DEPARTMENT OF ECONOMICS
OxCarre
Oxford Centre for the Analysis of Resource Rich Economies

Manor Road Building, Manor Road, Oxford OX1 3UQ
Tel: +44(0)1865 281281 Fax: +44(0)1865 271094
oxcarre@economics.ox.ac.uk www.oxcarre.ox.ac.uk

OxCarre Policy Paper 24

The Impact of Natural Resources
Survey of recent quantitative evidence

Frederick van der Ploeg
OxCarre

&

Steven Poelhekke*
VU University, Amsterdam

***OxCarre External Research Associate**

THE IMPACT OF NATURAL RESOURCES

Survey of recent quantitative evidence

Frederick van der Ploeg[a] and Steven Poelhekke[b]

Abstract

The cross-country empirical evidence for the natural resource curse is ample, but unfortunately fraught with econometric difficulties. A recent wave of studies on measuring the impact of natural resource windfalls on the economy exploits novel datasets such as giant oil discoveries to identify effects of windfalls, uses natural experiments and within-country econometric analysis, and estimates local impacts. These studies offer more hope in the search of quantitative evidence.

Keywords: natural resource curse, identification strategy, giant oil discoveries, natural experiments, within-country analysis, local impacts, geography, geology, development

JEL codes: C12, C13, F43, O41, Q3

Revised July 2015

[a] Oxford Centre for the Analysis of Resource Rich Economics (OxCarre), Department of Economics, University of Oxford, Manor Road Building, Oxford OX1 3UQ, United Kingdom. Also affiliated with St. Petersburg State University, 7/9 Universitetskaya nab., St. Petersburg, 199034 Russia and the VU University Amsterdam. Support from the BP funded OxCarre is gratefully acknowledged.
[b] Department of Spatial Economics, VU University Amsterdam. Also affiliated with OxCarre.

1. Introduction

The natural resource curse put forward by Sachs and Warner (1997) has been often put forward to explain why countries rich in natural resources varying from gold, silver, copper, diamonds to oil and gas often have poor growth and development performance. Countless studies have followed this seminal study to use cross-country and panel-data econometric analysis to document the negative impact of natural resource dependence (typically, the ratio of natural resource exports to GDP) on the rate of economic growth after controlling for initial income per capita, past investments, trade openness and a host of other variables. As the structural adjustments and appreciation of the real exchange rate associated with standard Dutch disease effects (Corden and Neary, 1982) in themselves do not harm welfare, the theoretical justification for the adverse effects on growth stresses the loss of learning by doing in declining traded sectors as factors of production move out to the booming traded sectors (van Wijnbergen, 1984). However, especially in federations of states, inward migration of labour and capital may relax bottlenecks in non-traded sectors which curb the appreciation of the real exchange rate (Beine et al., 2015; Raveh, 2015). Other potential explanations for the adverse impact of resource windfalls are unsustainable policies, bad institutions, poor rule of law, ethnic fractionalization, armed conflict especially if natural resource wealth is large relative to the opportunity cost of fighting (the wage), badly developed financial systems and crowding out of growth-promoting foreign direct investment or FDI for short (as surveyed in van der Ploeg, 2011).

For example, some countries such as Congo and Nigeria have in the past been unable to escape this resource curse, although other countries such Norway and Botswana have fared relatively well. Nigeria has during the last three or four decades of the last century seen a stagnant income per capita, declining total factor productivity growth and only a third of capital being utilized, whilst Botswana has experience rapid growth and its GDP per capita has become ten times that of Nigeria. These diverging experiences are often attributed to different qualities of institutions or due to ethnic fractionalization. Indeed, if there is a limited pool of talented people, then a windfall in a country with poor institutions will encourage more of these people to engage in rent seeking and taking as much as possible of the windfall. But a windfall in a country with strong institutions will lead to more complementary demand and encourages more talented people to engage in productive entrepreneurship (Mehlum et al., 2006). The cross-country empirical evidence also suggests that with good enough institutional quality a resource curse can

be turned into a blessing, especially for natural resources that are pointed such as diamonds or oil, rather than diffuse such as rice or coffee (Boschini et al., 2007).

However, most of the cross-country evidence on the natural resource curse is fraught with difficulties. First, the use of resource dependence (i.e., the ratio of natural resource exports to GDP) as an explanatory variable suffers from endogeneity issues, which is why some studies use resource abundance (the total amount of subsoil wealth) instead, to criticize the negative impact of natural resources on growth and development by finding that the curse effect then disappears (Brunnschweiler and Bulte, 2008. However, resource abundance is also an endogenous variable and therefore the econometric methodology of this study is flawed too (van der Ploeg and Poelhekke, 2010).[1] Second, it might be that not the level of natural resource dependence or abundance but the notorious volatility of commodity prices is the quintessence of the natural resource curse. Cross-country and panel-data evidence which estimates both a growth equation and an equation for the unanticipated variance of growth in GDP per capita suggests that the volatility of commodity prices indeed trumps the level of natural resources as the key explanatory variable (van der Ploeg and Poelhekke, 2009 and 2010). Furthermore, point-source natural resources, lack of financial development, ethnic fractionalization, landlocked geography, current account controls and capital account liberalization all add to unanticipated volatility and thus to depressed growth prospects. Third, in these studies it is very difficult or impossible to differentiate empirically between variables such as institutional quality, financial development and political environment as these are often correlated. Furthermore, macroeconomic data are typically quite poor and cross-country regressions inevitable suffer from omitted variable biases and from a multitude of confounding variables. Fourth, the natural resource course might be a statistical artefact when one considers resource drag. If growth in non-resource GDP exceeds that of growth in resource GDP and the share of natural resources in GDP is substantial, then poor aggregate growth performance inevitably occurs (James, 2015b). The point of this mechanical relationship is that one would not wish to conclude that this necessarily implies evidence for Dutch disease. Finally, others have offered empirical evidence that the effect of a large endowment of oil and other mineral resources has a positive effect on long-term growth (Alexeev and Conrad 2009).

In this paper, we conclude that the old cross-country evidence on the natural resource curse is mixed and not very strong and should not be relied on too much as there too many

confounding factors and endogeneity issues. The new evidence on the impact of natural resources attempts to use much better identification strategies and innovative datasets with much finer resolution than can be found in the traditional macroeconomic datasets. We therefore discuss some approaches that offer more hope of finding reliable and solid empirical evidence. We do not seek to offer a comprehensive survey, but instead try to discuss various approaches and examples of the way to move forward. The first approach is to use big oil discovery data to identify the impact of oil on macroeconomic outcomes as discussed in Section 2. The second approach is to use natural experiments. In this vain, Section 3 discusses a study of two similar islands, where one discovers oil and the other does not. The third approach is to use within-country econometric evidence as this ensures that there will be less variation in institutional, legal and political explanatory variables. As an example, Section 4 discusses frontier studies on this for the impact of natural resources on conflict in Colombia and on district budgets in Brazil. The fourth approach is to study the local impacts around mines or around shale gas developments. Section 5 discusses some of these studies. Section 6 presents some studies which attempts to make sense of the role of the detailed geography and geology of natural resources to explain oil exploration, trade diversion and armed conflict. Section 7 concludes.

2. Using big oil discoveries to identify the impact of natural resources

Macroeconomists inspired by Pigou and Keynes have been long interested in the possibility that anticipation effects may be important drivers of economic fluctuations. It is, however, fair to say that news shocks on total factor productivity are hard to observe or even fathom and the evidence is mixed in any case. However, discoveries of oil fields are quite common and might lead to large and observable anticipation effects of typically 4-6 years. Arezki et al. (2015) use a novel dataset on giant oil discoveries (i.e., at least 500 million ultimately recoverable barrels with median net present value of 6.6% of GDP) to isolate the precise timing when expectations change and estimate the magnitude of these anticipation effects at the macro level. This study not only offers estimates on the macro impact of natural resources, but also novel insights for the macro literature on anticipation effects and suggests that some of the channels that are part of the broad resource curse literature take root even before extraction begins.

Permanent income theory of the current account predicts that, in anticipation of the windfall, countries will borrow to finance exploration investment and smooth consumption, and, during the windfall, will save to sustain consumption in the long run. This implies current account deficits in anticipation of the windfall and surpluses during the windfall. Furthermore, a multi-sector model of a small open economy with nominal rigidities predicts drops in GDP and unemployment due to the appreciation of the real exchange rate and drop in net exports caused by the windfall-induced increase in aggregate demand during the anticipation period and over-employment during the windfall.

Using a dynamic panel distributed lag model with lags of up to 10 years on a sample of countries from 1970-2010, Arezki et al. (2015) indeed find controlling for country-fixed and time-fixed effects that the ratio of the current account to GDP swings negative for the first five years after a giant oil discovery and then becomes positive. The investment-GDP ratio rises in the first five years and then returns to normal, GDP does not start to rise until year five, and employment falls in both the short and immediate run. The negative anticipation effect resulting from an oil discovery of median size (worth 6.6% of GDP) is estimated to be about 0.67% of GDP. Hence, the anticipation effects are consistent with theory and economically significant.

Tsui (2011) uses the same dataset to exploit variations in the timing and size of oil discoveries to identify the impact of natural resource wealth on democracy. He finds that discovering 100 billion barrels of oil (compare initial endowment of Iraq) leads to drop in democracy of almost 20 percentage points below trend after three decades. These results are less strong and significant when measuring the effect of resource wealth per capita, so for politicians it is the value rather than the per-capita value of the discovery that matters.

Data for large oil field discoveries exists and is readily accessible. Most of these historical finds were conventional oil with low extraction costs and thus short investment phases. In recent years, such discoveries are increasingly rare. New supplies are still discovered but tend to be of the unconventional type, such as shale oil and gas (see section 5). These have much higher production costs and as such depend much more on the world oil price for their feasibility. This implies that anticipation effects of these finds may be more muted or stretched longer over time. Furthermore, a frontier of research is to examine discoveries of big copper or iron deposits. For example, the Simandou iron ore deposit, once developed, may double

Guinea's GDP. However, a 650 km railway has to be constructed first, before extraction can begin (Rio Tinto, 2013). The deposit was discovered in 1997, but the recent decline in the price of iron ore has further delayed development of the mine. Remote deep sea natural gas deposits in Mozambique also require massive investments before export can begin (Ledesma, 2013).

3. A tale of two islands

Another way to statistically identify the effect of a resource windfall is to take advantage of a natural experiment. Ideally, one would do a randomized controlled trial, but at a macro level that is not feasible. However, Sao Tome and Principe (STP) and Cape Verde share very similar recent and colonial political histories. They are both small island low-income democracies, which both received IMF and World Bank reforms and plenty of foreign aid. They are also both former Portuguese colonies (1500-1975) and former socialist dictatorships (1975-1991). STP had an anticipated oil windfall with oil prices tripling, amounting to a magnitude of 237% of GDP. Cape Verde did not have such a windfall, which makes it an ideal control. This is the identification strategy of a careful study conducted by Vicente (2010). Although STP was a cocoa exporter while Cape Verde was not, he argues that cocoa prices were stable over the sample period such that this difference does not invalidate the comparison. From the windfall in 2000 onwards, survey evidence suggests that corruption rose steeply in STP but not in Cape Verde.

Vicente (2010) puts forward two hypotheses: (1) the increased rents raise the value of being in office, which induces misallocation of funds towards vote buying and (2) increased corruption in public services. The difference-in-difference econometric results indeed indicate that after the announcement of the oil windfall in STP vote buying increased by 9%, corruption in customs by 11%, and in state procurement by 8%, but there was little or no effect on health and state jobs or on scholarship allocations, licenses or police. However, using a difference-in-difference-in-difference estimation to account for general perception of the quality of public services, it is found that the effects are stronger for informed or educated people. For informed people who are more likely to answer based on knowledge than on perception, subjective corruption in procurement, courts and schools went up by 14%, 10%, and 10%, respectively. The implication of these findings is that the quality of institutions may deteriorate as a result of

natural resource discovery, suggesting that even countries with relatively good institutions are not necessarily immune to the adverse effects of resource discovery. While STP and Cape Verde provide a unique case given the similar colonial and post-colonial experiences of these two islands, it will be very hard to find other such natural experiments.

4. Within-country evidence for the impact of natural resources

Various recent studies have attempted to improve the quality of the estimates of the impact of natural resources by focusing at within-country variations. Most of these have focused on the US (e.g. Michaels, 2011; James, 2015a), but here we will focus on two examples of within-country studies of public budgets in Brazil and on conflict in Colombia. Further discussion of the effects of fiscal decentralization on the sharing of natural resource rents in Indonesia and Chile can be found in Cust and Poelhekke (2015).

4.1. District budgets in Brazil

Natural resource windfalls also have a direct and important impact on local government finances. Several countries have seen a move to the decentralization of executive and fiscal powers to local administrative units to foster regional autonomy, improve service delivery, and improve accountability of government. This was in part driven by a process of democratization and the wish of (ethnic) minorities to have a say in political decisions, but natural resource extraction itself created demand for decentralization. This might have led to a higher impact of mines on their region, through the revenue channel, but the size of this impact depends on the sharing rules between regions and the way in which local governments spend the revenue.

It is thus of interest to study the effectiveness of rent sharing with local governments. For Brazil, Caselli and Michaels (2013) show that, unfortunately, corruption and embezzlement drive a wedge between the amount of fiscal transfers or royalty payments received and local outcomes. They find that municipal revenues increase with royalties from oil production, which amount to roughly 3% of gross oil output. To identify the impact on socio-economic outcomes, they compare coastal municipalities with no oil to those with only offshore oil. The latter has no systematic effect on non-oil GDP so that that the impact works through revenues only and not through spillovers from extraction activity. Their main finding is that the rise in municipal

spending is much below the increase in royalty payments, and it is not due to offsetting reductions in taxes or federal spending in municipalities. The suggestion is that mayors use money to create bogus public sector jobs for certain groups to improve reelection chances. Indeed, mayors of oil municipalities appear to be more often in the press in relation to corruption.

4.2. Conflict in Colombia

An interesting hypothesis tested by Dube and Vargas (2013) on Colombian data is that a rise in the price of capital-intensive natural resources such as oil boost the return on capital and thus fuels conflict over the control of natural resources. Similarly, a rise in the price of labour-intensive commodities such as coffee boosts the wage and diminishes the incentive to fight. This is in line with the notion that the grievance of the guerrilla movement Fuerzas Armadas Revolucionarias de Columbia (FARC) whom initially fought for injustice has been replaced by the greed of the United Self-Defence Groups of Colombia whom mostly fight to appropriate oil revenue. The identification strategy exploits the exogenous variation in international commodity price shocks (rising oil prices, falling coffee prices) and the variation across regions in production of commodity exports. The data cover about 1000 municipalities during 1988-2005, collected by neutral Catholic priests. The treatment variable is hectares of coffee land, and oil production. The difference-in-difference estimates approach interacts coffee intensity and coffee price as well as oil production and the oil price. The findings are that, as oil prices rose by 137% between 1998-2003, municipal revenues increased by 5%, guerrilla attacks by 8% and paramilitary attacks by 14%. Also in line with the hypotheses, as coffee prices fell by 68% between 1997 and 2003, wages fell by 38%, hours worked by 30%, guerrilla attacks by 18%, paramilitary attacks by 21%, clashes by 22%, and killing by 14%. Hence, this suggests that increases in the prices of capital-intensive resources indeed fuel conflict, while the opposite occurs for increases in the prices of labour-intensive resources.

5. Local impact of natural resources

Another approach is to focus not at macroeconomics effects, but at the local microeconomic impacts of mining, fracking or other exploration activities on local incomes per capita, local employment, et cetera. This provided a useful complement to the macroeconomic

effects estimated in the older resource curse literature. Furthermore, the local impacts are more likely to be positive. A comprehensive survey of these local impacts is given by Cust and Poelhekke (2015). Here we therefore restrict ourselves to a brief discussion of two classic studies on local impacts and a survey of recent studies on the local impacts of shale gas in US counties.

5.1. Local impacts of mines

One of the first studies to estimate the local impacts of natural resource exploration is Aragon and Rud (2013). They analysed a change in output and a change in the local procurement policy in the Yanacocha gold mine in Peru, which opened in 2000. Because the mine is large – one of the largest open-pit gold mines in the world – such a policy change can have substantial effects on the local economy. In fact, they allow the change in policy to affect households within 100km of the mine, and compare these to 'untreated' households further from the mine. The change in policy and expansion of the mine provides variation over time, while the two groups of households allow identification of a counterfactual. The difference-in-difference estimator suggests that real income levels for treated households rise more over time after the policy change than for the control households: a 10% increase in the total bill of local purchases and wages, increases real household income by 1.7%. These effects only apply to surrounding areas (within 100 kilometres distance of the mine). Interestingly, they do not find direct income effects from the increase in municipal finances, although public good provision does increase. They attribute the effects to local sourcing of inputs and argue that such a backward linkage channel can deliver positive spill-over effects. Moreover, housing rents rise, suggesting that workers' welfare increases and that they are more than compensated for any environmental risks they may face. Of course, this assumes that workers are aware of the environmental risks and that they optimize over the income stream and the lifetime health risk. One could also hypothesize that poor households give too little weight to (future) health risks and prioritize income and consumption today.

However, the change in policy of the mine is somewhat of a special case, because a sizeable minority share of the mine is held by two owners who pursue social goals as well: The International Finance Corporation, which is "a member of the World Bank Group, [and] is the largest global development institution focused exclusively on the private sector in developing countries", and the Benavides Group: "a provider of advisory services in microfinance, in the

small and medium enterprise industry and in charitable initiatives in Latin America, with a particular focus on the rural areas". If the change in policy only came about due to these particular owners, then it will be unlikely that other mines will follow the same policy; it would be unrealistic to assume that the IFC can co-own all mines in the world. Furthermore, its success depends on the local existence of a market for the goods and services demanded by the mine, and the effect may be negligible for smaller mines. Lack of the latter may result in mines mostly importing capital and labour from further away.

This study also finds evidence of an increase in the local price of non-tradable produce (self-reported house rental, potatoes, maize) but not of non-local food (rice, sugar, cooking oil) prices. This confirms the key mechanism underlying Dutch disease. One might conclude from these findings that there is a potential of backward linkages from extractive industries to create positive spill-over effects in less developed economies. Aragan and Rud (2013) dismiss the alternative explanation that it is a transfer to the local government ('canon minero') which explains the increase in real income. They also dismiss selective immigration as an alternative explanation.

The short-run effects estimated in the previous paper are complemented by the (very) long-run effects found in Dell (2010). She uses regression discontinuity design to estimate the long-run effects of an extensive forced mining labour system (the 'Mita') in Peru and Bolivia between 1573 and 1812. During the rule of the mita, Peru's indigenous communities were required to send one-seventh of their adult male population to work in silver and mercury mines. However, this befell only households living in the region, while communities on the other side of the administrative boundaries were exempt. This situation provides a natural experiment to study the long run impact of this 'institution' on development today, again by comparing otherwise similar communities who happened to live inside or outside the Spanish-imposed administrative boundary on a high plane in the Andes mountains. Results indicate that a *mita* effect can still be felt today. It lowers household consumption by around 25% and increases the prevalence of stunted growth in children by around 6 percentage points in subjected districts. The paper then uses detailed data from the Spanish Empire and the Peruvian Republic to trace channels of institutional persistence and shows that this effect has persisted through its impacts on land tenure and public goods provision. Inside the mita area, large landowners were less prevalent and educational attainment was lower. Large landowners and the resulting inequality may not be very

conducive to development, but nor were pre-colonial institutions. Also, the mita areas are less integrated into road networks and their residents are substantially more likely to be subsistence farmers. It is easy to imagine that mining regions throughout the world that can be traced back to colonial times may suffer from similar lack of institutional and public goods provision, following the logic that such regions were not colonized for settlement, but rather for extraction only (Acemoglu, Johnson, and Robinson, 2001). Nevertheless, this paper argues that an extractive state that at least provides some public goods is better than no state at all. Together with the Vicente (2010) study, the empirical evidence suggests that natural resource extraction can adversely affect national and local institutions, making prevention of a 'curse' even harder for countries with weak institutions.

Finally, a recent study uses novel data on the drilling of 20,000 oil wells in Brazil to exploit a quasi-experiment with municipalities with drilling but no discovery as the control group and municipalities with drilling and oil discoveries as the treatment group (Cavalcanti et al., 2015). The resulting empirical evidence suggests that oil discoveries significantly increase GDP per capita and urbanization, and lead to positive spill-over effects to non-oil sectors. The results suggest that greater local demand for non-tradable services is driven by highly paid oil workers.

5.2. Evidence for the local impact of shale gas

We now discuss some evidence on the local effects of shale gas. Since the abundance of shale deposits varies exogenously across US counties, this makes it a suitable setting for economic analysis.[2] In a sample of 188 rural counties of Colorado, Texas, and Wyoming, Weber (2012) finds positive effects of the boom in natural gas extraction in booming counties as opposed to the relatively unaffected control counties that do not border on booming counties. However, booming counties were already specialized in natural resource production at the start of the boom period. To overcome this, Weber (2012) takes a difference-in-difference-in-difference approach, by comparing county growth rates after the boom and before the boom in booming counties, with growth rates after the boom and before the boom in non-booming counties, while controlling for observed initial characteristics. Nevertheless, whether a county is booming or not may depend on the local decision to allow extraction, and wealthier counties may be less likely to allow fracking. As a final step, booming counties are instrumented with the percent of land area that covers shale deposits, which is exogenous if one is willing to assume

that exploration had been completed before the sample period. The IV results imply that total employment increased by 1.5% and wages by 2.6% of the baseline level for every 100 million dollars' worth of gas extracted. Weber (2012) finds less robust evidence that the *median* household income increased, and no significant evidence that poverty decreased, suggesting that profits were mostly concentrated in extraction companies and landowners.

In Weber (2014), he further refines these estimates by splitting total employment into mining and manufacturing employment to assess whether there may be long-run repercussions through Dutch disease. This could lead to mining and related sectors, and the non-traded sector, crowding out the traded manufacturing sector through an appreciating real exchange rate. Alternatively, rising low skilled wages may reduce the incentive to invest in education, lowering the average county level of educational attainment over time. Naturally, immigration will attenuate both these effects by keeping wage growth in check. The latter is confirmed by the data which shows a strong positive effect on total population, which mitigates the increase in wages. Finally, there is no significant effect on manufacturing employment growth. The paper finds that each mining job creates 1.3 non-mining jobs, leading it to conclude that dependence on mining does not increase. However, most of the non-mining jobs are thus created in in the non-traded service sector, which may thus depend *increasingly* on the mining sector. Interestingly, the positive local effects do not spill over into neighbouring counties, and there is some evidence that the stock of human capital did not erode.

Allcott and Keniston (2014) confirm the main results in Weber (2012, 2014) for a broader and longer sample. This allows them to combine the shale gas boom with another oil and gas boom – and bust - that started after the oil crisis in the 1970s. Furthermore, the high degree of disaggregation allows identification of spill-over effects across finer industry classifications and more counties. They find that a doubling of resource sector employment predicts a 2.9 percent rise in total employment. In contrast to Weber (2012, 2014), they find that manufacturing employment increases. Manufacturing wages also rise, which they attribute to imperfect elasticity of labour supply despite significant migration. Mostly, the increase in employment in manufacturing is due to linked sectors, that is, sectors up or downstream of the mining sector itself. They find only weak evidence that non-linked traded manufacturing employment contracts and thus no significant negative repercussions through Dutch disease.

Effects on electricity prices and lending

The limited negative effects of local resource production in the United States is to some extent not so surprising if one considers the high degree of labour mobility within a country as opposed to national labour supply. More crowding out, and thus more evidence for a 'curse', is expected at the aggregate level where multipliers are smaller (Moretti, 2010). In addition, the development of up and downstream industries in the United States suggest that a larger share of jobs can benefit directly from mining (Wright and Czelusta, 2007). Finally, the shale revolution has also decreased electricity prices and may have led to local improvements in public goods through increased tax receipts, or to tax cuts, which all lower costs for traded sector manufacturing firms and thus to less crowding out.

Fetzer (2014) specifically investigates the effects of the local reduction in United States electricity prices. A key feature of natural gas as opposed to crude oil is that it is only liquid at high pressure and costly to export overseas. It requires large and expensive LNG terminals at exporting and importing harbours, which inhibits international arbitrage of prices. This means that the natural gas price has fallen in the United States even when oil prices have remained high, leading to lower electricity prices in the United States. Fetzer (2014) uses variation in pipeline capacity and shows that electricity prices fall more in counties that are more constraint, thereby lowering production costs for manufacturing. This compensates any upward pressure on wages and thus is another channel through which Dutch disease can be mitigated at the local level. However, as more pipelines and LNG terminals are constructed one should expect this effect to decline over time.

Within the Corden and Neary (1982) framework, part of the crowding out mechanism relies on the spending effect, which in a local setting depends on whether the natural gas income is spent locally or not. Kelsey et al. (2011) found that among survey respondents about 10% of natural gas royalty payments to land owners was spent, leaving millions to be saved. Gilje et al. (2013) use shale gas related *bank* deposits as an exogenous shock to explain lending by banks across their branch networks. They find that each 1% increase in deposits in booming counties leads to 0.93% increase in mortgage lending in non-booming counties. The effect is stronger for loans that are less likely to be securitized such as home equity lines and new mortgages. This provides another channel through which the spending effect can propagate across counties.

However, in this case the effect does not decay uniformly over space (as above-mentioned papers have assumed) because it depends on whether the bank in the booming county has branches in other counties.

Environmental costs

Finally, an economic literature is emerging on the environmental effects of shale gas extraction. Direct beneficiaries include land owners who receive lease and royalty payments, but other local residents may worry that the drilling techniques affect their water quality adversely. The technique requires large amounts of water of which some return to the surface as waste water, containing the chemicals used in the process, such as heavy metals and salts, which pose considerable health risks if not contained properly. These may include real costs due to mismanagement or perceived costs by potential buyers of houses for sale. Gopalakrishnan and Klaiber (2013) find that houses within 0.75 miles of a well and rely on well water (as opposed to piped water) drop 21.7% in value. This effect attenuates across distance and time as the well dries up. The same effect is found in Muehlenbachs et al. (2014), although they find additionally that house prices increase on average on a larger geographical scale, which is consistent with the positive effects on wages found in the studies mentioned above. This shows however that people are at the minimum very concerned with environmental damages resulting from shale development. James and Smith (2014) extend the environmental costs to include crime hazards. They find that shale producing counties experienced significant increases in property and violent crimes. This suggests that some public goods, such as police protection, have lagged behind the boom in tax receipt.

6. Geography and geology

Recently, there has been a flurry of papers dealing explicitly with the geography and geology of natural resources. This affects the rate of resource exploitation, the structure of international trade and armed conflict. These papers make use of detailed specially constructed datasets.

Cust and Harding (2014) use cross-border data on the exact location of oil wells and national borders, where the latter is argued to be random with respect to geology and can be

viewed as a natural experiment in the assignment of institutional quality. They use their regression discontinuity design to establish that oil exploration takes place less in countries with bad institutions. This might explain why so many natural resources remain in the ground in developing countries with poor institutions and thus are not unleashed to be harnessed for growth and development. For example, most of the drilling has been concentrated in recent years on the Ugandan, but not the Congo side of the border. In fact, there is convincing evidence that expected volatility of the future price (backed out from future contracts) of oil has a negative impact on rig investment and drilling activity in Texas oil wells (Kellogg, 2014).

Much of infrastructure (roads, railways) was constructed to unlock inland mineral deposits and export these via ports to world markets. It has in the past been purpose-built to ship natural resources to the coast, especially in Africa, but such infrastructure can of course be used to import goods as well. Bonfatti and Poelhekke (2014) offer empirical estimates of a gravity model of a cross-section of bilateral trade that suggest that countries with more mines trade relatively less with neighbouring countries, especially so if mines are located closer to city-to-port roads. Such trade diversion effects might hamper regional trade integration. This is in line with the hypothesis that mine-to-coast infrastructure decreases trade costs with world markets relative to those with neighbouring countries. Furthermore, the effect reverses sign for landlocked countries that trade more with at least one (transit) neighbour, while no effect is found for oil and gas extraction, which is typically piped and does not reduce import costs, supporting the infrastructure channel.

Finally, Caselli et al. (2015) argue that by triggering a war a country has a probability of realizing a change in the border and thereby having a chance of grabbing the neighbouring country's oil. They use specially constructed detailed cross-border geographical referenced datasets consisting of 600 border-sharing country pairs in the period 1946-2008 that share a terrestrial border and/or a coast line that is a maximum of 400 miles apart. They then empirically establish that asymmetries matter as conflict is more likely to take place if oil deposits in one country are close to the border, while they are non-existent or located far from the border in the other country. They control for GDP per capita, population, democracy score and capabilities, land areas, civil wars and bilateral trade as fraction of GDP, and also show that their results are robust to border changes.

7. Conclusion

We have made the case for better econometric identification strategies and more innovative datasets to make progress in assessing the quantitative impact of natural resource windfalls. The picture that emerges is rather different from the one offered by the huge literature on cross-country evidence for the natural resource curse. Natural resource windfalls are not always a curse and their effect is more subtle than what we hitherto thought. Although much of the cross-country macroeconomic evidence suggests a negative relationship between natural resource dependence and the rate of economic growth driven by the temporary decline of the traded sector and the accompanied loss of learning by doing, this may be a statistical artefact and the empirical results are not very robust and suffer from endogeneity bias and confounding factors. More important, detailed micro empirical evidence on the local impact of natural resources obtained with sophisticated identification strategies typically finds a positive impact resulting from the mining industry employing local labour and purchasing non-traded goods and services. Within-country evidence also comes up with positive impacts, often from fairly weak spill-over effects resulting from employment programmes financed by natural resource revenue.

The answer to the question whether a resource curse exists thus depends on what type of data set is used and what question is asked. It matters whether we are interested in what drives differences across countries with very different institutions and political structures or whether we want to know what drives differences across districts or across time for a particular country with given institutions and political structures. Even though estimates of local impacts use an empirical design with non-resource areas as control groups, appreciation of the real exchange rate might bite more in these control groups and thus one might see a favourable development in the resource areas even though the economy experiences reduced growth at the macro level. Also, some of these apparently different effects might be the natural consequence of political distortions on the macro level. The main message is that estimates across different empirical approaches are far from trivial.

There are still a lot of empirical fruits to be picked in the search for quantitative knowledge on the impact of natural resource windfalls. For example, Dutch data on outward FDI suggests significant crowding out of non-resource FDI by resource FDI (Poelhekke and van der

Ploeg, 2013). For countries who hitherto did not undertake resource exploration, a resource discovery curbs non-resource FDI by 15.5%. For countries who were already undertaking resource exploration, a doubling of commodity prices curbs non-resource FDI by 13.7% in the long run. Much more work on the impact of natural resources on FDI and on other economic variables such as trade, inequality and happiness is needed. Furthermore, there is a parallel literature using cross-country regressions to assess the positive effect of natural resources on conflict and war (e.g., Collier and Hoeffler, 2004; Ross, 2004). This literature is flawed too for similar reasons, but the study by Dube and Vargas (2013) discussed in Section 4 gives an exciting example of the road ahead.

Although many recent studies move away from the traditional cross-country analysis of the natural resource curse towards studies with micro-level data, it must be said that the best studies attempt to get exogenous variation by using relatively recent resource discoveries and estimates of oil in the ground. The biggest problems stem from the data being cross-sectional rather than panel, so that it is difficult to use fixed effects for unobservable variables. The recent literature on resource curse effects uses more sophisticated cross-country techniques in combination with micro-level data to obtain a proper identification strategy. Like Arezki et al. (2015), Lei and Michaels (2014) is an excellent example of this. They also use data on giant oil discoveries to establish that they increase incidence of armed conflict by 5-8 percentage points, and even more for countries that have already experienced armed conflicts or coups in the preceding decade.

Bridges are thus built between the older and modern literatures on the resource curse, allowing assessment of the quantitative impact of natural resources on the economy, corruption and conflicts. These still provide exciting avenues of future research. The outcomes are of real importance for the plight of developing countries blessed or potentially blessed with natural resources.

Endnotes

1. Abundance, or the value of subsoil assets, depends on the present discounted value of future rents, and thus on price expectations (which depend on growth) and assumptions on the lifetime of reserves and the discount factor. Even not-yet-extracted reserves relate to economically

recoverability of the reserves and also depend on the price of resources and the state of technology. Finally, even reserves depend not only on geology but also on exploration effort. For the latter point, see Cust and Harding (2014). It is therefore difficult to defend common measures of natural resource wealth as exogenous.

2. This setting is ideal if (i) exploration effort was uniform across the counties, and (ii) development of shale was allowed in all counties. Shale formations have long been identified and horizontal drilling and fracking applied since the 1947. The boom of the 1970s and 1980s incentivized exploration. However, it was not until the recent oil price boom that many shale reserves became *economically* recoverable again. Shale development however, does vary by country, state and county. To what extend the decision to ban fracking is endogenous is still an open question. See https://en.wikipedia.org/wiki/Shale_gas and Allcott and Keniston (2014).

References

Acemoglu, D., S. Johnson and J. A. Robinson (2001). The colonial origins of comparative development: an empirical investigation. *American Economic Review*, 91, 1369–1401.

Alexeev, M. and R. Conrad (2009). The elusive curse of oil. *Review of Economics and Statistics*, 91, 3, 586-598.

Allcott H. and D. Keniston (2014). Dutch Disease or agglomeration? The local economic effects of natural resource booms in modern America. Working Paper 20508. Cambridge, MA: NBER

Aragan, F.M. and J.P. Rud (2013). Natural resources and local communities: evidence from a Peruvian gold mine. *American Economic Journal: Economic Policy*, 5, 2, 1-25.

Arezki, R., V.A. Ramey and L. Sheng (2015). News shocks in open economies: evidence from giant oil discoveries. Research Paper 153. Oxford: OxCarre, University of Oxford.

Beine, M. S. Coulombe and W. Vermeulen (2015). Dutch disease and the mitigation effect of migration: evidence from Canadian provinces. *Economic Journal*, 125, 1574-1615.

Bonfatti, R. and S. Poelhekke (2014). From mine to coast: transport infrastructure and the direction of trade in developing countries. Research Paper 107. Oxford: OxCarre, University of Oxford.

Boschini, A.D., J. Pettersson and J. Roine (2007). Resource curse or not: a question of appropriability. *Scandinavian Journal of Economics*, 109, 593-617.

Brunnschweiler, C. and E.H. Bulte (2008). The resource curse revisited and revised: a tale of paradoxes and red herrings. *Journal of Environmental Economics and Management*, 55, 3, 248-264.

Caselli, F. and G. Michaels (2013). Do oil windfalls improve living standards? Evidence from Brazil, *American Economic Journal: Applied Economics*, 5, 1, 208-238.

Caselli, F., M. Morelli and D. Rohner (2015). The geography of interstate resource wars. *Quarterly Journal of Economics*, 130, 1, 267-315.

Cavalcanti, T., D. Da Mata and F. Toscanini (2015). Winning the oil lottery: the impact of natural resource extraction on growth. Mimeo. Cambridge: University of Cambridge.

Collier, P. and A. Hoeffler (2004). Greed and grievance in civil wars. *Oxford Economic Papers*, 56, 663-695.

Corden, W.M. and J.P. Neary (1982). Booming sector and de-industrialisation in a small open economy. *Economic Journal*, 92, 825-848.

Cust, J. and T. Harding (2014). Institutions and the location of oil exploration. Research Paper 127. Oxford: OxCarre, University of Oxford.

Cust, J. and S. Poelhekke (2015). The local economic impacts of natural resource extraction. *Annual Review of Resource Economics*, 7, 251-268.

Dell, M. (2010). The persistent effects of Peru's mining *mita*. *Econometrica*, 78, 6, 1863-1903.

Dube, O. and J. Vargas (2013). Commodity price shocks and civil conflicts: evidence from Colombia. *Review of Economic Studies*, 80, 4, 1384-1421.

Fetzer, T.R. (2014). Fracking growth. CEP Working Paper 1278. London, U.K.: LSE.

Gilje E., E. Loutskina and P.E. Strahan (2013). Exporting liquidity: branch banking and financial integration. Working Paper 19403. Cambridge, MA: NBER.

Gopalakrishnan, S. and H.A. Klaiber (2013). Is the shale energy boom a bust for nearby residents? evidence from housing values in Pennsylvania. *American Journal of Agricultural Economics*, 96, 5, 1-24.

James, A. (2015a). US State fiscal policy and natural resources. *American Economic Journal: Economic Policy*, 7, 238-257.

James, A. (2015b). The resource curse: a statistical mirage?, *Journal of Development Economics*, 114, 45-63.

James, A. and B. Smith (2014). There will be blood: crime rates in shale-rich U.S. counties. Oxford: OxCarre Research Paper 140, University of Oxford.

Kellogg, R. (2014). The effect of uncertainty on investment: evidence from Texas oil drilling. *American Economic Review*, 104, 6, 1698-1734.

Kelsey, T.W., M. Shields, J.R. Ladlee and M. Ward (2011). *Economic Impacts of Marcellus Shale in Pennsylvania: Employment and Income in 2009*. Williamsport: Marcellus Shale Education and Training Center.

Ledesma, D. (2013). *East Africa Gas – Potential for Export*. NG 74 March. Oxford: Oxford Institute for Energy Studies.

Lei, Y.-H. and G. Michaels (2014). Do giant oilfield discoveries fuel internal armed conflicts? *Journal of Development Economics*, 110, 139-157.

Mehlum, H., K. Moene and R. Torvik (2006). Institutions and the resource curse. *Economic Journal*, 116, 1-20.

Michaels, M. (2011). The long term consequences of resource-based specialization. *Economic Journal*, 121, 551, 31-57.

Moretti, E. (2010). Local multipliers. *American Economic Review*. 100 (2), 373–377.

Muehlenbachs, L., E. Spiller and C. Timmins (2014). The housing market impacts of shale gas development. Working Paper 19796. Cambridge, MA: NBER

Ploeg, F. van der (2011). Natural resources: curse or blessing. *Journal of Economic Literature*, 49, 2, 366-420.

Ploeg, F. van der and S. Poelhekke (2009). Volatility and the natural resource curse. *Oxford Economic Papers*, 61, 4, 727-760.

Ploeg, F. van der and S. Poelhekke (2010). The pungent smell of "red herrings": subsoil assets, rents, volatility and the resource curse. *Journal of Environmental Economics and Management*, 60, 1, 44-55.

Poelhekke, S. and F. van der Ploeg (2013). Do natural resources attract non-resource FDI. *Review of Economics and Statistics*, 95, 3, 1047-1065.

Raveh, O. (2015). Dutch disease, factor mobility, and the Alberta effect: the case of federations. *Canadian Journal of Economics*, forthcoming.

Rio Tinto (2013). Simandou Economic Impact Report, May.

Ross, M.L. (2004). What do we know about natural resources and civil war? *Journal of Peace Research*, 41, 337-356.

Sachs, J.D. and A.M. Warner (1997). Natural resource abundance and economic growth, in G. Meier and J. Rauch (eds.), *Leading Issues in Economic Development*. Oxford, U.K.: Oxford University Press.

Tsui, K.K. (2011). More oil, less democracy: evidence from worldwide crude oil discoveries. *Economic Journal*, 121, 551, 89-115.

Vicente, P.R. (2010). Does oil corrupt? Evidence from a natural experiment in West Africa. *Journal of Development Economics*, 92, 1, 28-38.

Weber, J., 2012. The effects of a natural gas boom on employment and income in Colorado, Texas, and Wyoming. *Energy Economics*, 34 (5), 1580–1588.

Weber J. 2014. A decade of natural gas development: the makings of a resource curse? *Resource and Energy Economics*, 37:168-83.

Wijnbergen, S.J. van (1984). The Dutch disease: a disease after all?. *Economic Journal*, 94, 373, 41-55.

Wright G, Czelusta J. 2007. Resource-Based Growth Past and Present. In D. Lederman and W. Maloney (eds.), *Natural Resources: Neither Curse Nor Destiny*. Stanford, CA: Stanford University Press.