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Duch Disease after all?

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THE LONG NORWEGIAN BOOM:
DUTCH DISEASE AFTER ALL?

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ABSTRACT

The Norwegian non-oil economy has benefitted greatly from the presence of the oil sector. Compared to neighboring and otherwise similar Sweden, Norwegian non-oil (“mainland”) firms on average receive significantly higher product prices and pay higher wages. This development can be explained by a model where oil companies drive up the prices of domestic suppliers as they consider foreign suppliers imperfect and inferior substitutes. Although productivity also improved, the resulting increased prosperity is mainly the result of higher prices and wages. Despite a tax system designed to channel the entire resource rent into the sovereign wealth fund, more than half of the resource rent may have leaked to the private, non-oil economy because of the mechanisms studied here. Because the bonanza must end with the oil industry, important productivity gains have not saved Norway from the Dutch disease.

1. Introduction

Discoveries of oil and gas have invariably implied considerable consequences for the surrounding economy. The boom-bust experience in Northwestern Pennsylvania after the first oil discovery there in 1859 has been well documented by, for example, Yergin (2009). Many other similar episodes followed, like the discovery of the Black Giant in East Texas in 1930, when the combination of the new supply and the depression-driven drop in demand drove prices almost to zero.

Fundamentally, new discoveries of natural resources should be positive economic events because they represent opportunities to harvest the corresponding resource rent. The empirical estimates of Sala-i-Martín et al (2004) and Brunnschweiler and Bulte (2008) are consistent with this view. However, the boom-bust experiences just mentioned suggested that the full story may be more complex. This is particularly the case for developing economies, where the ”resource curse” has been coined as a concept to describe the various possible negative effects (Sachs and Warner, 2001; Frankel, 2012; Ross, 1999, 2015; Robinson, Torvik, and Verdier, 2006; Mehlum, Moene, and Torvik, 2006; and many others) These damaging effects may occur because the resource wealth allows or encourages bad policy choices; because of resulting rent seeking, corruption, and armed conflicts (Andvig and Moene, 1990; Collier and Hoeffler, 2004; and Fearon, 2005); or because resource activities crowd out learning by doing in other traded-good industries (Rodrik and Rodíguez, 2001; and Torvik, 2002). Negative effects have also been found in some cross-sectional studies of U.S. states and counties (Papyrakis and Gerlagh, 2007, and James and Aadland, 2011)

For developed countries, the concern has centered around the Dutch disease, so named after the experience following the discovery of the Groningen gas field in the Netherlands in 1959. In the boom that followed, non-traded industries expanded and manufacturing contracted. Then, as production declined, the rebuilding of manufacturing was hampered by a “hangover” problem consisting of a combination of high wages (or a real-appreciated currency) and lagging productivity in a labor force that had not maintained its manufacturing expertise. This experience has been thoroughly analyzed by a number of authors, such as Corden and Neary (1982), Corden (1984), van Wijnbergen (1984), Krugman (1987) and Sachs and Warner (1995).

In this perspective, the Norwegian experience has stood out as somewhat of an exception. Manufacturing has not disappeared, but to a large extent been converted to a supplier industry for the oil companies. Productivity has improved rather than stagnated, as documented by Bjørnland, Thorsrud, and Torvik (2019). Two major policy instruments have been implemented to prevent Dutch disease. On is the establishment of the sovereign wealth fund, the Government Pension Fund Global; the other is the tax system for oil companies operating on the continental shelf. This system is designed to soak up the entire resource rent, at least in an approximate sense, transfer all of it to the fund, and then allow only the normal real financial return on the fund to be spent as part of the regular annual budget.[1]

[1] The principles for managing and drawing on the fund are the subjects of an ongoing political debate. Some of the relevant issues are discussed in Lindset and Mork (2019) and Mork, Eap, and Haraldsen (2020).

If this policy scheme had worked as intended, none of the resource rent should go to the private sector. Thus, there should be no oil bonanza except possibly as a result of productivity improvements. Yet, since the turn of the century, the non-oil ("mainland") economy has experienced a veritable boom, now perhaps brought to an end by the Covid-19 pandemic and its devastating effects on oil prices.

Although productivity did improve, this growth no more than matched the one in neighboring Sweden during the same period. In fact, the Norwegian experience during this period stands out spectacularly in comparison with its Nordic neighbors. That creates a suspicion that important parts of the resource rents may have leaked out to the private sector despite the policies intended to prevent that from happening.

This paper seeks to explain these facts as results of a scarcity of domestic resources. The driving force in this story is the demand for supplies and services by oil companies operating in Norwegian watersf. In particular, it has been driven by oil-company home bias in that they have displayed a strong preference for buying supplies and services, including field installations and other major investment goods, from domestic suppliers, in Norwegian nomenclature referred to as the *Mainland* economy.

The effects are similar to the Belassa-Samuelson effect[2] in that wages are driven up by an increased demand for domestic labor. However, whereas that effect results from the movement of labor resources from low-productivity to high-productivity sectors, this paper is about the movement from lowly-paid to highly-paid sectors. Where the Balassa-Samuelson story focuses on physical marginal products, this paper looks at value marginal products.

In the very early period, this bias may have been the result of protectionist policies. However, the lifting of these policies in the mid-1980s did not seem to make any difference. A perhaps more important early factor was the high level of maritime expertise in the domestic work force from a history of fisheries and merchant shipping. This came in especially handy as the North Sea presented challenges for offshore oil activity that were both different from and greater than the ones encountered previously in places like Lake Maricaibo in Venezuela and the Gulf of Mexico in the United States. Quality elementary and secondary education contributed to the high general level of work-force competence, typical of a Nordic country. Universities and research institutes followed up with specialized higher education as well as research and development of oil and gas technology adapted to the Northern waters. Productivity improved steadily as workers learned on the job, as documented by Bjørnland et al. (op. cit).

Major international oil service and oil supply companies certainly have contributed as well. However, as a rule, they have operated via Norwegian subsidiaries or branches, using mainly Norwegian employees. Despite the generally high English proficiency among Norwegian workers, speaking the same language may have been important, literally speaking, but also in an extended sense of sharing a common culture. The many quirks of the Scandinavian welfare state must have been an important part of that culture, including strict labor laws

[2] Balassa (1964), Samuelson (1964)

and union rights as well as the process of government approval for a wide range of business decisions.

The most visible part of oil companies' demands come with the production of field installations and equipment. The effects have become much wider via the demands by suppliers and service providers to their subcontractors, and so on in multiple steps. Furthermore, oil companies are major byers of financial, legal, and ICT services as well as hotel services, catering, and health services. Based on input-output analysis, researchers at Statistics Norway (Eika et al, 2010a, 2010b) have estimated that close to one half of the mainland economy is affected this way. Bjørnland and Thursrud (2016) concluded, on the basis of a Bayesian dynamic factor model analysis, that 70% or more of the variation in Norwegian mainland GDP growth can be traced back to impulses originating in the petroleum sector. Even sectors with no input-output link to the oil industry have been affected indirectly because they compete about the same talent pool.

As this demand surge has been directed at the limited pool of domestic labor, management and other expertise, it has resulted in an extraordinary increase in output prices as well as wages. Consumer prices have been driven up as well by the wage increases; but by much less than the movement on output prices and wages. It should thus be clear that the private sector has experienced a real surge of prosperity. Because the ultimate cause is the extraction of a non-renewable resource, this newfound prosperity should reasonably be classified as resource rent. Quantitively, it is comparable in magnitude to that part of the rent that the government receives in the form of oil-company taxes and the return on the government's direct financial participation in oil fields. Thus, about half of the resource rent may have leaked out to the private sector in this period.

The generous earnings enjoyed by the owners and employees in most of the private sector do not seem to have resulted from frictions, but of competitive equilibrium in well-functioning markets. However, frictions may well arise once the resource boom ends. Wages may be less downward than upward flexible. Real depreciation will probably need to happen. Despite the long-lasting success of the Norwegian oil experience, the challenges of the Dutch disease may eventually materialize after all.

Current estimates do not indicate an early end to Norwegian oil and gas production under current policies. However, the oil-market collapse following the Covid-19 pandemic in 2020 may serve as a reminder of the uncertainty of such estimates. Going forward, global oil demand may remain low or decline if climate policies are sharpened as intended under the Paris accord. Inside Norway, political demands are rising from several quarters for a permanent phasing out of fossil fuel extraction. A team of distinguished economists have called for a unilateral halt[3] in domestic extraction and even for an international agreement with other oil and gas producing countries to do the same[4].

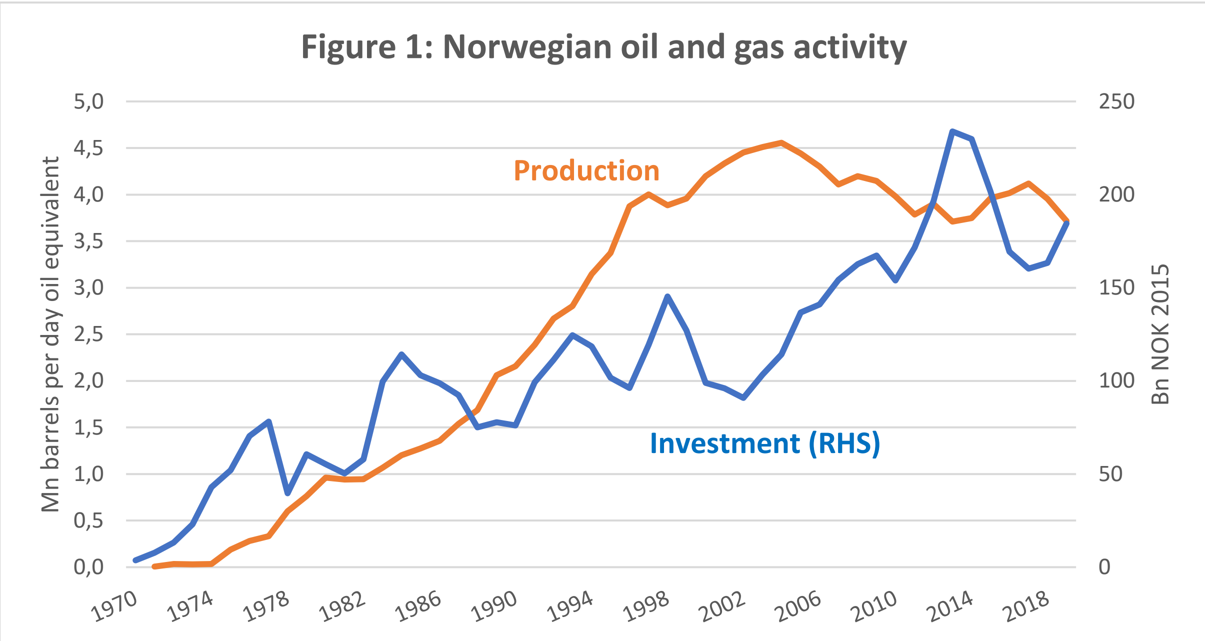
In any event, the growth face of Norwegian oil and gas activities seems likely to be over. Oil production peaked already in 2001. Increasing gas production has made up for part of the ensuing decline; but total hydrocarbon production also peaked in 2004. Although the laws of

[3] Fæhn et al (2017).
[4] Asheim et al (2019).

diminishing returns produced a growth spurt for oil and gas investment activity after production had peaked, that period also seems over. Even if markets normalize after the Covid-19 pandemic, significant challenges may lie ahead.

The rest of this paper is organized as follows. Section 2 presents the evidence of the superior profitability of the Norwegian non-oil economy since 2000 compared to its Nordic neighbors. Section 3 outlines a model that is consistent with this evidence. Section 4 analyzes the model and confronts it with the data. Section 5 discusses the implications, and Section 6 concludes.

2. Evidence



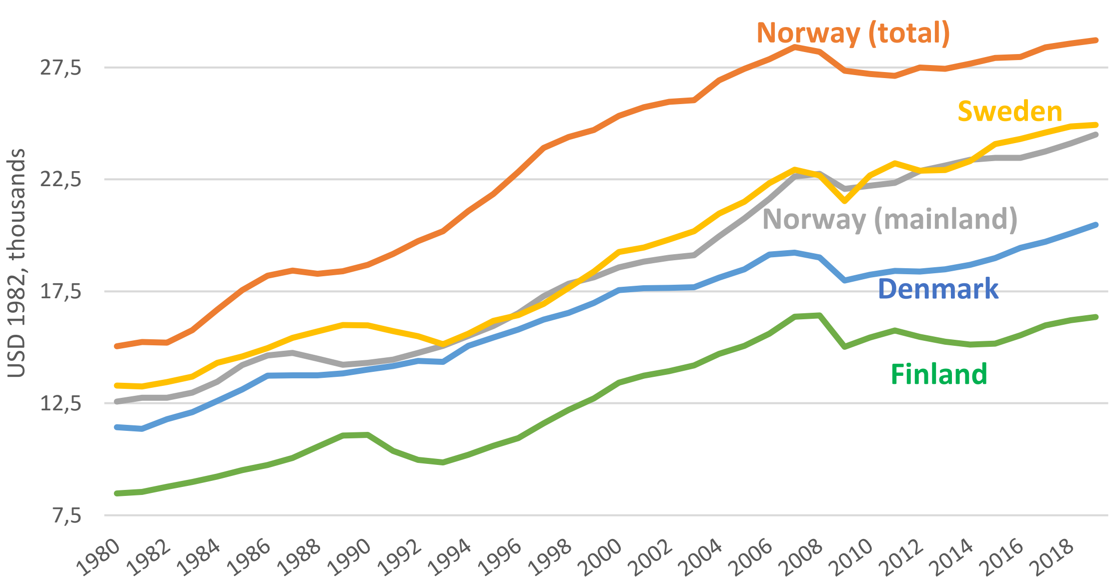
Although the first Norwegian oil discovery was made already in 1969, it took at least two decades for the industry to develop fully. As Figure 1 shows, production reached 2 million barrels per day of oil equivalents in 1990 and accelerated rapidly through the 1990s until it peaked in 2005. Interestingly, oil and gas *investment* activity accelerated dramatically just as production was about to peak. As will be explained in the next section, this time lag can essentially be explained from the law of diminishing returns: Once the low-hanging fruits have been picked, getting to the more marginal deposits requires a lot more effort.

As mentioned in the introduction, Norwegian national accounts distinguish between the mainland and the offshore economy. Because all oil and gas extraction is done from offshore deposits, offshore GDP is essentially limited to the value added created by the oil companies themselves[5]. However, supplies and services that the oil companies buy from domestic providers are classified as produced by the mainland economy. These supplies and deliveries include the production of investment goods such as oil field installations and equipment as well as installation services. This means that the value added created by the oil and gas *investment* activity is to be found in mainland GDP almost entirely.

[5] Plus a much smaller contribution from ocean transport services.

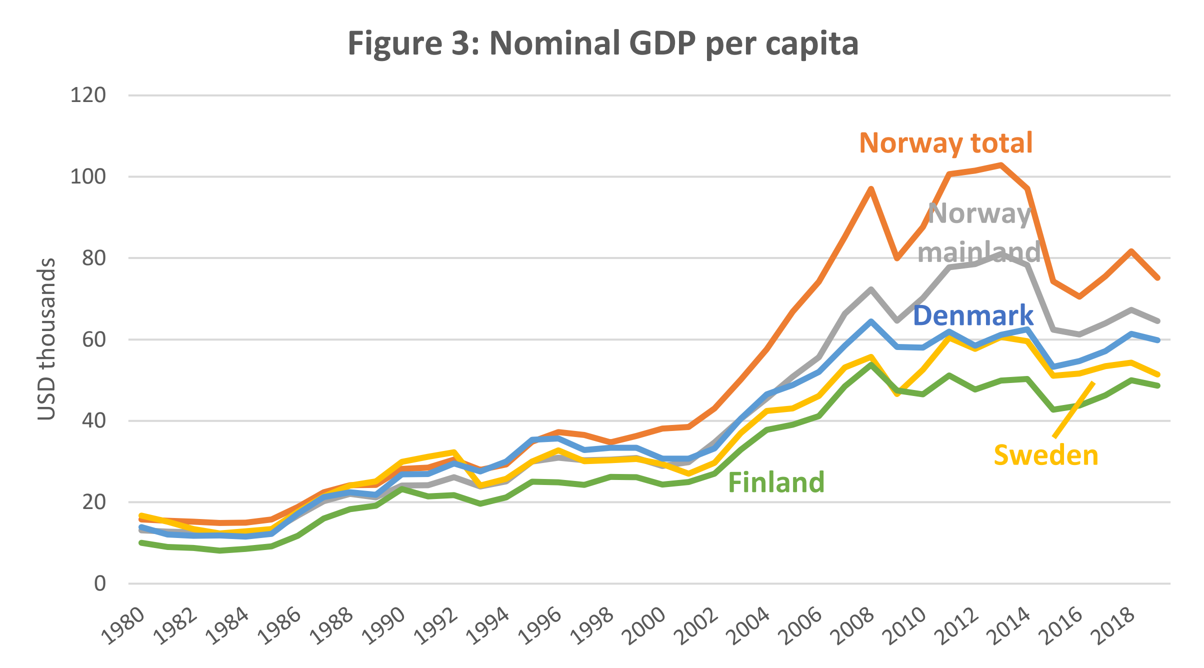
On this background, one might expect to find an extraordinary boost to real mainland GDP growth after the turn of the century. However, such a bump is hard to find in Figure 2, which shows real GDP per capita for Norway—mainland as well as total—along with its three Nordic neighbors. The substantial difference between total and mainland GDP reflects the value added of oil and gas extraction in the narrow sense, i.e. oil companies' value creation, which includes the resource rent. It varies with the oil and gas extraction volume, as expected.

Figure 2: Real GDP per capita[a]



[a]The data for Finland before 1999 are uncertain because of the country's change of currency. They are included here and in Figure 3 for illustration only.

Considering that the oil and gas investment activity is included in mainland GDP, it seems more surprising that this quantity has developed almost completely in line with that of Sweden. On further thought, however, this was actually to be expected considering that both the Swedish and the Norwegian economy have enjoyed more or less full employment since the mid-1990s, except for the global financial crisis; and even the effects that crisis were mild in these countries. With full employment, expanded activity in one sector is accommodated by reduced activity elsewhere rather than causing a boost to overall activity. Counted at fixed prices, there is then no change in overall production other than from productivity growth, which has developed more and less in tandem in the two countries, as shown below. However, relative prices are likely to have changed. In particular, demand pressure from the oil companies may have enabled companies in mainland Norway to get better paid for their products than their Nordic neighbors. To get a picture of that, we need to look at current-price GDP, which we do next.



The contrast with Figure 2 is striking. Mainland (as well as total) Norway saw a big bump following the turn of the century over and above that seen by the neighboring countries. Because prices are the only difference between the data in Figures 2 and 3, this picture must have been driven by differences in output price developments. The hypothesis is that these differences were mainly driven by oil company input demand.

The difference seems clearest when we compare mainland Norway with Sweden. The comparison with Sweden is particularly useful because the two countries are so similar in almost all other ways than oil and gas. In fact, I will argue that the similarity is close enough that the development of the Swedish economy since the turn of the century can serve as a counterfactual base for developments in Norway. Needless to say, both countries are politically stable and have highly developed economies with typical Scandinavian welfare states[6]. Geographically, they share the Scandinavian peninsula. Historically, they have been politically intertwined, at one point both under Danish rule, at others, the Norwegian king ruled parts of present-day Sweden; and from 1814 to 1905 the two countries were joined in a union under a common king. Cultural similarity has been greatly facilitated by the fact that the languages are mutually understandable. Although Norway, unlike Sweden, is not a member of the European Union, the country participates fully in the EU internal market (except for agriculture and fisheries) via the European Economic Area (EEA) agreement. Both countries furthermore have national currencies with floating exchange rates and inflation-targeting monetary policy.

Comparisons with Finland and Denmark would have been complicated by the special factors in those countries. Finland is part of the euro area and has suffered important shocks of its own related to the collapse of the Soviet Union and the disappearance of Nokia. The change in currency from the markka to the euro in 1990 makes data comparisons tenuous. Denmark has its own currency, but with a special arrangement with the ECB that ties the Danish krone

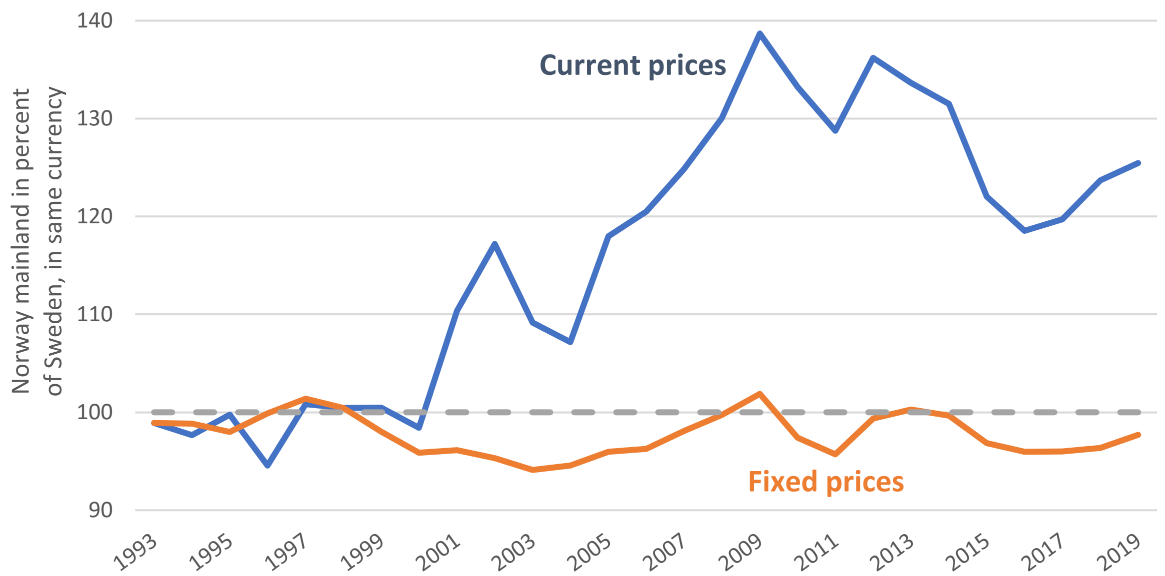
[6] Barth, Moene, and Willumsen (2014)

tightly to the euro. More importantly, Denmark has its own oil and gas industry, which, albeit smaller than the Norwegian one, tends to disqualify it as a counterfactual. The importance of agriculture in the Danish economy further makes for unequal comparison. No such special factors appear to have driven the Swedish economy since the mid-1990s, however[7].

Mideksa (2013) constructs an alternative counterfactual in his study of the effect of oil on Norwegian (total) real GDP. His alternative is to construct a synthetic control using the methods of Abadie and Gardeazabal (2003) and Abadie et al (2012), which lets the data pick the countries that in some specified ways behaved the most similarly to the country studied before the treatment, in Mideksa's case the discovery of oil deposits. Although the idea of letting the data speak for themselves is appealing, this method also depends on subjective choices regarding the choice of candidate control countries as well as the similarity criteria. At the same time, the choices made by the data leaves a certain impression of having been made inside a black box, which seems apparent in Mideksa's results. In contrast, the simple choice of next-door Sweden seems like a more transparent alternative with rather obvious justification. I have therefore chosen to study the differences in performance between Norway and Sweden during the 2000s and 2010s as the results of a natural experiment.

Figure 4 displays mainland Norway's GDP per capita as a percent of Sweden's, in current as well as fixed prices. Both countries' data are expressed in the same currency, converted at market exchange rates. This graph starts a decade later than Figures 2 and 3 so as not to be disturbed by the financial boom-bust period of the 1980s, which hit both countries, but with a somewhat different timing. The pattern in Figures 2 and 3 is reproduced, but Figure 4 gives a clearer picture of the dramatic difference.

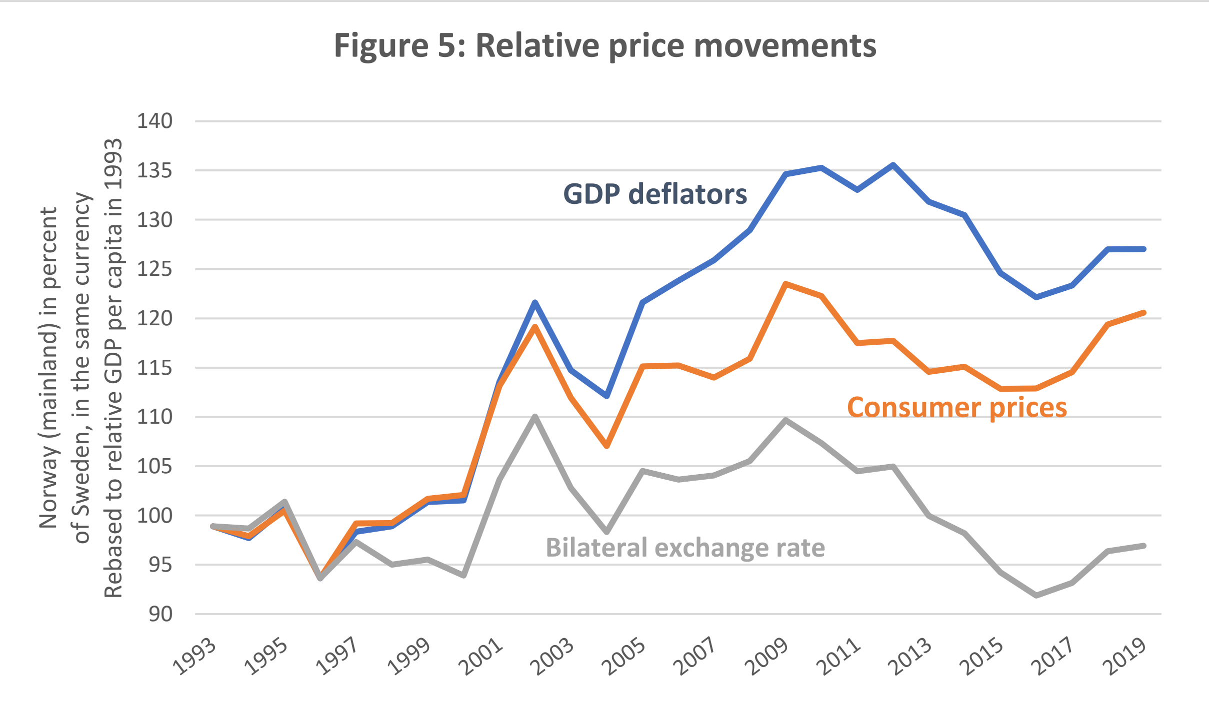
Figure 4: Relative GDP per capita



[7] Assar Lindbeck (1997) dates the «collapse» of the Swedish model to the early 1990s. This may have affected the Norwegian relative catch-up during the early 1990s, but not the spectacular Norwegian performance in the two decades following the turn of the century.

Whereas fixed-price GDP per capita is essentially the same for both countries for the entire period, Norway pulled dramatically ahead in terms of current-price GDP per capita after the turn of the century, reaching a peak of 38% percent above Sweden in 2009 before pulling back partially during the 2010s. Even so, Norwegian mainland GDP per capita remained 25% above Sweden's in 2019.

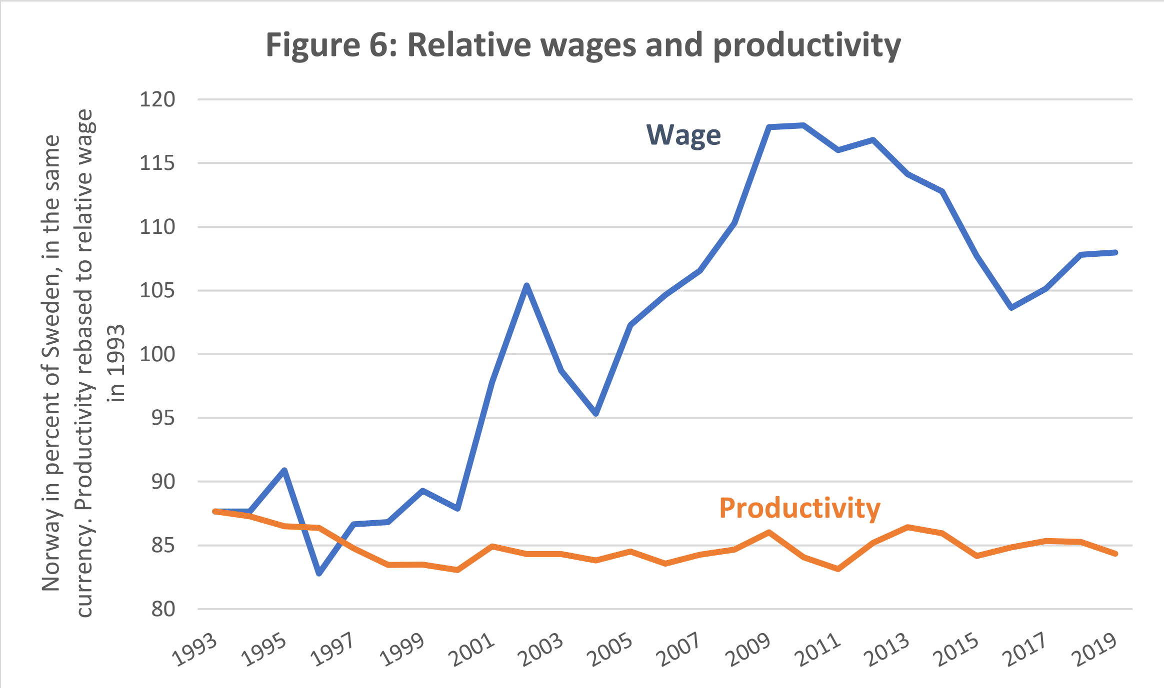
In terms of the mechanics of national accounting, this means that the deflator for Norwegian mainland GDP greatly surpassed the one for Sweden after conversion to the same currency. Naturally, this could just be a case of differing overall inflation. That could occur even with both countries being inflation targeters[8] because, in the presence of non-traded goods, exchange-rate movements could have made the relative consumer price indices diverge when expressed in the same currency. That complication could perhaps have been avoided by making currency conversions with purchasing-power adjusted exchange rates. It seems clearer cut, however, to present the relative movements of the GDP deflators, the consumer price indices, and the bilateral market exchange rate in the same diagram, which is done in Figure 5. All series have been anchored at the level of the relative current-price per capita GDP in 1993.



As can be seen in this graph, the relative CPI did indeed rise soon after the turn of the century, mainly in parallel with a strengthening of the Norwegian krone relative to the Swedish krona. However, this movement leveled out with a relative difference between 15% and 20% in the first half of the 2000s whereas the relative GDP deflator continued to rise until it peaked at 36% in 2012. Thus, the diverging path of the GDP deflators is not simply a result of differing overall inflation. In fact, we can conclude that higher product prices have made Norwegians on average richer compared to their Swedish neighbors during this period.

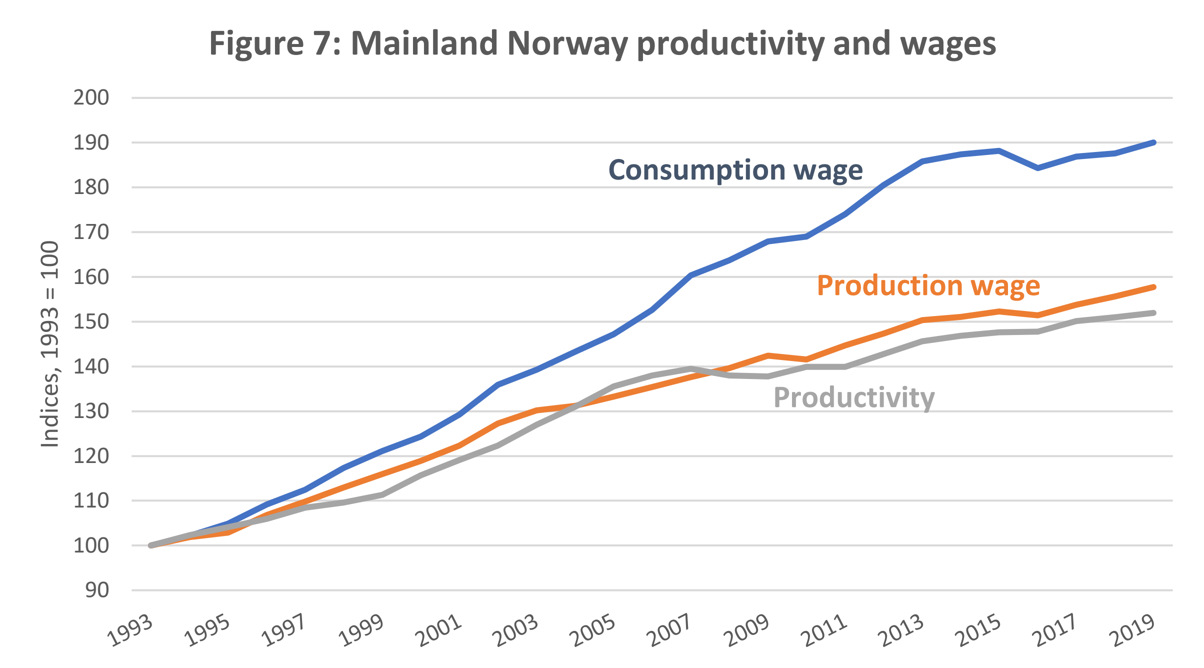
[8] Formally, Norway's inflation target was 2.5% between 2001 and 2018, whereas Sweden's was 2%. That does not seem to have made much of a difference in practice for the two central banks, however.

This prosperity has "trickled down" from companies to their workers. Figure 6 shows the relative developments in wages (per hour worked) and labor productivity (measured as real value added per person hour) between mainland Norway and Sweden. It repeats the pattern from Figure 4 by describing the relative productivity as roughly constant. However, Norwegian wages have completely outgrown Swedish wages. It is worth noting that this graph starts with Norwegian wage being only 88% of their Swedish counterparts in 1993. Thus, the rise in the relative wage to 110% in 2009 –10 completely outgrows the corresponding rise in relative consumer prices.



Standard microeconomic theory predicts that the production wage, defined as the nominal wage deflated by the product price, follow productivity in equilibrium. That would nevertheless allow the consumption wage, defined as the nominal wage deflated by the CPI, to rise faster than productivity if the output price rises faster than the CPI. In Figure 7, where the Norwegian production wage is defined as the average mainland compensation per hour deflated by the GDP deflator, shows that this is exactly what happened in this period. Real wages, as seen by workers (namely, the consumption wage), grew at an average annual rate of 4% from 1993 to 2019. Productivity growth was healthy as well at an also-healthy 2.7% per year, which is consistent with the findings of Bjørnland, Thorsrud, and Torvik (op. cit.). However, productivity alone can only explain two thirds of the wage growth.

To the extent that this long Norwegian boom has been driven by the presence of the oil and gas industry and is not a result of exceptionally high productivity growth, it can be viewed as part of the resource rent. The excess of Norwegian mainland GDP over Sweden's in current prices, converted to the same currency, can serve as a rough estimate for the magnitude of this rent that flowed to the mainland economy during the 2000s and 2010s. Converted to 2019 prices by means of the Consumer Price Index, the average annual value between 2000 and 2019 was NOK 90,411 or USD 9,378 per capita.



This was not the intended consequence of the Norwegian tax system for the oil sector. Rather, the intention was for the government to capture the entire resource rent. The 78% marginal tax rate on oil company earnings was designed with that purpose in mind. However, the payments received by oil company suppliers and service providers are an important part of the costs that oil companies can deduct from their taxable earnings. This way, the government implicitly has subsidized the transfer of parts of the resource rent to the non-oil sector.

The government nevertheless has received comfortable amounts of revenue from the oil sector, in the form of oil-company taxes, net revenues from the government's direct financial investments in oil and gas fields, and as dividends from Equinor (formerly Statoil). These revenues are all deposited into the Government Pension Fund Global, and their magnitudes are in the public domain. Converted to 2019 prices, these revenues for 2000–2019 amounted to NOK 66,906 or USD 7,603 per capita.

My estimate for the private-sector resource rent is undoubtedly crude. I nevertheless suspect that the order of magnitude is not completely off the board. It suggests that the private, non-oil sector has managed to appropriate more than half of the total resource rent. The next section presents a model aiming to explain this result.

3. A Stylized Model of the Non-oil Economy

The model has three parts. The first part is a specification of oil-company behavior by which production may peak before investments. The second part explains the extreme home bias. The third part is a three-sector model of the mainland economy that can explain the effects of changes in oil-company input demand on the GDP deflator and consumer prices.

3.1. Oil Company Behavior

Oil companies make decisions on the extensive as well as the intensive margin. On the extensive margin, they consider projects or fields, whether to take them on or not. The potential projects may be presented by government authorities one or a group at a time, as they are in Norway. Geological and technological factors, as well as management capacity, may also favor a strategy of one field at a time. Once a field has been decided upon, the company will seek to exploit it as much as possible.

Mathematically, we then specify oil company period profits as

$$\pi = (1 - \tau)(P_O O - P_S S), \qquad (1)$$

where the period is a decade or two, P_O the price of oil, O the quantity produced, S an aggregate of inputs to oil company production, including, but not limited to investment goods, and P_S its aggregate price. In practical terms, S can be referred to as oil company supplies and services. τ is the corporate tax rate for oil companies, in Norway as high as 78% to make up for the fact that oil companies pay nothing for their concessions.

Each field or group of fields is assumed to have a capacity limit $\bar{O}$, such that $O \leq \bar{O}$. The company will take the project if

$$\pi = (1 - \tau)[P_O \bar{O} - P_S f(\bar{O}, R)] > 0,$$

where R is resources in the ground and f the oil company production function, specified as

$$f(O, R) = \gamma_O(R)O,\ \gamma_0' > 0,$$

meaning that productivity is a decreasing function of depletion.

Given the extensive-margin decision, the decision on the intensive margin becomes trivial:

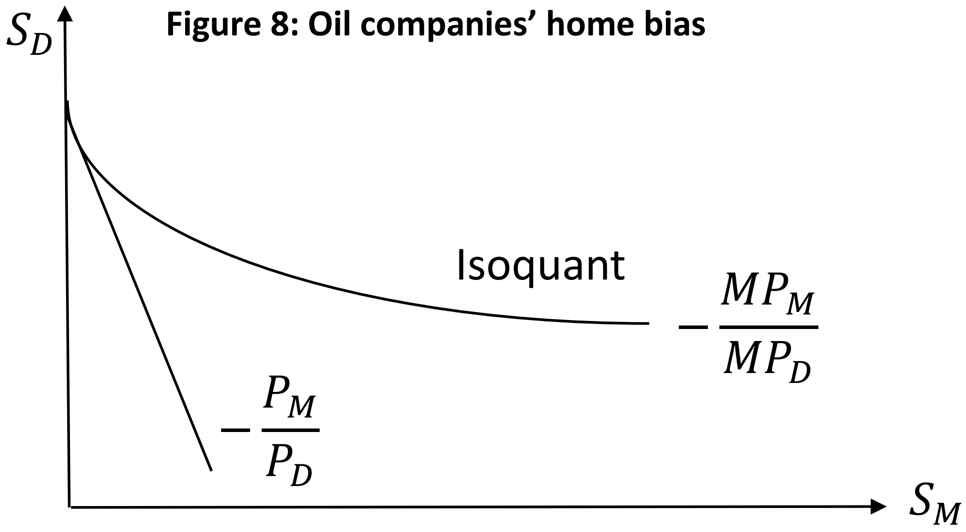
$$S = f(\bar{O}, R) = \gamma_O(R)\bar{O}. \qquad (2)$$

Thus, the demand for oil-company supplies and services becomes an increasing function of depletion. We also expect $\bar{O}$ to be a decreasing function of depletion. Thus, investment demand may well peak after production, which is consistent with the empirical pattern in Figure 1. Fundamentally, it is a consequence of the law of decreasing returns.

3.2. Home Bias

Globally, there is no shortage of suppliers of the many inputs that oil companies need. Several are huge, global corporations. In many oil-producing companies, these global actors dominate the oil companies' lists of suppliers. The Norwegian home bias stands out as an anomaly. Analytically, it can be illustrated by the graph in Figure 8, which illustrates oil companies' choice between domestic (S_D) and imported (S_M) supplies and services. The extreme bias is illustrated by the fact that the isoquant and the relative-price line meet only at the vertical axis, where the demand for imported inputs is zero. Foreign outputs are an imperfect and inferior substitute that need to be much cheaper to be preferred.

Figure 8: Oil companies' home bias



The interesting question is what has caused this extreme preference for domestic products in the case of oil companies operating on the Norwegian shelf. In the early years after the 1969 discovery, oil companies were required to buy domestic whenever possible; however, these regulations were relaxed in the 1980s along with the more general deregulation efforts of that decade. However, this relaxation did not seem to induce any change in oil company behavior. A possible explanation for that might be that the early restrictions were a successful case of baby industry protection, allowing domestic suppliers to learn the ropes before being exposed to foreign competition.

If so, we would have to ask why this policy, which has failed so many other places, happened to succeed in this particular case. That brings us to the many other features that has made the Norwegian case stand out among most other small-country petroleum industries. First of all, the Norwegian economy was highly developed long before oil was discovered. General industrial know-how was thus amply present. An excellent school system, colleges, and universities were ready to prepare new generations to fill demanding jobs. A stable democracy provided well-functioning institutions for predictable and fair government regulations as well as conflict resolution.

More specifically, from fisheries and overseas shipping, Norway already had a workforce with extensive expertise in maritime operations, which were essential for operating offshore oil and gas installations. As is well known, all Norwegian oil and gas fields are offshore. Moreover, experience from offshore exploration elsewhere, such as the Gulf of Mexico, were of limited use in the harsh winds, waves, and temperatures of the North Sea and, by extension, in the Norwegian and Arctic Seas further north. Fortuitously for the oil industry, failing herring catches made workers eager to try new ventures.

After this beginning, the advantages of the domestic operators piled on themselves as geologists and engineers gained experience and workers learned by doing. Significantly, new technologies, tailored to the local needs, were developed in cooperation between the companies and first-rate academic institutions.

English proficiency is generally very good and was good already in the early 1970s, which made communication easy with foreign oil companies such as Phillips Petroleum (now part of ConocoPhillips), which discovered and developed Ekofisk as the first, major oil field, which is still very much in operation. However, as the foreign oil companies recruited Norwegian employees, communication could also very much be conducted in the local language. With time, that may indeed have become one of the major advantages of local suppliers.

The ability to communicate with locals is furthermore about more than language in the narrow sense. In communication with people with similar backgrounds it is easier to trust that specific formulations and actions have shared meanings. Although the legal profession undoubtably has had plenty to do in assisting Norwegian oil firms, common frames of reference are likely to have made agreement easier to reach and conflicts easier to avoid.

Although geographic proximity would have been similar in other countries where oil companies made different choices, it naturally became an additional advantage once the pattern had been established. Physical meetings, clarifying phone queries, etc. all are easier when distances are shorter.

3.3. The market for domestic resources.
This subsector models the non-oil (mainland) economy as three sectors:

- Oil and gas supply and service, with output S and input L_S,
- Non-traded goods and services, with output N and input L_N, and
- Traded goods, with output X and input $L_x = L - L_S - L_N$, L fixed.

The inputs can be interpreted as combinations of labor and capital, henceforth referred to simply as labor. Because the model is for the intermediate term, lasting one or two decades, each period should allow sufficient time for labor and capital to move freely across sectors and for investment to adjust to current conditions. Each sector has a simple Cobb-Douglas technology:

$$S = \gamma_S L_S^{1-\varepsilon} \tag{3a}$$

$$N = \gamma_N L_N^{1-\eta} \tag{3b}$$

$$X = \gamma_X L_X^{1-\delta} \tag{3c}$$

The productivity factors γ_S, γ_N, and γ_X are all assumed constant because of the observed similar performance with Sweden as the chosen counterfactual case. Scarcity of management resources in the supply and service sector makes the technology of this sector more convex than that of the other two:

$$1 > \varepsilon > \eta \approx \delta > 0. \quad (4)$$

The traded good X serves as numéraire. The prices of the two other goods are P_S and P_N, respectively. w is the common wage rate.

Labor market equilibrium is characterized by the equality between the wage rate and the value marginal product in each of the three sectors:

$$P_S(1-\varepsilon)\gamma_S^{1/(1-\varepsilon)}S^{-\varepsilon/(1-\varepsilon)} = w \quad (5a)$$

$$P_N(1-\eta)\gamma_N^{1/(1-\eta)}N^{-\eta/(1-\eta)} = w \quad (5b)$$

$$(1-\delta)\gamma_X^{1/(1-\delta)}X^{-\delta/(1-\delta)} = w \quad (5c)$$

In the literature, it is common to close this kind of model by imposing external balance, which essentially means balanced trade. This does not seem like an adequate specification of the Norwegian case during this period, however, as the country consistently ran huge current-account surpluses, matched by the accumulation of the sovereign wealth fund, the Government Pension Global, from nothing in 1995 to about USD 100 billion in 2019.

This accumulation nevertheless contributed significantly to domestic demand as a result of the Fiscal Rule passed by Parliament in 2001, which allowed the government to spend annually an amount corresponding to the expected real return on the fund's investments. This motivates modeling the demand for non-traded goods as the product of a private and a public part, where the private part is proportional to private-sector income:

$$P_N N = k(P_S S + P_N N + X)S^g. \quad (5d)$$

Here, k is some constant, and the factor S^g represents government spending financed by the fund. The reason for this particular formulation will be clear shortly.

4. Analysis

We now use this model to analyze the effects of a change in oil-company input demands. We start by deriving the overall effects. Then, we consider a breakdown between a spending effect and a resource-movement effect before we confront the model with the data.

4.1 Overall effects

We use equations (5a) – (5d) to derive the comparative-static effects of a change in oil-company input demand. Letting $\hat{Z}$ denote the log derivative of a variable Z denote its log-derivative with respect to S, total log differentiation of (5a) – (5d), making use of (3a) – (3c), then readily yields:

$$\hat{P}_S - \frac{\varepsilon}{1-\varepsilon} = \hat{w},$$

$$\hat{P}_N - \frac{\eta}{1-\eta}\hat{N} = \widehat{w,}$$

$$-\frac{\delta}{1-\delta}\hat{X} = \widehat{w},$$

and

$$(1-\beta)\left(\hat{P}_N + \widehat{N}\right) = \alpha\left(\hat{P}_S + 1\right) + (1-\alpha-\beta)\hat{X} + g,$$

where

$$\alpha = \frac{P_S S}{P_S S + X + P_N N}$$

and

$$\beta = \frac{P_N N}{P_S S + X + P_N N},$$

not necessarily constant.

Using the labor-market equilibrium conditions together with the labor constraint, we find

$$\hat{X} = -\left(\frac{1}{1-\alpha-\beta}\right)\left(\alpha + \beta\widehat{N}\right).$$

Thus, our system of comparative-static equations can be written on compact form as

$$\hat{P}_S - \frac{\varepsilon}{1-\varepsilon} = \widehat{w} \tag{6a}$$

$$\hat{P}_N - \frac{\eta}{1-\eta}\widehat{N} = \widehat{w} \tag{6b}$$

$$\delta\left(\alpha + \beta\widehat{N}\right) = (1-\delta)(1-\alpha-\beta)\widehat{w} \tag{6c}$$

$$(1-\beta)\hat{P}_N + \widehat{N} = \alpha\hat{P}_S + g \tag{6d}$$

The solution is presented in the Appendix. It shows that, as long as all sectors have decreasing returns ($\varepsilon, \eta, \delta > 0$), $\widehat{w}$ and $\hat{P}_S$ are unambiguously positive. The assumption that the returns to scale decrease faster for oil supply and service than for traded goods ($\varepsilon > \delta$), is a sufficient, but not necessary condition for $\hat{P}_N$ and $\widehat{N}$ to be positive and $\hat{X}$ to be negative.

We note, in particular, that the GDP deflator increases:

$$\hat{P}_Y \equiv \alpha\hat{P}_S + \beta\hat{P}_N > 0, \tag{7a}$$

independently of the relative size of ε and δ. However, because of the aggregate labor constraint, fixed-price GDP does not change:

$$\hat{Y} = \alpha + \beta\hat{N} + (1 - \alpha - \beta)\hat{X} = \alpha + \beta\hat{N} - \left(\alpha + \beta\hat{N}\right) = 0. \tag{7b}$$

Thus, aggregate income, that is, current-price GDP, increases:

$$\widehat{P_Y Y} = \hat{P}_Y + \hat{Y} = \hat{P}_Y > 0. \tag{7c}$$

For this increase to represent a real improvement in prosperity, the income change must exceed the increase in the cost of living. For this purpose, we define the consumer price index relative to the price of traded goods, as

$$P_C = P_N^a \cdot 1^{1-a} = P_N^a,$$

So that

$$\hat{P}_C = a\hat{P}_N > 0 \tag{7d}$$

This increase could conceivably be greater than the one for the GDP deflator. However, that turned out not to be the case for any realistic parameter values, meaning that the increase in oil-company input demand translates into a real improvement in the standard of living.

3.2 Spending vs. resource movement

Important contributors to the literature on Dutch disease like Corden and Neary (1982) and Corden (1984) have distinguished between a spending effect and a resource-movement effect as drivers of the decline in traded industries in the wake of natural-resource recoveries. The model in this paper obviously includes both. To isolate the resource-movement effect, we drop equation (6d) and replace it with the restriction that spending on non-traded goods remains unaffected by oil companies' demand for inputs:

$$\hat{P}_N + \hat{N} = 0 \tag{6d'}$$

The solution formulae are shown in the Appendix. Not surprisingly, they show that, in the absence of the spending effect, the production of both traded and non-traded goods decreases. Thus, we may conclude that the positive effects on these two variables that we found above are due to the spending effect. However, wages rise even in the absence of the spending effect, though less so. The same does the price of non-traded goods, so that the effect on the GDP deflator continues to be positive, although less than when the spending effect is included.

3.3. Calibration and Quantitative Results

A quantitative view of these effects can be seen from a calibrated version of the model. For this purpose, we need the value shares of the respective sectors in Norwegian mainland GDP. The national income accounts imply a traded-goods share of 15%, implying $1 - \alpha - \beta = 0.15$. The division between non-traded goods and oil-company supplies and services is much more nebulous. For one thing, the oil companies buy a wide range of legal, financial, ICT, and other services, which are usually classified as non-traded. For another, detailed studies of the input-output tables, such as the ones by Eika et al. (2010a, 2010b), reveal substantial indirect effects via subcontractor value chains. Based on their work, we fix the value of β at 0.45. That leaves $\alpha = 0.4$. For the traded-goods weight in the CPI, we assume $a = 0.6$ based on the weights used by Statistics Norway.

The parameter g ireflects the elasticity of government spending with respect to the change in oil-company demand for inputs. To estimate it, we start by computing the government's average annual draw from the sovereign wealth fund during 2000 –19. This number is obtained from the official government accounts as NOK 27,600 per capita in 2019 prices. Government spending increased a lot more than this after 2000. However, the remaining part of the increase was financed by taxes levied on the higher mainland incomes; thus, including them would imply double counting. For the years 1993 – 99, which is our basis for comparison, the average mainland GDP per capita, in current prices, but converted to 2019 prices by the CPI, was NOK 327.000. The increase in government spending per capita funded from the sovereign wealth fund is 100*27.6/327 = 8.4%. The percentage increase in annual (fixed-price) oil and gas investments from 1993 – 99 to 2000 – 19 was 31.6%. The implied elasticity is then 8.4/31.6 = 0.265, which we use as our estimate of the parameter g.

For the elasticities in the three production functions, we pick values that make the model roughly fit the data, specifically, $\delta = \eta = 0.17$ and $\varepsilon = 0.3$.

The elasticities with respect to oil companies' input demand are presented in the three first columns of Table 1. They suggest that about half of the total elasticity is due to the spending effect and the rest to the resource-movement effect for wages, traded-goods production, and the GDP deflator. For the price of oil-company inputs, we are not surprised to see that the split is closer to two thirds for resource movement and one third for the spending effect. For the price of non-traded goods (and thus for the CPI), the split is the opposite, which is also as expected.

The fourth column shows the results that would obtain without the public contribution to the demand for non-traded goods, in other words, with $g = 0$. The effect on non-traded output is then much weaker. The effect on its price is weaker as well, though less so because the wage effect is still substantial. The effect on the price of oil company inputs is almost as large, which is what we would expect. In total, the government seems to have contributed

Table 1 **Elasticities with respect to oil companies' demand for inputs S**

Variable	Model with spending effects	Model without spending effects	Share spending effects in model	Model without government spending	Data
$\hat{w}$	0.73	0.36	50%	0,59	0.70
$\hat{N}$	0.29	-0.30	--	0,07	--
$\hat{X}$	-3.54	-1.77	50%	-2,89	--
$\hat{P}_S$	1.15	0.79	32%	1,02	--
$\hat{P}_N$	0.79	0.25	68%	0,61	--
$\hat{P}_Y$	0.81	0.43	47%	0,68	0.83
$\hat{P}_C$	0.47	0.15	68%	0,36	0.52

significantly to the increase in the GDP deflator, but also to consumer prices, and almost to the same extent. Thus, although the increase in government spending has contributed to the aggregate public-private income in a real sense, its effect on real private income seems to have been minimal.

3.4. Data vs model

We have already found that fixed-price GDP per capita hardly changed at all during this period when we compare with Sweden as the counterfactual. The changes in the output levels of the respective sectors is somewhat uncertain because of the ambiguity about the sector definitions. That makes empirical measurements on the sector prices $\widehat{P}_S$ and $\widehat{P}_N$ uncertain as well. However, the elasticities for the wage, the GDP deflator, and the CPI can be estimated unambiguously from the data. For each of them, we consider its development since 1993 relative to its Swedish counterpart and compute the relative change from the 1993 – 99 average to the 2000 – 19 average. To get elasticities, we then divide each of them by the corresponding change in oil and gas investments as a proxy for the total aggregate of oil company supplies and services. The results are listed in the rightmost column of Table 1.

The match with the data is remarkably close. The closeness of the fit should not be exaggerated because the observed increase in oil and gas investments is only a rough proxy for the actual output of the S-sector in the model, and because the elasticities of the respective production functions have been chosen so as to maximize the fit. Even so, the model seems able to reflect the main forces at work in the creation of the oil-driven wealth in the Norwegian private sector during the first two decades of this century.

5. Discussion

The model in this paper explains the rise in Norwegian incomes during the 2000s and 2010s as a result of market forces in competitive equilibrium, not of frictions or monopoly power. Concentration or price cooperation among supply and service providers is a possible alternative to the decreasing returns assumed in this paper; but the above analysis shows that such deviations from competitive behavior is not necessary to explain the observed data movements.

Likewise, the observed deviation of wage movements from productivity growth can be explained without considering deviations from competitive labor market equilibrium[9]. Business and political leaders' oft-repeated warnings of excessive wage growth hurting competitiveness seem to miss the point. Competitiveness in the traded-goods industry needed to be sacrificed to satisfy the rise in oil companies' demand for mainland resources.

The long Norwegian boom could thus be interpreted as a refutation of the Dutch disease. However, the equilibrium reached in the first two decades of this century cannot last. The oil and gas resources are finite and non-renewable, so the is doomed to end eventually. Indeed, rising costs due to gradual depletion may put an end to new developments long before the resources are depleted. If the low oil prices at the time of this writing persist, the end may

[9] There may have been examples of deviations from the competitive model, however. Dyrstad (2016) makes the case that joint intervention by the government and the Norwegian Federation of Trade Unions (LO) put a stop to excessive wage inflation in the early 1980s. In 1981, this intervention removed the right that drilling companies had had since 1974 to negotiate wages locally.

come sooner than later. Concerns for the global climate adds another layer of warning. Although the Norwegian government currently supports continued operations, I have elsewhere (Mork, 2020) expressed support for the proposals advanced by a group of economists (Fæhn et al, 2018; Asheim et al, 2019) to phase out the oil and gas industry in Norway and work for an international agreement among oil and gas producers to do the same.

Regardless of how the boom of the 2000s and 2010s will end, it will end eventually. To preserve equilibrium will full employment, that will require a reversal of the price and movements we now have observed. That reversal is likely to meet with much more resistance than the increases of the last two decades, especially from workers and their unions. Nominal wage cuts have proved hard to implement even in highly coordinated labor markets like the Scandinavian ones. Norway may be suffering from Dutch disease after all.

6. Summary and Conclusions

The improvement in Norwegian prosperity since the turn of the century has been remarkable. It is not apparent in the conventional real GDP figures because the improvement has come almost exclusively in terms of higher wages and product prices. However, as these increases have been significantly higher than the rise in consumer prices, they represent real improvement in real incomes.

The driving force is not difficult to find. It clearly seems to be the substantial rise in oil and gas investment activity that started around the turn of the century. Oil company demand for other goods and services followed in their wake. Interestingly, this surge came after the peak in oil and gas production. The reason is diminishing returns: Because low-hanging fruits tend to be picked first, later developments needed so much more resources to be implemented.

Norwegian companies and workers have furthermore been the fortunate beneficiaries of a rather extreme home bias among oil companies operating on the Norwegian shelf. This bias seems to be the result of a combination of an advanced economy and well-trained workforce in the beginning of the process, special proficiencies in maritime activities inherited from shipping and fisheries, and a continued development of know-how and specialized technology over time.

The rest has followed as this demand surge has worked its way through competitive markets. Because oil and gas extraction is the ultimate driver, the resulting gains should be classified as resource rent. This is somewhat paradoxical considering the fact that the taxation of oil companies is designed to make the entire resource rent accrue to the government. However, the analysis in this paper suggests that part of this rent has nevertheless leaked out to the private sector. In fact, more than half of the rent extracted in 2000 – 19 may have been diverted this way.

The diversion is not the result of any corrupt or otherwise illegal activity. It can be explained as a straightforward result of the interaction of supply and demand in competitive markets. No special frictions need to be invoked to explain the observed facts. However, the reversal of this process may prove significantly more difficult to manage when Norwegian oil and gas activity eventually ends.

Appendix
Solutions to equations (6a) – (6d):

Define

$$D \equiv (1-\alpha-\beta)(1-\varepsilon)[1-\beta\eta-(1-\beta)\delta].$$

Then,

$$\hat{w} = \delta D^{-1}\{\alpha[1-\beta\eta-(1-\beta)\varepsilon] + \beta(1-\eta)(1-\varepsilon)g\},$$

$$\hat{P}_S = D^{-1}\{\alpha\delta[1-\beta\eta-(1-\beta)\varepsilon] + (1-\alpha-\beta)\varepsilon[1-\beta\eta-(1-\beta)\delta]$$
$$+\beta(1-\eta)(1-\varepsilon)\delta g\},$$

$$\hat{P}_N = D^{-1}\{\alpha\delta[1-\beta\eta-(1-\beta)\varepsilon] + \alpha(1-\alpha-\beta)\eta(\varepsilon-\delta)$$
$$+[\beta\delta(1-\eta) + (1-\alpha-\beta)(1-\delta)\eta]g\},$$

$$\hat{N} = D^{-1}(1-\alpha-\beta)[\alpha(1-\eta)(\varepsilon-\delta) + (1-\eta)(1-\delta)(1-\varepsilon)g],$$

and

$$\hat{X} = -D^{-1}\{\alpha(1-\varepsilon)[1-\beta\eta-(1-\beta)\delta] + \alpha\beta(1-\eta)(\varepsilon-\delta)$$
$$+\beta(1-\eta)(1-\delta)(1-\varepsilon)g\}.$$

When (6d) is replaced by (6d’), the results become

$$\hat{w} = \frac{\alpha\delta}{(1-\delta)(1-\alpha-\beta)+\beta\delta(1-\eta)},$$

$$\hat{P}_S = \frac{(1-\delta)(1-\alpha-\beta)+\delta[\alpha(1-\varepsilon)+\beta(1-\delta)]}{(1-\varepsilon)[(1-\delta)(1-\alpha-\beta)+\beta\delta(1-\eta)]},$$

$$\hat{P}_N = \frac{\alpha\delta(1-\eta)}{(1-\delta)(1-\alpha-\beta)+\beta\delta(1-\eta)},$$

$$\widehat{N} = -\frac{\alpha\delta(1-\eta)}{(1-\delta)(1-\alpha-\beta)+\beta\delta(1-\eta)},$$

and

$$\widehat{X} = -\frac{\alpha(1-\delta)}{(1-\delta)(1-\alpha-\beta)+\beta\delta(1-\eta)}.$$

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