to the gestation lag. The parameters included are also industry specific and mappings of parameters of the production function in each industry. There are factor demand equations for labour (L), energy

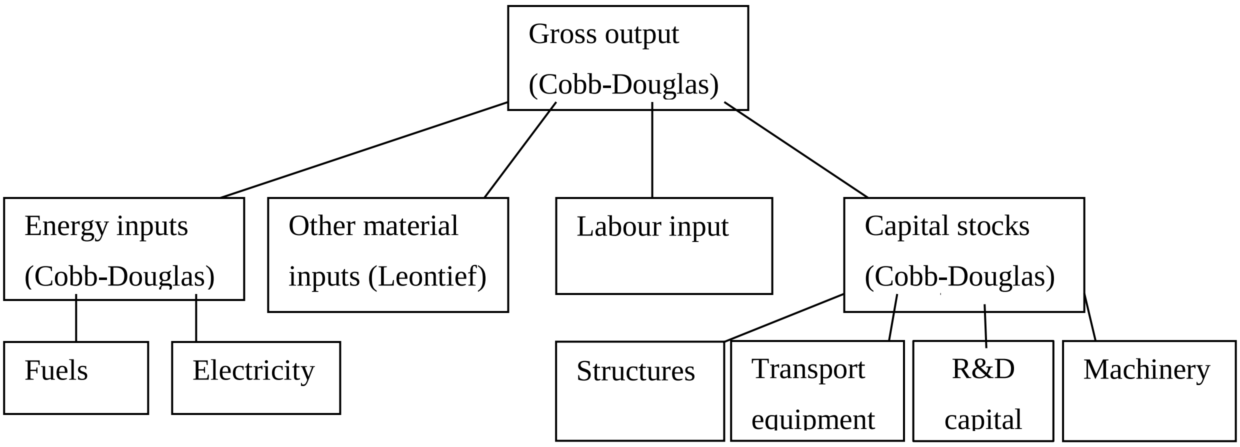
[11] The variable M should be substituted with E for the electricity supply and use equation and similarly with F for the fuels equation.

goods (E and F) and capitals stocks (K) similar to the equation for M. For each capital type r and industry j the standard capital accumulation equation applies

$$K_{j\ r,t} = K_{j\ r,t-1} + J_{j\ r,t} - DEP_{j\ r,t}$$

Depreciation (DEP) is geometric and depreciation rates vary across the r investment categories and by industry. The user cost of capital defined in a standard way is important for determining demand for capital, cf. Hungnes (2011). Together with the demand for capital stock based on the production function in a standard way, the capital accumulation equations determine gross investments by industry. The production structure by industry is shown on Figure B.1.

Figure B.1. The structure of production by industry



Household consumption is largely determined by a macro consumption function depending on household real income, total real wealth and after tax real interest rate, cf. Jansen (2013). Consumption of housing is not part of this aggregate as this category is modelled simply as proportional to the housing capital stock. Housing investment and linkages to consumption and saving include a financial accelerator mechanism as explained in Anundsen and Jansen (2013). Household expenditures by categories (the C's in the supply and use equations) are modelled using a dynamic version of the Almost Ideal Demand System, cf. Deaton and Muellbauer (1980) and Anderson and Blundell (1983).

Labour participation rates (labour force by age and gender divided by the various resident population groups) depend on after tax consumer real wages in addition to a discouraged worker effect. These equations are estimated using employment survey data but are in line with the results in Dagsvik et al.

(2013) as well as Dagsvik and Strøm (2006). Note that resident population is endogenous due to immigration as explained in Appendix A. Unemployment is simply the difference between the labour force (supply) and employment.

Wage formation in Norway is modelled in Gjelsvik et al. (2015). In line with institutional features of wage bargaining in Norway, wage bargaining in manufacturing provides a norm for wages in private service industries and in the government sectors. Wage rates in manufacturing are in general related to value added deflators and productivity in manufacturing as well as aggregate unemployment in line with the "wage curve" literature, cf. Blanchflower and Oswald (1994). In addition, the changes in labour market regulations and migration in particular have changed how we might measure labour market pressures (as measured by the unemployment rate) and bargaining strength. Empirically this has resulted in including labour immigration in addition to unemployment in the wage equations so that immigration has a dampening effect on wages, cf. Gjelsvik et al. (2015). Otherwise the model is mainly in line with a large literature on wage bargaining in Norway, cf. Hoel and Nymoen (1988) and Bowitz and Cappelen (2001) and references therein.

Finally, the model includes a Taylor-type interest rate reaction function for the central bank reflecting a flexible exchange rate system introduced in 2001 where the short-run market rate is a function of inflation (in deviation of a 2.5 percent target inflation rate) and the inflation difference compared to the euro-zone and unemployment which is used as a proxy for the output-gap. The euro/NOK rate is modelled as depending on the difference in short term real interest rates between Norway and the euro zone as well as the nominal oil price.

Appendix C. Detailed simulation results

Table C.1: Resource movement with endogenous immigration: Effects of changes in demand from the petroleum industry after 2004. Difference in per cent from counterfactual baseline, unless otherwise stated

	2005	2006	2007	2008	2009	2010	2011	2012	2013
Household consumption	0.1	0.3	0.8	1.3	2.0	2.5	3.0	3.7	4.6
Public consumption	0.0	0.0	0.1	0.2	0.3	0.5	0.7	0.9	1.1
Gross investments	4.2	4.7	6.5	8.3	10.2	8.5	12.3	17.5	25.1
Petroleum sector	19.8	23.3	34.2	41.5	45.8	32.1	47.4	70.4	102.9
Business sector, mainland	0.4	0.9	1.2	2.0	3.0	3.2	4.1	5.0	7.2
Housing	0.0	0.0	0.1	0.5	1.5	3.3	6.1	9.1	12.3
Public sector	0.1	0.4	1.3	1.4	1.5	1.9	2.9	3.4	3.3
Export	2.0	4.5	7.1	9.8	12.1	12.2	12.6	15.3	17.5
Mainland export	0.0	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0
Import	1.0	2.4	3.0	4.0	5.4	4.9	5.8	7.6	9.7
GDP	1.5	2.5	4.0	5.4	6.5	6.3	7.2	9.1	11.1
Mainland GDP	1.0	1.3	2.1	2.8	3.3	2.9	3.7	5.0	6.5
Value added manufacturing	0.6	2.0	2.9	5.2	6.4	4.0	7.0	11.2	12.4
Employment	0.4	0.7	1.3	1.8	2.2	2.1	2.6	3.5	4.4
Work force	0.1	0.3	0.7	1.2	1.5	1.5	1.7	2.4	3.0
Rate of unempl., percentage points	-0.3	-0.3	-0.6	-0.7	-0.8	-0.6	-0.9	-1.2	-1.5
Population, 1000 persons	0.0	0.0	0.1	0.3	0.4	0.5	0.7	0.9	1.2
Gross immigration, 1000 persons	0.5	1.3	5.2	6.5	7.1	8.5	12.6	13.8	14.6
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wage rate (nominal)	0.3	0.6	1.2	1.9	2.6	2.9	3.5	4.4	5.5
Wage rate, manufacturing	0.3	0.6	1.2	1.8	2.0	2.0	2.5	3.4	4.3
CPI	0.0	0.1	0.1	0.2	0.3	0.5	0.8	1.0	1.4
Import weighted krone	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.5
Money market rate, percentage points	0.00	0.02	0.03	0.05	0.07	0.09	0.11	0.13	0.17

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