The Long Norwegian Boom: Dutch Disease After All?

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ABSTRACT

Norway's famed success against the Dutch disease did not extend to the petroleum investment boom of 2000–19. This paper takes a fresh look at the post-2000 data and shifts the focus from quantities and productivity to product prices and wages. Sweden, which is used as the control, had similar developments for real GDP and productivity, but mainland Norway outpaced Sweden in terms of product prices and wages, far in excess of the corresponding divergence of consumer prices. This real appreciation is explained as a result of new demand pressure from oil companies with a strong home bias. It also implies that about half of the resource rent, all of which was to be appropriated by the government, leaked to the private sector. Thus, rent management has not been nearly as effective as claimed. And the real appreciation is likely to cause major adjustment problems once the resource boom ends.

Keywords: Resource boom, Home bias, Rent diversion, Dutch disease, Norway

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1. INTRODUCTION

In the debate about the macroeconomic effects of natural-resource discoveries, the literature appears to be unanimous in holding up Norway as a beacon of success. It has neither been plagued by the resource curse, i. e. weak or negative GDP growth due to rent seeking with weak institutions, nor by the Dutch disease, i.e. manufacturing decline and productivity weakness with subsequent loss of competitiveness. That, at least, was the verdict by the end of the 20th century. This paper asks the question of whether this success continued through the post-2000 oil and gas investment boom. The answer is in the negative. By looking at post-2000 data and moving the focus from quantities to relative prices and wages, the paper finds symptoms of the Dutch disease. Its basic message is that the investment wave produced a boom that lifted product prices and wages to levels that will be unsustainable once the resource boom is over. Furthermore, the plan to have the government collect the entire resource rent failed as about half of the rent in this period leaked out to the private sector.

In terms of basic economics, the discovery of a valuable natural resource should be good news for the owner as well as the economy of which the owner is part, evidence of which was found by e.g. Sala-i-Martín et al (2004) and Brunnschweiler and Bulte (2008). However, a large body of literature presents evidence to the contrary. The resource curse, as documented by e.g. Ross (1999, 2015) and Frankel (2012), is mostly associated with rent seeking, corruption, and armed conflicts (Andvig and Moene, 1990; Collier and Hoeffler, 2004; Fearon, 2005; and Robinson, Torvik, and Verdier, 2006). The explanations center mainly around institutions, which may have been too weak

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to prevent rent seeking (Mehlum, Moene, and Torvik, 2006), or whose strength may have been hampered by resource discoveries (Sachs and Warner, 1995, 2001).

Whereas the resource curse is typically a problem of developing economies, Dutch disease is an issue for advanced economies rich in natural resources, especially non-renewable ones because of the temporary nature of their harvesting. As is well known, the name is derived from the experience following the discovery and development of natural-gas resources in Groningen in the Netherlands. Briefly put, the problem consists of a loss of competitiveness in export-oriented manufacturing, caused by real appreciation as natural-resource revenues boost the demand for services and crowd out manufacturing, which in turn is hurt by weakened learning by doing. These issues have been analyzed thoroughly by Corden and Neary (1982), Corden (1984), van Wijnbergen (1984), and Krugman (1987).[1]

Dutch disease seems to be preventable, however; and Norway has been held up as an example of success. That has been the virtually unanimous verdict of Norwegian (e.g. Bjørnland, 1998; Larsen, 2005 and 2006; and Holden, 2013) as well as non-Norwegian authors (Gylfason, 2002; Thurber, Hults, and Heller, 2011; and Ramírez-Cendrero and Wirth, 2016). Larsen (op. cit.) found that the discovery of oil in Norway accelerated GDP growth, allowing the country to overtake its neighbors Sweden and Denmark during the 1980s. Bjørnland (op. cit.) looked at the effects of oil discovery on manufacturing employment in Norway and the United Kingdom, finding some evidence of Dutch disease in the United Kingdom, but none in Norway.

The Norwegian success has partly been ascribed to fortuitous coincidences, such as the high state of development of the Norwegian economy at the time of the oil discovery (e.g. Ramirez-Cenero and Wirth, op. cit), and the easy conversion of domestic skills from shipping and fisheries to offshore exploration and production (Nerheim, 1992a, b, Holden, op. cit.). As a late entrant, Norway was furthermore able to learn from other countries' experience (Vislie, 2017).

However, the main emphasis has been on the policy regime that the government established in response to the resource discovery. A legal framework of government ownership and control was developed already in the 1960s (Vislie, op. cit.; Gylfason, op. cit.) and formed the basis for the development of key institutions (Larsen, 2006; Thurber et al., op. cit.) that allowed the government to strike a balance between multinationals' know-how and its transfer to domestic agents. A tax system was established that was sufficiently market oriented to maintain oil company interest and at the same time designed to allow the government to appropriate the entire resource rent. As these flows grew large enough to matter, they were shunted into a sovereign wealth fund, the Government Pension Fund Global (GPFG). The final step, taken in 2001, was the introduction of the Fiscal Rule limiting the government's spending from the fund to the expected real return on the fund's assets (Gylfason, op. cit; Ramirez-Cenero and Wirth, op. cit; Larsen, 2005; and Holden, op. cit.).[2] Some authors, like Larsen (2006) and Gylfason (op. cit.) add more general policies on education and research, as well as the tripartite cooperation on incomes policy, which they claim prevented wages from rising out of control. Dyrstad (2016) emphasized this point especially.

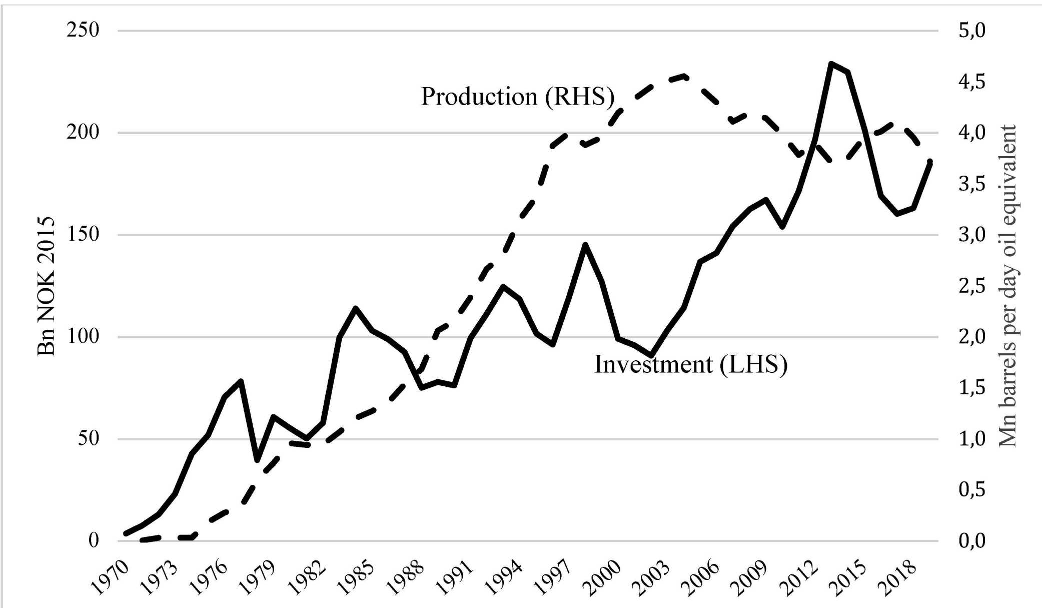
The acceptance of this narrative seems to have been universal, at least through the end of the 20th century. However, the big boom of oil and gas activity in Norway did not take place then, but during the subsequent two decades. This paper exploits the fact that we now have complete data for this period. Stimulated by the combination of improved technology and an unprecedented

1. 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).

2. Similar rules for developing economies have been discussed by Torvik (2018) and Hassler, Krusell, Shifa, and Spiro (2017).

strengthening of the world oil market following the powerful emergence of China, oil and gas investment activity during this period more than doubled from an already high level between 1999 and 2013 and remained high through 2019, as shown in Figure 1. At the peak it made up 43 percent of all fixed-investment activity in the country and 9 percent of mainland GDP. This paper asks what kind of mark this wave left on the overall economy, in particular, whether the boom it created set wages and product prices off on an unsustainable path from which the economy may have trouble returning once the boom is over. It also asks whether the government succeeded in its plan to avoid a boomtown spending spree by collecting all the rent as taxes and accumulate it in the GPFG. The answer is that it did not.

Figure 1: Norwegian Oil and Gas Activity



Sources: Norwegian Petroleum Directorate and Statistics Norway

Two papers that have looked at the post-2000 data conclude that the success against Dutch disease remains in place. Bjørnland and Thorsrud (2016) and Bjørnland, Thorsrud, and Torvik (2019) find that productivity in the traded-goods sector has not only continued to grow but has slightly outpaced that of neighboring Sweden since 1970. Their explanation is learning by doing as technologically advanced oil companies place orders with domestic manufacturing firms.

This paper does not contradict their finding. Although noting that the productivity advantage over Sweden disappears when the scope is widened to the entire non-oil economy, it shifts the focus from production and productivity to product prices and wages. It finds that oil companies' demands have bid up product prices and wages much more than in neighboring Sweden after 2000 and that these increases have greatly outpaced consumer prices, so that living standards have been lifted significantly. That is good news. The not so good news is that this is exactly a case of the real appreciation that is uniformly identified as typical of the Dutch disease. In particular, downward wage stickiness (Holden and Wulfsberg, 2009) is likely to hamper the adjustment back to normal levels once the boom is over.

Moreover, this paper finds that the effect of oil-company input demands has been exacerbated by raised household spending resulting from the increased incomes of households employed in the non-oil economy. This effect constitutes a major leakage from the government's plan to soak up the entire resource rent in the form of taxes and dole it out only gradually and sparingly in the form of contributions to the national budget. The leak comes from the oil companies' deductible costs when the prices of goods and services that oil companies demand are driven up by the positive shock to these demands. For the period 2000 – 2019, I estimate that roughly one half of the resource rent was diverted to the private sector via this mechanism. That is unfortunate from the microeconomic point of view of a government that had intended this flow to be collected and controlled by the public sector and spent on public rather than private goods. Macroeconomically, it would not be a problem if households saved this temporary windfall in a manner similar to the government's plans for the GPFG. However, the findings of Halonen and Mohn (2018) suggest otherwise.

Taken together, I interpret these findings as evidence that the Norwegian government's efforts to steer clear of the Dutch disease, which had seemed to work so well through the 1990s, fell short of its targets during the first two decades of the 21st century. This does not mean that the economy did badly during those years. To the contrary, the long Norwegian boom was spectacular, and the wealth generated was very real. However, about half of it ended up in hands it was not supposed to, politically speaking. Furthermore, the effects of the boom have made the transition to a post-petroleum economy more difficult.

The timing of the boom is worth noting. By the turn of the century, oil and gas had been lifted for almost 30 years and had, by the mid-1990s, reached about the same level as it has currently (cf. Figure 1). Although activity, compared to neighbors, had been good in the preceding three decades, as noted by Larsen (op. cit.), the investment boom of the two most recent decades has been unprecedented. At least three forces were at work. First, the emergence of China raised oil prices and with that the government's oil-related revenues. Second, new technology, such as directional drilling and floating platforms made more reserves profitable. The third force was more subtle, but important. Because of depletion, and despite the technology improvements, the investments needed to reach the remaining reserves tended to be greater than for the low-hanging fruits of the earlier discoveries. Thus, oil companies' demand for investment goods skyrocketed. Simultaneously, and importantly, oil companies operated on the Norwegian shelf displayed a rather extreme form of home bias, whether they were headquartered in Norway or not. The result was an unprecedented increase in the demand for goods and services from the rest of the Norwegian economy. Because Statistics Norway maintains separate accounts for the non-oil part of the economy, statistically termed the mainland economy,[3] we can study how this demand surge affected prices and quantities in this part of the economy.

The most visible part of oil companies' demands come in 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 buyers 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 (op. cit.) 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

3. The remaining part is called the offshore economy. Its contribution to total GDP consists of the value added created by the oil companies themselves plus a much smaller contribution from ocean transport services.

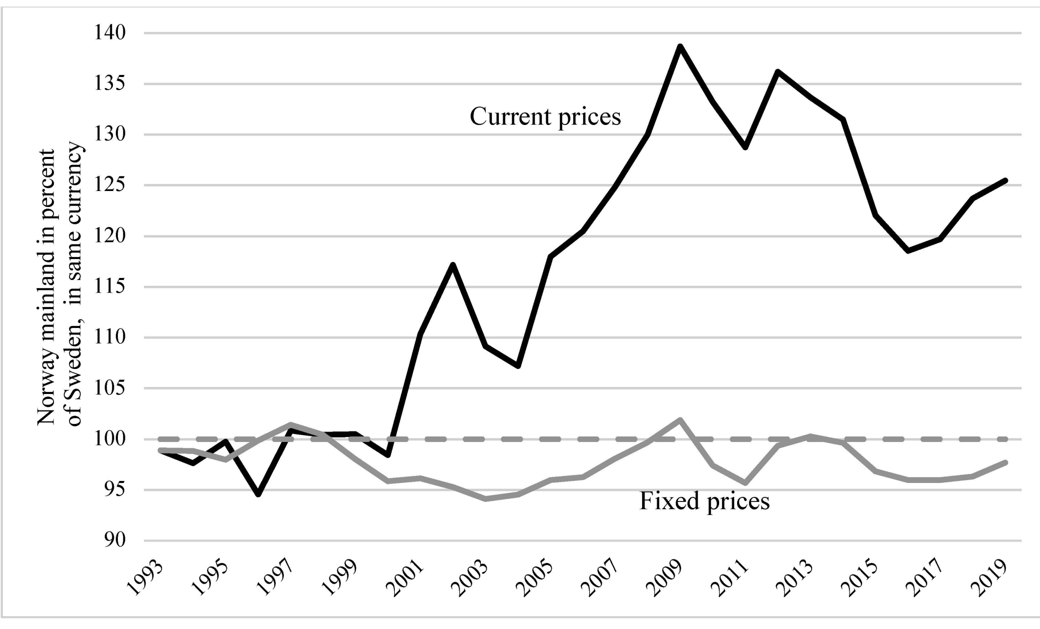
the petroleum sector. Even sectors with no input-output link to the oil industry have been affected indirectly because they compete in the same talent pool.

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 peers. 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

Figure 2 compares nominal and real GDP per capita for mainland Norway with those of neighboring Sweden. Both countries' data are expressed in the same currency, converted at market rates. For the respective variables, the graph shows the ratio of the Norwegian to the Swedish data. The graph starts in 1993, which marked the end of the long slump in the Norwegian economy that started with the 1986 oil price drop and continued with a banking crisis. The subsequent Swedish banking crisis, which followed the Norwegian crisis with a lag, also ended at about the same time.[4]

Figure 2: Relative GDP per capita, Norway mainland vs. Sweden



Sources: Statistics Norway, Statistics Sweden, Norges Bank, Sveriges Riksbank

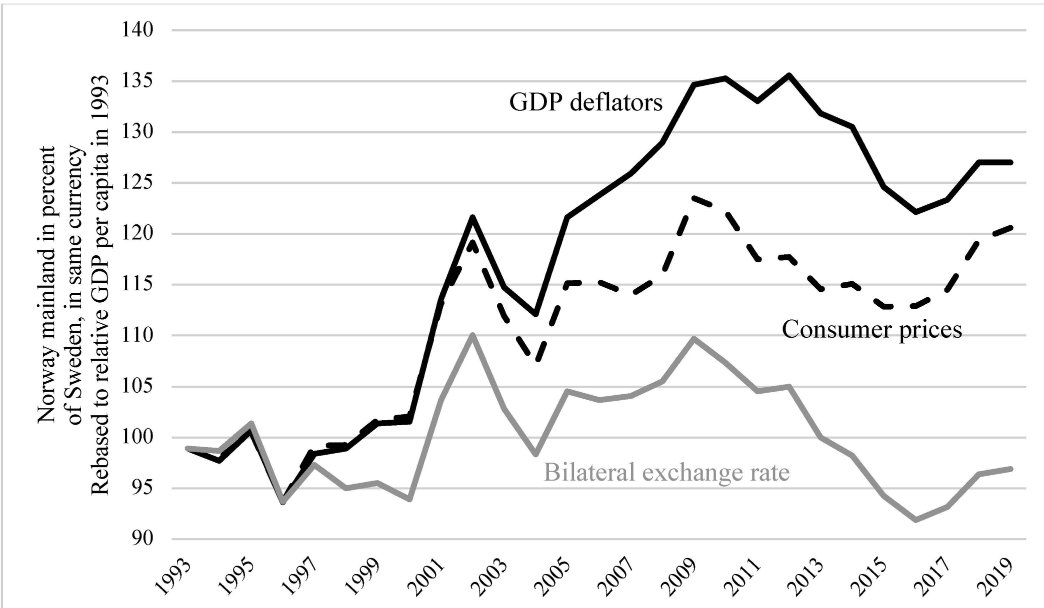
The pattern in the graph is striking. Whereas fixed-price GDP per capita is essentially the same for both countries for the entire period, Norway pulled dramatically ahead in terms of current-price GDP per capita after the turn of the century, reaching a peak of 38 percent above Sweden in 2009 before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

4. The end of the Swedish banking crisis is usually dated at 1994.

Naturally, this could just be a case of differing overall inflation. That could occur even with both countries being inflation targeters[5] 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, as is done in Figure 3. All series have been anchored at the level of the relative current-price per capita GDP in 1993.

Figure 3: Relative price movements, Norway mainland vs. Sweden



Sources: Statistics Norway, Statistics Sweden, Norges Bank, Sveriges Riksbank

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 percent and 20 percent in the first half of the 2000s whereas the relative GDP deflator continued to rise until it peaked at 36 percent in 2012. Thus, the diverging path of the GDP deflators is not simply a result of differing overall inflation, which allows the conclusion that higher product prices made Norwegians on average richer compared to their Swedish neighbors during this period.

Figures 2 and 3 implicitly use Sweden as control, a counterfactual display of how the Norwegian economy would have worked in the absence of the petroleum investment boom. The comparison with the closest neighbor follows the tradition of Card (1990), Card and Krueger (1994), and Larsen (2005). However, it may raise questions of whether Sweden had been hit by some other shock around the turn of the century and whether the similarity during the 1990s was limited to this

5. 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.

period. By way of answering these concerns, Figure 4 shows data going back to 1970[6] for nominal (upper panel) and real (lower panel) GDP of three other possible controls: the Netherlands (used in comparison with Norway by Gylfason, op. cit.), an unweighted average of all surrounding countries in Northern and Western Europe,[7] and a synthetic control based on the same set of candidate countries, using the technique proposed by Abadie and Gardeazabel (2003) and used by Abadie, Diamond, and Hainmuller (2010), as well as Mideksa (2013) in his study of the effects of oil and gas on the Norwegian economy. This technique gives a weight of 96.6 percent to Denmark and 3.5 percent to Belgium and can thus essentially be viewed as a Danish control.[8]

Three features stand out in Figure 4. First, there is nothing special about the 1990s that can bias the impression from Figures 2 and 3. Second, the comparisons between mainland Norway and the respective controls depend only trivially on the choice of control, qualitatively as well as quantitatively. Although Abadie's technique does not report standard errors, the close collinearity visible in the graph clearly means that uncertainty must be substantial. Third, the lower panel shows that mainland Norway and Sweden performed rather differently from the rest in the post-2000 data for real GDP per capita. The graph strongly suggests that these two countries were influenced by a common positive shock during this period, alternatively that they were spared for a negative shock that hit all the rest. The obvious candidate is the Great Recession, during which Norway and Sweden were helped by the automatic stabilization effect of having national currencies with flexible exchange rates.

This circumstance had obviously nothing to do with the petroleum investment boom. The simplest way to weed it out from the analysis is then to use Sweden as the control as in Figures 2 and 3. This choice also seems natural because the two countries are so extremely similar in non-economic respects. Politically both are stable and highly developed with typical Scandinavian welfare states.[9] Historically, they have been politically intertwined, from 1814 to 1905 joined in a personal union under a common king.[10] Geographically, they share the Scandinavian peninsula with a 1,630 km land border, the longest in Europe, across which large volumes of business take place daily, including a substantial number of daily commuters. These movements are facilitated by the fact that the languages are mutually understandable. Although Norway, unlike Sweden, is not a member of the European Union, both countries participate fully in the EU internal market via the European Economic Area (EEA) agreement. In contrast, Norway and Denmark separated politically over 200 years ago, have no land border, and have much less interaction in the form of daily flows of people, goods, or services.

The comparison thus continues to be with Sweden as the attention is turned to the labor market, where the prosperity of the mainland Norwegian companies "trickled down" to workers. Figure 5 shows the relative developments in wages (per hour worked) and labor productivity (real

6. The choice of 1970 as the starting point was based on data availability in the OECD data base. Although it ignores data from before the discovery of Norwegian oil, that limitation should not matter much for the study of the effects of the post-2000 oil and gas investment boom.

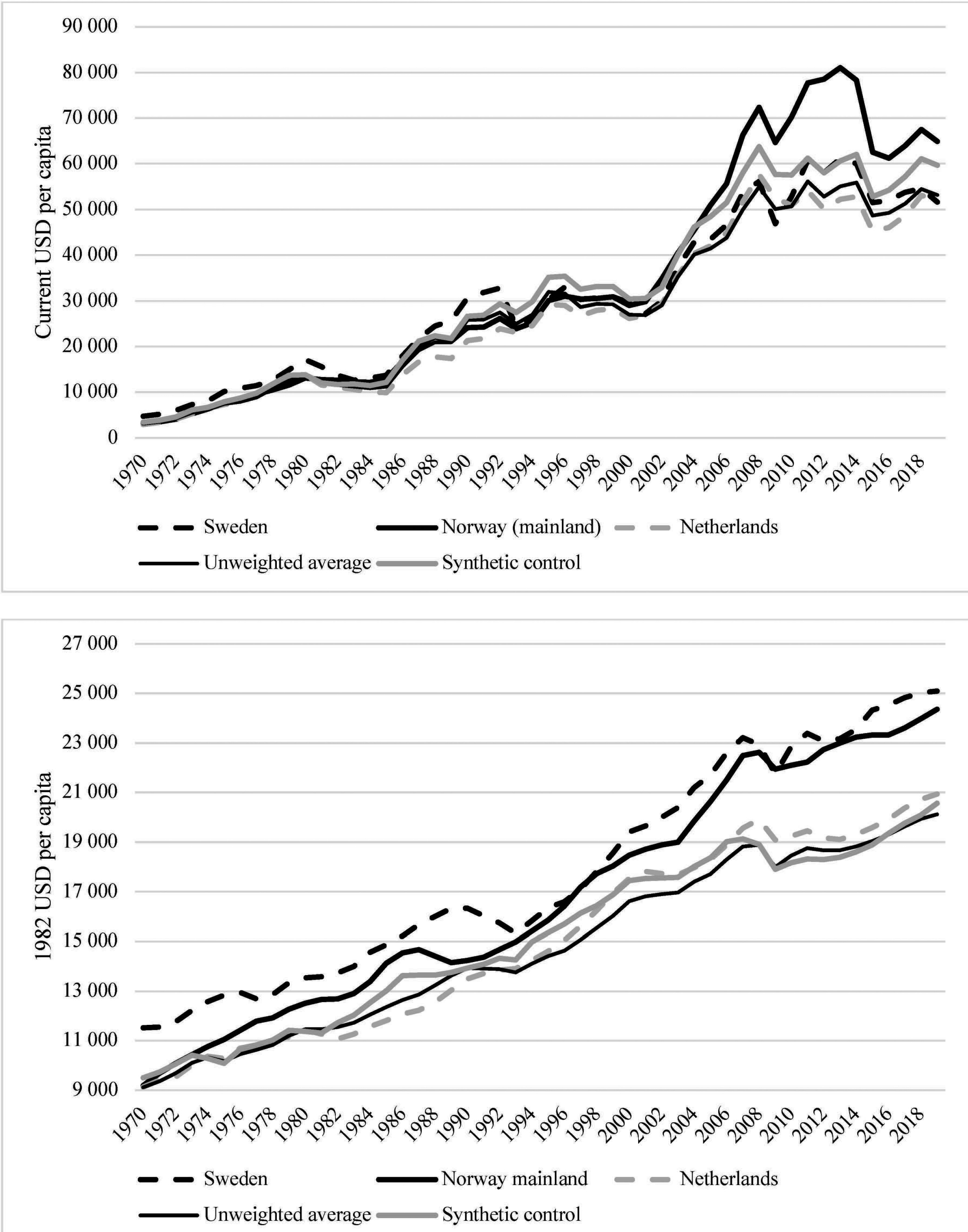
7. The following countries were included: Sweden, Denmark, Finland, the Netherlands, Belgium, Austria, Switzerland, Germany, and France. The United Kingdom was excluded because of its petroleum reserves. Ireland was excluded as well because of the special shocks to its economy during the relevant period. Iceland and Luxembourg were excluded because of size. Denmark was included in despite its share of North Sea petroleum reserves because this share is so small.

8. Predictor variables for Abadie's method were, as in Mideksa (op. cit.), namely, the investment share of GDP, labor force participation, openness, CPI inflation, and mean years of schooling. Initial-year real GDP per capita was also included as a predictor. The details of this method are presented in Appendix I.

9. Barth, Moene, and Willumsen (2014)

10. My colleague Pål Thonstad Sandvik in the NTNU history department helped me get the exact description of this union straight.

Figure 4: GDP per capita



Upper panel: Current USD prices. Lower panel: 1982 USD fixed prices.
Currency conversion at market rates.
Sources: FRED, OECD, Statistics Norway

value added per person hour) between mainland Norway and Sweden. It repeats the pattern from Figure 2 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

Figure 5: Relative wages and productivity, Mainland Norway vs. Sweden

Sources: Statistics Norway, Statistics Sweden, Norges Bank, Sveriges Riksbank

wages at only 88 percent of their Swedish counterparts in 1993. Thus, the rise in the relative wage to 110 percent in 2009–10 completely outgrows the corresponding rise in relative consumer prices.

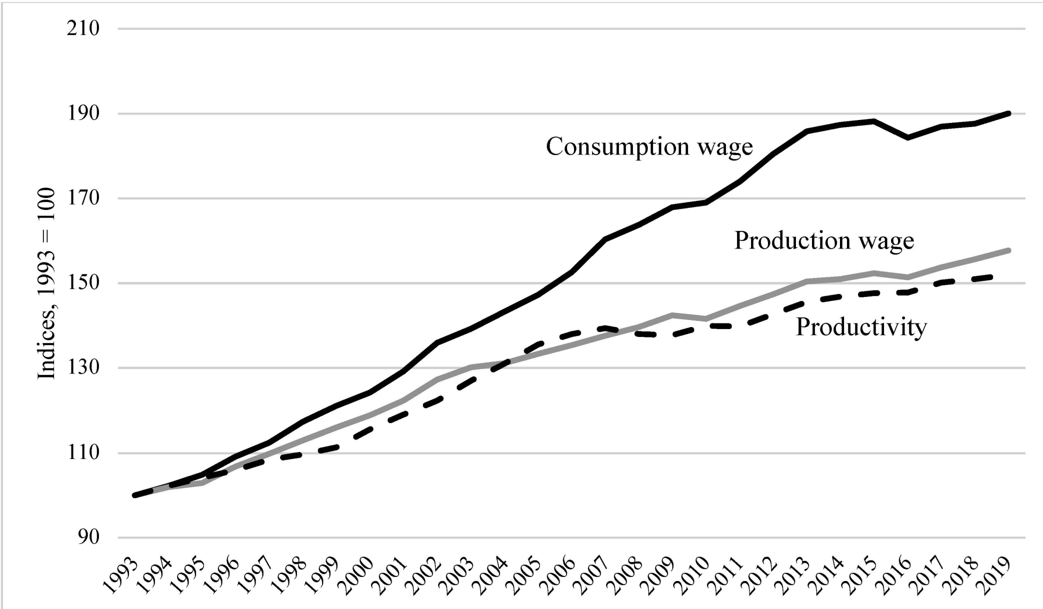
Standard microeconomic theory predicts that the production wage, defined as the nominal wage deflated by the product price, follows productivity in equilibrium. That would nevertheless allow the consumption wage, defined as the nominal wage deflated by the CPI, to rise faster than productivity if the output price rises faster than the CPI. In Figure 6, where the Norwegian production wage is defined as the average mainland compensation per hour deflated by the GDP deflator, suggests that this is exactly what happened in this period. Real consumption wages grew at an average annual rate of 2.5 percent from 1993 to 2019. Productivity growth was healthy as well at 1.6 percent 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, the resulting earnings increase 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 amount is more than three times as large as the benefit the private sector was intended to receive in the form of lower taxes or improved government services as the government financed part of its budget from the financial returns on the GPFG. According to government records, this benefit amounted to an annual average of NOK 27,617 or USD 3,138 per capita.

Apart from the budget contribution, the intention was for the government to capture the entire resource rent. The taxation of oil company earnings was designed with that purpose in mind. However, the payments received by oil company suppliers and service providers are important parts

Figure 6: Mainland Norway productivity and wages



Source: Statistics Norway

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 for 2000–2019, in 2019 prices, which have all been deposited into the GPFG, amounted to NOK 66,906 or USD 7,603 per capita. These estimates are 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 deals with oil companies' 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, oil company period profits can be written as

$$\pi = (1-\tau)(P_O O - P_S S), \tag{1}$$

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, including capital goods, all of which the oil companies buy from foreign or domestic suppliers.[11] τ is the corporate tax rate for oil companies, in Norway as high as 78% on the margin, part of the government strategy to appropriate the resource rent.

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

$$\pi = (1-\tau)\left[P_O O - P_S f(O,R)\right] \ge 0,$$

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

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

meaning that productivity is a decreasing function of depletion.

Given the extensive-margin decision, the decision on the intensive margin is typically trivial, namely, to run the project to the limit:

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

Thus, for given $\bar{O}$, the demand for oil-company supplies and services becomes an increasing function of depletion. Typically, $\bar{O}$ is a decreasing function of depletion. As a net effect, investment demand may well peak after production, which is consistent with the empirical pattern in Figure 1. The distinction between the extensive and the intensive margin helps derive this implication.

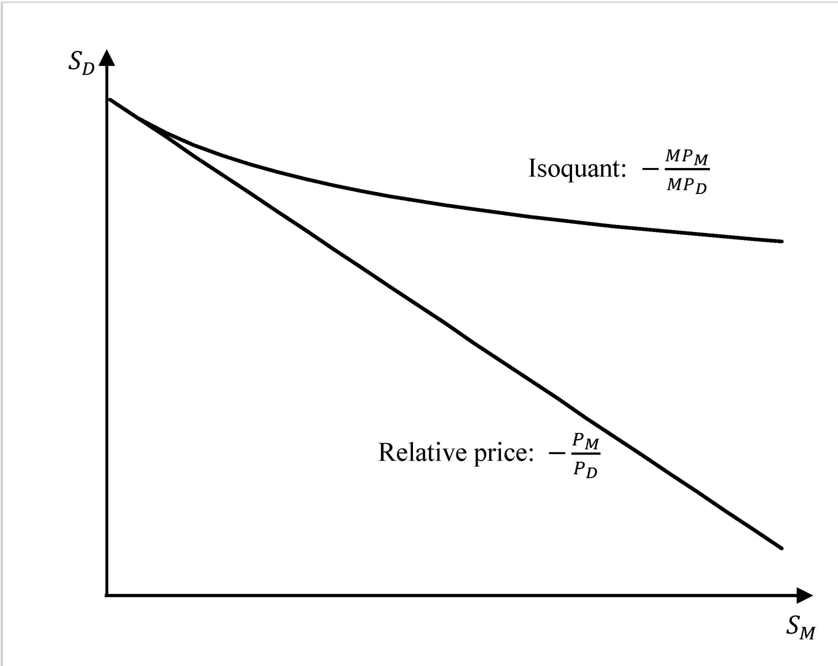
3.2 Home Bias

Globally, there is no shortage of suppliers of the many inputs that oil companies need. Several are huge, global corporations. In many oil-producing countries, 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 7, 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.

This home bias occurred despite a complete absence of government restrictions or incentives to buy Norwegian, at least during the period studied here. It can thus be specified as simply the equilibrium result of oil company preferences and relative prices, as is implicitly done in Figure 7. It is nevertheless interesting to ask what brought the market to exactly this equilibrium.

11. Oil company employment is too small to matter macroeconomically and is ignored here.

Figure 7: Oil companies' home bias



During the 1970s and early 1980s, oil companies were required to buy domestic whenever possible; but these regulations were relaxed in the 1980s in line with the more general deregulation efforts of that decade. However, the liberalization of the 1980s did not seem to induce any change in oil company behavior. A possible explanation for this continuity 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. As pointed out in the introduction, 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. 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 eased communication with foreign oil companies such as Phillips Petroleum (now part of ConocoPhillips), which discovered and developed Ekofisk as the first, major oil field. 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.

Broader cultural factors may have been even more important than just language in communication with locals. Having similar backgrounds makes 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 became an additional advantage once the pattern had been established. Physical meetings, clarifying phone queries, etc. are all easier when distances are shorter.

3.3 The Market for Domestic Resources

This subsection 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.

For this analysis, we assume that the home bias is complete, such that all of oil companies' supplies and services, which we denote S, must be produced by the domestic sector for oil and gas supply and service.

The input to production in sector j, denoted L_j, $j = S, N, X$, 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 productivity 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:

$$1 > \varepsilon > \eta \approx \delta > 0. \tag{4}$$

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:

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

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

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

In the literature, it is common to close this kind of model by imposing external balance, which essentially means balanced trade. This specification would work extremely poorly for the Norwegian case during the period considered her, however, as the country consistently ran huge current-account surpluses, matched by the accumulation of savings in the GPFG, from nothing in 1995 to about USD 100 billion in 2019. Apart from oil and gas exports, the country ran substantial and persistent deficits.

Although the government deposited all its oil and gas revenues into the GPFG from 1996 on, the Fiscal Rule passed by Parliament in 2001 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:

$$P_N N=k\left(P_S S+P_N N+X\right)G. \tag{5d}$$

Here, k is some constant, and the factor G represents government spending financed by the fund.

4. ANALYSIS

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

4.1 Overall Effects

I 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

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

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.

The solution to this system is presented in Appendix II. It shows that, as long as all sectors have decreasing returns ($0 < \varepsilon, \eta, \delta < 1$), $\hat{w}$ 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 $\hat{N}$ to be positive and $\hat{X}$ to be negative.

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

$$\hat{P}_Y \equiv \alpha \hat{P}_S + \beta \hat{P}_N > 0, \tag{6a}$$

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

$$\hat{Y} = \alpha + \beta \hat{N} + \left(1 - \alpha - \beta\right)\hat{X} = \alpha + \beta \hat{N} - \left(\alpha + \beta \hat{N}\right) = 0. \tag{6b}$$

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

$$\widehat{P_Y Y} = \hat{P}_Y + \hat{Y} = \hat{P}_Y > 0. \tag{6c}$$

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

$$\hat{P}_C = a\hat{P}_N > 0. \tag{6d}$$

This increase could conceivably be greater than the one for the GDP deflator. However, that turns 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.

4.2 Spending vs. Resource Movement

Corden and Neary (op. cit.) and Corden (op. cit.) distinguish 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 present model obviously includes both. To isolate the resource-movement effect, we replace equation (5d) with the restriction that spending on non-traded goods remains unaffected by oil companies' demand for inputs:

$$\hat{P}_N + \hat{N} = 0 \tag{5d'}$$

The solution formulae are shown in Appendix II for this case as well. 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 is the case for the price of non-traded goods, so that the effect on the GDP deflator continues to be positive, although less so than when the spending effect is included.

4.3 Calibration and Quantitative Results

For a quantitative view of these effects, we need estimates of the value shares of the respective sectors in Norwegian mainland GDP. Conventional classifications yield a traded-goods share of mainland GDP of 15 percent. However, at least one third of these industries are important suppliers to the oil companies.[12] I thus specify $1-\alpha-\beta=0.1$. 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. (op. cit.), reveal substantial indirect effects via subcontractor value chains. Based on their work, I fix the value of β at 0.4. That leaves $\alpha=0.5$. For the non-traded-goods weight in the CPI, I assume $a=0.6$ from the weights used by Statistics Norway.

To estimate $\hat{G}$, the elasticity of government spending with respect to the change in oil-company demand for inputs, I 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 amount to 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. From this base, the increase in government spending per capita funded from the sovereign wealth fund is 100*27.6/327 = 8.4 percent. The percentage increase in annual (fixed-price) oil and gas investments from 1993–99 to 2000–19 was 31.6 percent. The implied elasticity is then 8.4/31.6 = 0.265, which I use as my estimate of $\hat{G}$.

For the elasticities in the three production functions, I pick values that make the model roughly fit the data, specifically, $\delta=\eta=0.13$ and $\varepsilon=0.2$. I have made no further attempt to validate these elasticities from other sources. Out-of-sample tests make very little sense considering that the *S*-sector has been defined by the oil-companies' demands for all sorts of goods and services and will presumably cease to exist as a sector once the oil and gas era is over. But then the purpose of this exercise is not to estimate a stable model of the production possibilities of the respective sectors of the Norwegian economy. Rather, it simply seeks to demonstrate that the apparent effects of the oil and gas activities can be derived as the straightforward implications of a competitive, neoclassical model.

The elasticities with respect to oil companies' input demand are presented in columns (2)–(4) 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

12. The following industries contributed 8 percent of mainland GDP: Service activities incidental to oil and gas; Building of ships, oil platforms, and modules and other transport equipment; Machinery and other equipment not elsewhere classified; and Repair and installation of machinery equipment. However, the same industries also have other clients, such as ferry companies.

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

(1) Variable	(2) Model with spending effects[a]	(3) Model without spending effects[b]	(4) Share spending effects in model[c]	(5) Model without government spending[d]	(6) Data[e]
$\hat{w}$	0.79	0.36	54%	0,62	0.70
$\hat{N}$	0.26	–0.32	—	0,03	—
$\hat{X}$	–5.31	–2.42	54%	–4.17	—
$\hat{P}_S$	1.04	0.61	41%	0.87	—
$\hat{P}_N$	0.83	0.27	67%	0,63	—
$\hat{P}_Y$	0.83	0.38	54%	0,66	0.83
$\hat{P}_C$	0.50	0.16	67%	0,38	0.52

a. Equations (5a)–(5d) and (6d).
b. Equations (5a)–(5c), (6d), and (5.d').
c. [(2) – (3)]/(2)
d. Equations (5a)–(5d) and (6d) with $\hat{G} = 0$.
e. Changes (diff-in-diff) from 1993–99 to 2000–19 for mainland Norway, with Sweden as control.

the price of oil-company inputs, we are not surprised to see that the split is three fifths for resource movement and two fifths for the spending effect. For the price of non-traded goods (and thus for the CPI), the split is almost the opposite, which is also as expected.

Column (5) shows the results that would obtain without the public contribution to the demand for non-traded goods, in other words, with $\hat{G} = 0$. 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 much closer to the one with government spending, which is what one would expect. In total, the government seems to have contributed significantly to the increase in the GDP deflator, but also to consumer prices, and pretty much 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.

4.4 Data vs. Model

We have already found that fixed-price GDP per capita hardly changed at all during this period in comparison with the Swedish counterfactual. The changes in the output levels of the respective sectors are somewhat uncertain because of the ambiguity about the sector definitions. That makes empirical measurements on the sector prices $\hat{P}_S$ and $\hat{P}_N$ uncertain as well. However, the elasticities for the wage, the GDP deflator, and the CPI can be estimated unambiguously from national-accounts data supplemented by the bilateral exchange rate. 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 (6) of Table 1.

The match with the data is remarkably close. The significance of the closeness should not be exaggerated because the elasticities of the respective production functions have been chosen so as to maximize the fit. However, the model does seem to work as an illustration of 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 is capable of explaining the rise in Norwegian incomes during the 2000s and 2010s as a result of market forces in competitive equilibrium. 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 are 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. True, centralized wage settlements based on tripartite cooperation have probably played an important institutional role, as argued e.g. by Larsen (2006). And Dyrstad (op.cit.) argues 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. However, the analysis in this paper indicates that such institutional mechanisms mainly facilitated the implementation of competitive equilibria.

In such equilibria, product wages follow productivity. Loss of productivity, a typical feature of Dutch disease, has not been uncovered in this paper. Instead, oil-company quality requirements have stimulated productivity growth in oil supply and services, as found by Bjørnland et al. (op.cit.). It is worth noting, however, that parts of this productivity may be industry specific and not necessarily transferable to other traded industries once the resource boom is over. Even if it is, the elevated wage level created by the oil boom will be unsustainable once the boom ends. There will then be no more resource rent to divert. Downward wage rigidity is then likely to be a problem, possibly leading to increased unemployment,

A possible solution to this adjustment problem may come via the foreign exchange market. In this regard, a national currency with a floating exchange rate my prove to be an advantage. The experience during the Great Recession as well as the Covid-19 pandemic raises some hopes in this regard. Any such conclusion is premature at this time, however.

Furthermore, wage equalization may not be sufficient to regain competitiveness because the boom also has affected non-wage benefits, thus adding costs to employment beyond the wage increases. A piece of telling anecdotal evidence comes from the case of a Swedish nurse who had been granted sick leave for work-related stress but spent her time off working at a Norwegian hospital. Not surprisingly, she was convicted of welfare fraud. But the interesting part was her legal defense to the effect that work at the Norwegian hospital was so much more leisurely as to serve as rest and recreation.[13]

Sooner or later, the Norwegian oil and gas industry will have to come to an end. Indeed, rising costs due to gradual depletion may put an end to new developments long before the resources are depleted. Concerns about 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 by Fæhn et al. (2018) and Asheim et al. (2019) to phase out the Norwegian oil and gas industry and work for an international agreement among oil and gas producers to do the same.

13. "Utbrent i Sverige, i full jobb i Norge" ("Burnt out in Sweden, full-time employed in Norway") NTB (Norwegian news service), July 5, 2000.

6. CONCLUSIONS

The discovery of oil on the Norwegian continental shelf has not made productivity suffer. In fact, during the oil and gas investment boom of the 2000s and 2010s, Norwegian prosperity surpassed that of neighboring Sweden.

However, this prosperity came from high product prices and wages rather than superior productivity. Because of oil companies' home bias, domestic labor, capital, and managerial talents have enjoyed special local scarcity and have thus been able to appropriate part of the resource rent. This fortuitous situation cannot persist once the Norwegian oil and gas age ends. In this sense, Dutch disease has not been avoided at all.

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APPENDIX I: RESULTS OF SYNTHETIC CONTROL COMPUTATION

Treated unit: Norway mainland

Treatment period: 2000 – 2019

Control units: Austria, Belgium, Switzerland, Germany, Denmark, Finland, France, the Netherlands, and Sweden

Dependent variable: Nominal GDP per capita. Sources: FRED, Statistics Norway

Predictors:
- Initial real GDP per capita. Sources: OECD, Statistics Norway
- Investment share of GDP, in fixed prices. Source: OECD
- Labor force participation. Source: OECD
- Openness, defined as (Exports – Imports)/(2*GDP) in fixed prices. Source: OECD
- CPI inflation. Source: OECD
- Mean years of schooling. Source: UN Development Programme, Human Development Reports, http://hdr.undp.org/en/content/mean-years-schooling-males-aged-25-years-and-above-years, accessed Feb 25, 2021.

Table A1: Results for weights and mean square prediction error

	Sample starting 1970	Sample starting 1980	Sample starting 1990
Root mean square prediction error	2091.1	2337.6	1650.6
Weights			
Austria	0	0	0
Belgium	3.5%	0	0
Switzerland	0	3%	0
Germany	0	0	0
Denmark	96.5%	73.3%	69.6%
Finland	0	0	0
France	0	0	0
Netherlands	0	0	16.1%
Sweden	0	23.7%	14.3%

Table A2: Results for predictor balance

	Sample starting 1970		*Sample starting 1980*		*Sample starting 1990*	
	Treated	**Synthetic**	**Treated**	**Synthetic**	**Treated**	**Synthetic**
Initial GDP	9185.2	9498.7	12505.2	12128.1	14230.4	14381.6
Investment share of GDP	20.4	21.3	20.4	22.4	20.4	22.0
Labor force participation	79.1	79.0	79.1	79.4	79.1	78.4
Openness	26.5	25.4	26.5	26.3	27.7	31.9
CPI inflation	6.4	6.1	5.4	4.7	2.4	2.3
Mean years of schooling	10.3	10.0	10.3	10.0	11.1	10.2

APPENDIX II: MODEL SOLUTION

The combined condition of labor market equilibrium and full employment implies

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

Using this result, we can write the system as

$$\hat{P}_S - \frac{\varepsilon}{1-\varepsilon} = \hat{w} \tag{A1}$$

$$\hat{P}_N - \frac{\eta}{1-\eta}\hat{N} = \hat{w} \tag{A2}$$

$$\delta\left(\alpha+\beta\hat{N}\right) = (1-\delta)(1-\alpha-\beta)\hat{w} \tag{A3}$$

$$(1-\beta)\hat{P}_N + \hat{N} = \alpha\hat{P}_S + \hat{G}. \tag{A5}$$

Define

$$D \equiv (1-\alpha-\beta)(1-\varepsilon)\left[1-\beta\eta-(1-\beta)\delta\right] > 0.$$

Then,

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

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

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

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

and

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

When the spending effect is shut off, the results are changed to

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

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

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

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

and

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