The Extractives Dependence Index (EDI)

By

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1. Introduction

There is a wealth of research that discusses the negative and positive aspects of relying on non-renewable resources such as oil, gas and minerals for development. However, the empirical results vary depending on the dimensions used to measure natural resource dependence.

Following the seminal work of Sachs and Warner (1995), the share of oil, gas and mineral in total exports (or in GDP) has become perhaps the most common proxy for resource dependence.[2] Another common variation of this proxy is net resource exports per worker as used by Lederman and Maloney (2008) and mineral exports in total merchandise exports as used by Davis (1995).

Alexeev and Conrad (2009) use per capita hydrocarbon/mineral deposits and the value of oil/mineral produced to measure resource dependence. They argue that using resource exports to GDP: 1) is not independent of economic policies and institutions; therefore the ratio can suffer from endogeneity problems; and 2) does not address the possible bias that can result from high domestic consumption of oil, gas and minerals.

Ding and Field (2005) measure resource dependence as the proportion of total capital that is accounted for by natural resource capital. While Wizarat (2014), Brunnschweiler (2008), Nunn (2008) and Davis (1995) use the value of resource production ratios (per capita or percent of GDP). In addition to production, Stijins (2005) uses fuel and non-fuel mineral reserves per 1,000 inhabitants. Sala-i-Martin *et al.* (2004) use share of mining in GDP.

The International Monetary Fund classifies resource dependent countries as those with oil, gas and mineral revenues or exports of at least 20% of total fiscal revenue and exports, respectively (Baunsgaard et. al, 2012).[3] The Oxford Policy Management has used a similar threshold where a country is defined as resource dependent if resources account for 25% or more of total exports.

[2] See Stijins (2001), Ding and Fields (2005) Brunnschweiler and Bulte (2008a) on the difference between resource abundance (i.e., stocks of natural resource wealth) and resource dependence as (i.e., natural resource exports as a percentage of GDP)

[3] The IMF identified twenty-nine low income or lower middle-income countries as resource rich. The list includes Gabon and Equatorial Guinea because they are members of CEMAC. Liberia, Niger, Cote I'voire and Uzbekistan are also included despite incomplete data. Myanmar is not included "as the artificially low official exchange rate that was in place in the period before April 2012 hampers analysis." In addition, twenty-two upper middle income and high-income countries were classified as resource rich.

Noting that not all resource rich countries are also resource dependent, McKinsey Global Institute, in 2014, classified resource driven countries as those that met any of the following three criteria: resource exports greater than 20% of total exports in 2011; resource revenues more than 20% of government revenue on average from 2006 to 2010; and resource rents[4] greater than 10% of GDP in 2011.[5]

The International Council of Mining and Metals (ICMM) developed the Mining Contribution Index (MCI) to assess the contribution of mining in national economies and consequently an economy's dependence on the mining sector. The MCI is based on three variables: 1) mineral export contribution in 2010; 2) increase/decrease in mineral export contribution 2005-2010; and 3) mineral production value (%GDP) in 2010. The MCI is constructed by first ranking countries in descending order for each of the three variables after which the three variables are weighted equally at 1/3, summed up and multiplied by 100.[6]

To add to the literature on resource dependence, in this paper we propose a composite index.[7] The three indicators that make up our index are: a) the share of export earnings from extractives in total export earnings; b) the share of revenue from extractives in total fiscal revenue; and c) extractives industry value added in total value added.

Our approach, however, goes beyond a simple creation of an index from the above three indicators. We weigh each of the indicators to capture the productive environment under which the extractive sector exists. First, we adjust export earnings from oil, gas and minerals by the share of high-skill and technology intensive manufactures in total exports. This is because, even if two countries have equal shares of export earnings from extractives, the country with a higher degree of skill and technology intensity is likely to have higher productive capabilities and greater probability of spillover of skills to other industries that are export oriented.

[4] Used as a proxy for value added
[5] Eighty-seven countries are identified as resource driven by MGI, including Afghanistan, Guatemala, Madagascar, Sao Tome and Principe, Togo and Uganda who are expected to be resource driven in the future.
[6] See http://www.icmm.com/document/4440 on MCI rankings, methodology and how missing data is dealt with.
[7] We focus on resource dependence, as opposed to resource abundance, as the role of natural resources in an economy cannot be expected to materialize until resources are extracted.

Second, the revenue generated by the extractive sector is adjusted to take account of tax revenue collected from other sources. Countries that generate a significant percentage of their fiscal revenue from oil, gas and minerals are vulnerable to commodity price volatilities. Such vulnerability is best tackled if countries generate revenue from other sources including, for instance, personal income tax, corporate income tax and capital gains tax.

Third, the capacity to domestically process oil, gas and minerals into intermediate and final goods is an important indicator of the difference among countries in terms of their dependence on the extractive sector. In a country where domestic value addition is higher, there are also technological and skill transfers to other sectors. In other words, a higher capacity in value addition is likely to be associated with a higher level of diversification within GDP.[8]

The rest of the paper is organized as follows. Section 2 presents the conceptual approach for the evolution of resource dependence. Section 3 constructs the model for the Extractives Dependence Index (EDI). Section 4 presents the results of the EDI calculations and shows the ranking of the countries in our sample. Concluding remarks are provided in Section 5.

2. The conceptual framework

We hypothesize; following the patterns of development as put forth by the staples thesis, that as an economy increases the rate of its oil, gas and mineral extraction, its dependence on the extractive sector first increases and then decreases. The explanation for such progression comes from the fact that many countries have embarked on their economic development based on extraction of commodities. But these countries have subsequently reduced their dependence on oil, gas and minerals by reducing the amount of foreign exchange and tax revenue they generate from these commodities.

Australia's extractive sector, for instance, illustrates this pattern of first increasing then gradual decline of dependence on the sector. A resurgence of Australia's mining sector in the 1960s led to a change in the composition of exports, tilting the balance towards mineral commodities, including coal, bauxite, iron ore, nickel, manganese, titanium and zirconium. By the 1980s, the commodity boom and development of industries around new mineral discoveries resulted in a significant increase in

[8] See Hausmann and Hidalgo (2011) for the process of accumulating capabilities that drive product diversity

dependence on the mining sector. The sector accounted for 60% of total export revenues, compared to 8.8% in 1920s and the its contribution to GDP increased to 6.5% from 1.7% in 1962 (Robertson 2008, Attard n.d., and The Commonwealth Treasury 2006). As Table 1 shows, the value of minerals produced has continued to increase from AUD 342.6 million in 1969 AUD 113,800 million in 2013. Similarly, mining sector royalties increased from AUD 1.3 million in 1969 to AUD 5100 million in 2013

Table 1: Value of Australia's extractive sector output and royalties

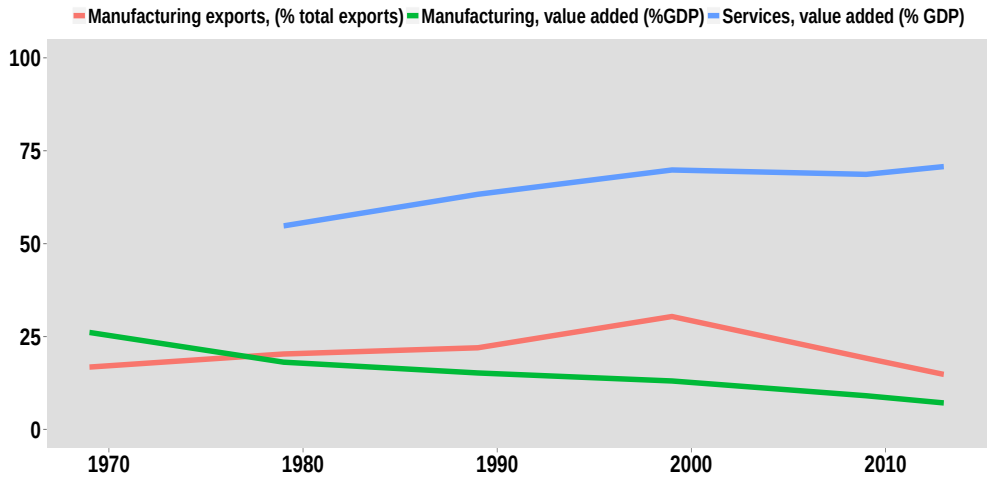
	1969	**1979**	**1989**	**1999**	**2009**	**2013**
Minerals produced (AUD million)	342.6	2134	10438	16700	61000	113800
Royalties (AUD million)	1.3	58	139.49	692.9	3700	5100

Souce: Department of Mines and Petroleum, Government of Australia

To avoid a staples trap, the government began introducing liberalization and structural reforms to increase efficiency and productivity gains from both traded and non-traded sectors. As a result, since the mid-1980s until 2000, manufacturing production volumes grew by an annual rate of 2% and manufacturing exports grew by an annual rate of 11% (Lowe 2012). Since then, manufacturing exports has declined as Australia transitioned to a more service-based economy similar to those of high-income countries (Figure 1**)**. Manufacturing share of GDP had begun to decline by the 1970s. The growth in manufacturing exports consisted of more complex products including specialized machinery and scientific instruments. As Figure 2 shows, employment in services sector grew from approximately 52% from 1961/62 to over 75% in 2011/12. Conversely, manufacturing and agriculture share of employment declined, indicating structural change.

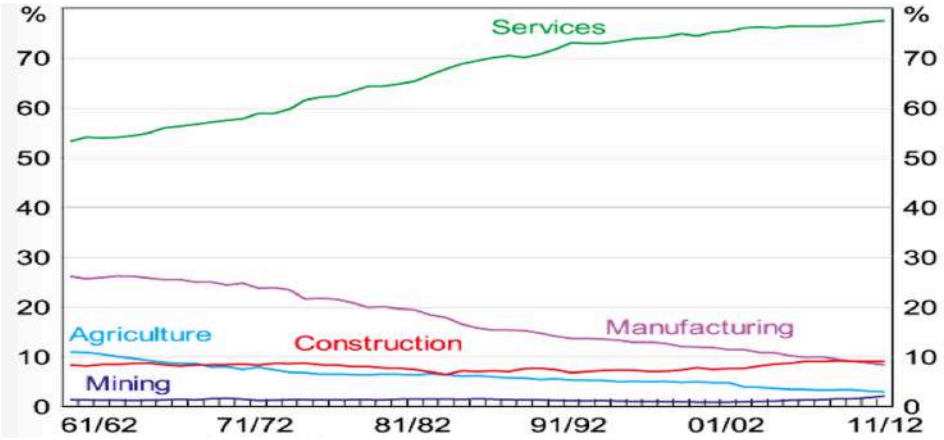
Capturing the benefits of innovation and knowledge, the mining sector also became more mechanized and grew in sophistication. By 1999, over USD 1.2 billion of mining related intellectual property was exported and 60% of the world's mines used software created by Australian companies (Australian Bureau of Statistics 2001). The sector also saw increases in vertical and horizontal integration with every one mining job leading to the creation of another two in sectors such as construction, telecommunications and the sciences (Clements et al., 1996).

Figure 1: Manufacturing and service sectors



Source: Australian Bureau of Statistics and World Bank Development Indicators

Figure 2: Employment by Industry (shares in total employment)



Source: Lowe, Phillip. "The Changing Structure of the Australian Economy and Monetary Policy." Reserve Bank of Australia.

Australia continues to retain a strong mineral sector and export of minerals remain high, averaging 63% since 2005. However, the country developed a relationship between the extractive sector and overall economic performance and has achieved significant diversification in economic activity.

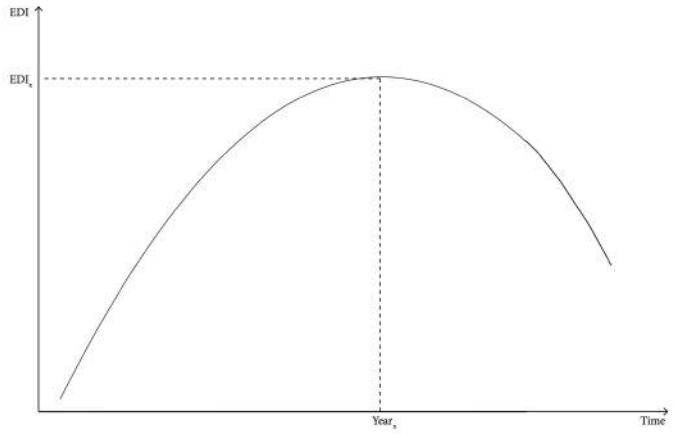
The development of profitable secondary and tertiary sectors, largely supported by the mining sector's ability to generate foreign exchange for imports of capital goods, has reduced the country's dependence on the extractive sector. Today, Australia's extractive sector accounts for 5% of total

government revenues and the sector's contribution to GDP has averaged around 7%. Exports of high skilled products have averaged 10% (of total exports) and the service sector accounts for 42% of exports in value added terms. In addition, the development of skills and human capital of its population has presented alternative opportunities to develop the domestic economy and build on comparative advantages in other sectors. Similar to the Australian experience, countries such as Canada, Finland, Norway, the Netherlands and New Zealand have also developed their secondary sectors based on the resource sector.

Therefore, one possible representation of a country's resource dependence trajectory over time is to look at it as an inverted-U. Initially, a larger share of foreign exchange and tax revenue is derived from non-renewable resources. Hence, any measure of resource dependence has to first increase. As the economy diversifies and other source of foreign exchange and revenues emerge, the measure of dependence begins to decline.

This relationship is depicted in Figure 3 below. The EDI in our case is expected to rise and reach a point of high resource dependence and then decline as alternative sources of finance emerge. Therefore, having a high EDI does not necessary imply a dependence on resources that has to be avoided. Rather it is an indication of the need to adopt strategies for future diversification of economic activity within GDP. What policy makers need to worry about is persistent dependence on resources and not transient ones.

Figure 3: The EDI Curve



We take a closer look at the extractive sector dependence of Mongolia, Nigeria and Botswana to further illustrate the different stages of the EDI curve.

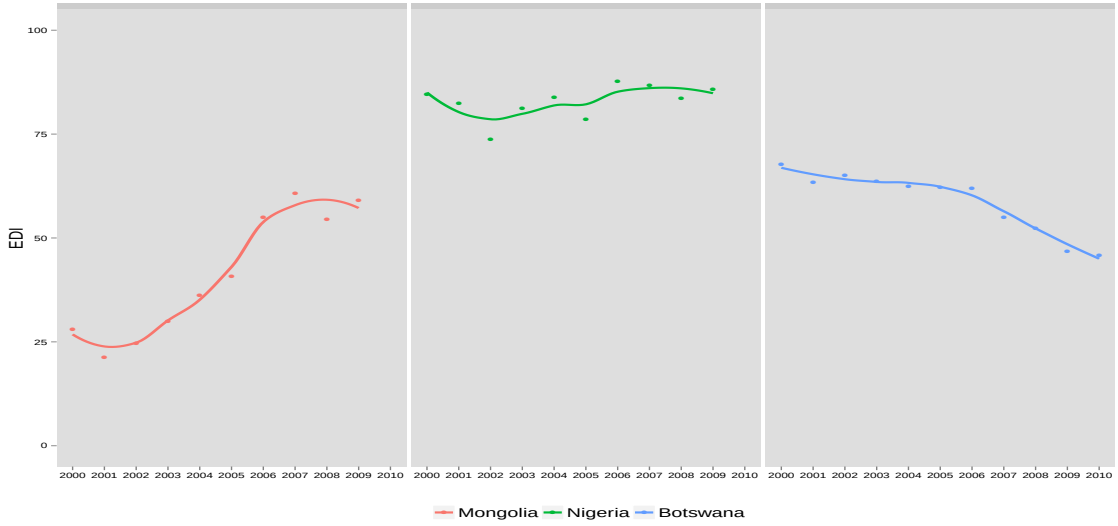
Mongolia's mining sector has been active since the 1970s, but the country's extractive sector is relatively nascent. It was not until the 1990s that Mongolia experienced a significant expansion of mineral exploration and mining. With the discovery of the Oyu copper and gold deposits in early 2000s and commencement of large scale mines, the mining sector has become the largest financial contributor to the economy. As Figure 4 shows, Mongolia is in the first stage of the EDI curve and its dependence has followed an upward rise since 2000.

Oil and gas operations began in Nigeria in 1908 and the country started commercial production of oil in 1958 at a rate of 5,100 barrels of crude oil per day. By 1973, production rose to over 2.0 million barrels per day and today Nigeria is Africa's largest and the world's 13th largest oil producer (BP Statistical Review of World Energy 2015).[9] After 80 years of production, however, the economy continues to be dominated by the oil and gas sector. For the past three decades oil has provided 90% of foreign exchange earnings and financed 80% of total government revenues. As Figure 4 shows, from 2000 to 2010, Nigeria remained in the second stage of the EDI curve and has not undergone the structural transformation required to decrease the dependence on the extractive sector.

Since the 1980s, Botswana has experienced an average economic growth rate of 7.8%, of which the mining sector is responsible for 40% (Iimi 2006). The government's efforts to promote downstream value addition; to develop non-resource sectors including agriculture and tourism; and mainly to de-link expenditure from resource revenues have enabled the country to slowly transition to the third stage of the EDI curve. As Figure 4 shows, although Botswana remains dependent on the extractive sector, for instance, diamonds, nickel, copper, gold and other resources continue to bring in an average of 85% of total export earnings, its dependence has slowly declined since 2000. However, diversification to non-resource sectors still remain a work in progress as does building resilience to price volatility.

[9] In addition to oil, Nigeria is rich in natural gas, tin, iron ore, coal, lead, and zinc.

Figure 4: The EDI Curve: Botswana, Mongolia, and Nigeria



3. The EDI Formula

The equation from which the EDI is derived is given below:

$$\mathbf{EDI_{ct}} = \sqrt[3]{[\mathbf{EIX_{ct}}\times(\mathbf{1}-\mathbf{HTM_{ct}})] * [\mathbf{Rev_{ct}}\times(\mathbf{1}-\mathbf{NIPC_{ct}})] * [\mathbf{EVA_{ct}}\times(\mathbf{1}-\mathbf{MVA_{ct}})]}$$

EDI is Extractives Dependence Index for country **c** in time **t**;

EIX is export revenue from oil, gas, and minerals as a share of total export revenue;

HTM is export revenue from high-skill and technology intensive manufactures as a share of total HTM exported in year **t**;

Rev is revenue generated by the extractive industry as a share of total fiscal revenue;

NIPC is the total tax revenue collected from non-resource income, profits and capital gains as a share of GDP;

EVA is extractives industries value added as a share of total value added; and

MVA is the per capita manufacturing value added used as a proxy for domestic industrial capability

In the next sections, we discuss each of the three components of the above Equation.

3.1 Share of extractive exports in total exports

Higher degrees of export concentration around extractive commodities are correlated with greater volatility in export earnings and economic growth rates. Lessening the dependence on the extractive sector, therefore, requires additional sources of foreign exchange (other than oil, gas and minerals), particularly from high skill and technology intensive manufactured exports.[10]

Hence, the first term in Equation 1, $[\boldsymbol{EIX_{ct}}\times(\mathbf{1}-\boldsymbol{HTM_{ct}})]$, shows the adjustment of the export earning variable ($\boldsymbol{EIX}$) by the strength of the earnings from high-skill and technology intensive manufactured goods ($\boldsymbol{HTM}$). This takes into consideration a country's competitiveness in global trade. Higher shares of skill and technology intensive products imply well-developed capabilities to compete in the global market. The same capabilities can be used to diversify into a range of export products, hence lessening the dependence on the extractive sector.

We use Norway and Zambia as examples to illustrate the intuition behind the variables chosen, and the resulting calculation of the EDI. In 2008, the share of export earnings from the extractive sector for Norway and Zambia were 74% and 76%, respectively. While the extractive industry export share of the two countries is similar, their levels of economic development, human capital and technological progress are very different. Hence the degree of dependence on the extractive sector must also be different.[11]

In 2008, with a different share of high skill and technology exports, the first component of the $\boldsymbol{EDI}$ in Equation 1 results in more than a 10-point difference in the degree of dependence in export earnings between the two countries. Norway is less dependent with a first term value of 57.84 and the more dependent Zambia has a value of 70.93. Using just the export share of extractive commodities to measure dependence on the industry would have placed the two countries, with very different productive capabilities, in the same category. See the calculations below:

[10] The manufacturing sector contains greater learning effects and skills transfers that would lead an economy into a steeper productivity curve.

[11] In 2008, $\boldsymbol{GNI}$ per capita in Norway was USD 85,580 and the country was ranked at the top of the Human Development Index ($\boldsymbol{HDI}$). On the other hand, $\boldsymbol{GNI}$ per capita in Zambia was USD 970 and the country was ranked 141 out of 187 countries in the $\boldsymbol{HDI}$ rankings. Similarly, about 60% of Zambians live below the national poverty line while in Norway the figure is 4.3%.

Norway	Zambia
$[\boldsymbol{EIX_{2008}} * (\mathbf{1} - \boldsymbol{HTM_{2008}})]$ $= \mathbf{73.8} * [\mathbf{1} - \mathbf{0.22}]$ $= \mathbf{57.84}$	$[\boldsymbol{EIX_{2008}} * (\mathbf{1} - \boldsymbol{HTM_{2008}})]$ $= \mathbf{76.3} * [\mathbf{1} - \mathbf{0.07}]$ $= \mathbf{70.93}$

3.2 Share of extractive revenues

Commodity price volatility has implications for governments' fiscal position by subjecting them to boom-bust cycles. In the upswing, while some governments save a large proportion of increased revenues, others use the windfall to finance government spending. In the downswing, inability to finance expenditure commitments built-up during boom years can result in a fiscal crisis. Establishing a reliable revenue base is therefore an important determinant of a sustainable fiscal position, particularly for resource rich countries.

The second term in Equation 1, $\boldsymbol{Rev_t}$, partly captures the extent of dependence on the extractive sector for government revenue. It is the ratio between government revenue from the extractive sector and total fiscal revenue. To take into account alternative sources of revenue, we adjust the $\boldsymbol{Rev}$ term by **NIPC**, which is total non-resource tax from incomes, profits and capital gains as a share of GDP. A higher ratio between non-resource tax from incomes, profits and capital gains and GDP reflects an economy with a larger non-resource revenue base. Moreover, because collection of taxes from this category is more complex than other categories such as property taxes or taxes on imports/exports, it requires greater tax collection capacity.[12]

Therefore, our second term in the EDI equation above will be: $\mathbf{Rev_{ct}} \times (\mathbf{1} - \mathbf{NIPC_{ct}})$. If there are two countries with the same $\boldsymbol{Rev}$ but different **NIPC** values, the country with a higher **NIPC** score will have lower extractives-related revenue dependence [i.e.: $\mathbf{Rev_{ct}} \times (\mathbf{1} - \mathbf{NIPC_{ct}})$ will be relatively lower].

[12] Fenochietto and Pessino (2013) find that countries with higher values of GDP per capita are relatively closer to their tax capacities while for developing countries, high levels of tax exemptions and low tax rates in part are responsible for the greater distance between actual tax revenues collected and what could be collected (tax capacity). Resource rich countries, in particular, display greater inefficiencies in tax collection. For example, from 2010 to 2012, tax exemptions to mining companies in Sierra Leone cost the government USD 597.6 million, equivalent to 57.7% of total domestic revenues collected or 140% of international aid receipts over the same period (NRW, 2014). Similarly, it is estimated that earlier changes in legislation in Zambia could have raised additional copper revenues as large as 3.7% of GDP between 1997 and 2012 (Simpasa et al. 2013)

Using the same illustration as above, in 2008, the extractive sector's contribution to government revenue as a share of total fiscal revenue for Norway and Zambia, were 26.8% and 15.4%, respectively. In the same year, NIPC for the two countries was 17.2% and 8.5%, Thus, although Norway collects close to double the revenues from the extractive sector compared to Zambia, the index takes into account Norway's larger non-resource tax base giving it a revenue dependence score only 5 points higher than Zambia.[13] Calculations using square root transformed **NIPC** values are shown below.

Norway	**Zambia**
$[\boldsymbol{Rev}_{\mathbf{2008}} * (\mathbf{1} - \boldsymbol{NIPC}_{\mathbf{2008}})]$ $= \mathbf{26.78} \times (\mathbf{1} - \mathbf{0.42})$ $= \mathbf{15.66}$	$[\boldsymbol{Rev}_{\mathbf{2008}} * (\mathbf{1} - \boldsymbol{NIPC}_{\mathbf{2008}})]$ $= \mathbf{15.378} \times (\mathbf{1} - \mathbf{0.29})$ $= \mathbf{10.88}$

3.3 Extractives value added

Lower levels of dependence on oil, gas and minerals require diversification of economic activity within GDP. Therefore, we take account of the extent to which a country can add value domestically to oil, gas and minerals. To illustrate the point, think of a country that is highly dependent on oil. Its GDP is entirely driven by oil exports. Think of another country with the same size of the oil sector, but this country processes its oil into petroleum products domestically. While the traditional measures of extractives consider both countries as highly dependent on the sector, our index adjusts the extractives value added term in Equation 1 by how good the country is in domestic value addition. The reason is to give a higher weight to the country that processes its raw materials domestically and treat it as relatively less dependent on resource extraction.

We illustrate the reasoning by taking Equatorial Guinea as an example. From 2001 to 2009, the extractive sector value added as a share of total value added in Equatorial Guinea ranged from 73% to 92%. However, the high value added figure exists within a largely underdeveloped industrial base, where the average manufacturing value added as a share of GDP during the same period was

[13] The extent to which oil, gas and mineral revenues are the main source of public finance will also affect how dependent an economy is on extractives. However, because of limited data, our Index does not include public expenditure from commodity revenues.

7.14%.[14] Equatorial Guinea's value added figures are largely based on primary extraction of crude oil rather than processing it into petroleum products.[15]

Therefore, when calculating the EDI, the third term in Equation 1, $\boldsymbol{EVA_{ct}} \times [(\mathbf{1} - \boldsymbol{MVA_{ct}})]$, shows the value added contribution from the extractive sector adjusted by per capita manufacturing value added (MVA). Higher values of per capita manufacturing value added reflect a more mature industrial base with higher capacities to turn raw materials into processed or semi-processed goods, hence retaining more value within the resource producing country.[16]

One caveat is in order. A country that domestically adds value to its own extractive commodities is, by intuition, dependent on the extractive sector. Our argument is that, such dependence is relatively better than a dependence on raw extractive commodity exports without domestic value addition. One justification for our argument is that value addition allows countries to fetch higher prices for their exports. For instance, from 2005 to 2010, average annual prices for iron ore stood at USD 62.94 PMT while the average price of hot rolled steel and steel wire rods during the same period were more than five times that of iron ore prices – selling for USD 677 PMT and USD 732 PMT, respectively.[17] Greater value addition also means higher level of transferable skills that can increase technology transfer and employment mobility within and between sectors.

Using our country illustration, in 2008, value added figures from the extractive sector (%EVA) for Norway and Zambia were 28.9% and 4.12%, respectively. Per capita manufacturing value added for the two countries were US$8,054.63 and US$112.68, respectively. Using normalized values for both EVA and MVA, the calculations for the third component of EDI in Equation 1, are as follows:

Norway	**Zambia**

[14] UNSD National Accounts, National Accounts Main Aggregates Database and African Development Bank Group, Open Data for Africa
[15] U.S. Energy Information Administration (2013).
[16] Our calculations show that the Pearson correlation between normalized values for MVA and UNIDO's Competitive Performance Index was approximately 0.63.
[17]Calculated using data from IndexMundi Commodity Prices

$\boldsymbol{EVA_{2008} \times (1 - MVA_{2008})}$ $\boldsymbol{= 89.90 \times (1 - 0.78)}$ $\boldsymbol{= 19.45}$	$\boldsymbol{EVA_{2008} \times (1 - MVA_{2008})}$ $\boldsymbol{= 65.81 \times (1 - 0.02)}$ $\boldsymbol{= 64.41}$

Although Norway's EVA (%) is higher than that of Zambia's, by taking into account Norway's capacity to process the raw materials, the EDI ranks Zambia as more dependent on the extractives sector in value added terms.

Finally, we take the geometric mean of the three components to construct the EDI.[18] The EDI values range from 0 to 100, with 100 being the highest dependence score. Putting together the three components of Equation 1, the EDI values for Norway and Zambia in 2008 were 26.02 and 36.77 respectively. Out of the 64 countries for which data was available in 2008, Norway and Zambia ranked 21 and 31 on the Index, respectively.

4. The EDI calculation and the results

Due to limited availability of extractive industry data, the index values were calculated for 67 countries from 2000 to 2010. Table 2 and Figure 5 list the EDI scores for 2009 and rank the countries for that year in terms of their dependence on the extractive sector (EDI value of 0 indicates no dependence and a value of 100 high dependence). Table 3 lists the EDI values for all years between 2000 and 2010.

[18] We use the min/max normalisation method where $normalised\ value = \frac{value - \min(x)}{\max(component) - \min(x)}$. Raw data for the value added component are highly skewed to the right. We perform a statistical transformation by first taking the natural log then to put the two indicators on a common basis, we normalize them either using the min/max method or by converting percentiles and mapping them to a 0-1 scale, i.e. normalized values of EVA and MVA are first calculated after which value added component is calculated. We perform square root transformation on HTM and NIPC.

Table 2 Ranks, EDI values and its components for 2009

Rank	EDI	Country	EI Export Share	HTM *	Export Component	Revenue	NIPC*	Revenue Component	EI Value Added *	MVA *	Value Added Component
1st.	2.85	Afghanistan	3.65	0.06	3.42	0.33	0.16	0.28	24.22	0	24.22
2nd.	4.76	Philippines	6.38	0.29	4.55	0.81	0.24	0.61	51.26	0.25	38.61
3rd.	5.68	Madagascar	10.05	0.06	9.48	2.12	0.14	1.83	10.56	0	10.56
4th.	5.76	United Kingdom	15.74	0.41	9.32	1.58	0.36	1	59	0.65	20.4
5th.	6.36	Canada	31.7	0.35	20.49	0.89	0.39	0.54	73.37	0.69	23.09
6th.	7.35	Albania	14.97	0.08	13.72	1.05	0.18	0.87	41.77	0.2	33.27
7th.	8.75	Liberia	16.64	0.02	16.32	13.48	0.28	9.72	4.22	0	4.22
8th.	8.82	Lesotho	22.65	0.05	21.44	0.74	0.35	0.48	70	0.05	66.29
9th.	8.92	Brazil	21.6	0.27	15.84	2.34	0.27	1.71	50.43	0.48	26.28
10th.	12.41	Burkina Faso	26.3	0.04	25.34	1.41	0.16	1.18	64.02	0	64.02
11th.	12.83	Mozambique	38.01	0.06	35.64	1.47	0.23	1.13	52.21	0	52.21
12th.	12.90	Kyrgyzstan	13.12	0.06	12.29	6.36	0.23	4.92	37.52	0.05	35.51
13th.	14.36	Ghana	20.45	0.07	19.03	2.62	0.18	2.15	72.58	0	72.58
14th.	14.61	Sierra Leone	43.68	0.05	41.51	1.58	0.17	1.31	57.24	0	57.24
15th.	15.26	Australia	65.07	0.24	49.63	5.03	0.42	2.91	73.06	0.66	24.64
16th.	16.10	Tanzania	37.97	0.08	35.06	2.28	0.22	1.79	66.59	0	66.59
17th.	19.98	Cote d'Ivoire	31.81	0.11	28.23	5.96	0.2	4.77	67.78	0.13	59.17
18th.	20.11	Namibia	42.22	0.09	38.51	5.68	0.31	3.92	79.56	0.32	53.86
19th.	21.59	Viet Nam	17.06	0.2	13.62	14.18	0.18	11.57	74.9	0.15	63.83
20th.	21.80	Central African Rep.	43.82	0.02	42.79	4.42	0.15	3.76	64.35	0	64.35
21st.	21.85	Mexico	17.46	0.38	10.86	31.03	0.22	24.12	74.18	0.46	39.82
22nd.	22.82	Malaysia	16.7	0.38	10.31	41.33	0.27	30.01	80	0.52	38.41
23rd.	24.21	Norway	67.71	0.22	52.91	19.79	0.37	12.52	87.04	0.75	21.43
24th.	26.82	Colombia	54.32	0.17	45.01	16.19	0.43	9.27	72.43	0.36	46.23
25th.	28.33	Chile	61.38	0.17	51.23	12.05	0.2	9.68	84.59	0.46	45.86
26th.	30.19	Niger	34.43	0.09	31.16	14.21	0.13	12.32	71.65	0	71.65
27th.	31.53	Indonesia	38.19	0.25	28.81	27.27	0.23	20.92	77.13	0.33	52.03
28th.	32.92	Ecuador	51.11	0.09	46.58	16.56	0.22	12.92	88.82	0.33	59.29
29th.	33.18	Russian Federation	68.35	0.25	50.98	25.4	0.3	17.76	75	0.46	40.33
30th.	33.55	Peru	69.56	0.12	61.12	14.11	0.18	11.54	79.3	0.33	53.53
31st.	35.06	Myanmar	38.46	0.05	36.46	37.75	0.11	33.66	36.53	0.04	35.13
32nd.	36.41	Dem. Rep. Congo	78.8	0.06	74.22	9.45	0.16	7.98	81.55	0	81.55
33rd.	37.01	Venezuela	90.27	0.15	76.44	18.66	0.19	15.08	91.21	0.52	43.96
34th.	37.01	Azerbaijan	92.33	0.08	85.29	9.58	0.19	7.76	95.14	0.19	76.62
35th.	37.51	Syrian Arab Republic	41.05	0.12	36.1	21.33	0.2	17.13	88.52	0.04	85.35
36th.	38.04	Zambia	76.39	0.07	70.72	22.11	0.28	15.92	48.9	0	48.9
37th.	38.56	Mali	54.82	0.06	51.45	18.39	0.16	15.37	72.51	0	72.51

38th.	40.95	Cameroon	42.92	0.08	39.66	30.1	0.17	24.91	77.61	0.1	69.48
39th.	42.41	Qatar	85.74	0.16	71.72	48.97	0.13	42.78	94.69	0.74	24.86
40th.	43.22	Trinidad and Tobago	72.3	0.15	61.71	50.02	0.26	37.06	85	0.58	35.31
41st.	46.85	Botswana	72.9	0.08	66.75	30.27	0.25	22.61	90	0.24	68.12
42nd.	48.13	Mauritania	66.83	0.03	64.7	24.76	0.2	19.7	87.53	0	87.53
43rd.	49.37	United Arab Emirates	67.38	0.26	49.92	69.73	0.04	67.16	92.07	0.61	35.89
44th.	50.27	Bolivia	69.39	0.07	64.2	37.52	0.25	28.18	83.52	0.16	70.21
45th.	51.65	Kazakhstan	82.35	0.16	69.36	49.86	0.25	37.44	84.9	0.38	53.04
46th.	54.34	Bahrain	64.29	0.13	56.05	83.21	0	83.21	86.08	0.6	34.41
47th.	55.05	Guinea	83.7	0.05	79.78	26.72	0.09	24.21	86.37	0	86.37
48th.	55.51	Oman	78.37	0.15	66.55	79.77	0.24	60.48	95	0.55	42.49
49th.	58.29	Iran	86.17	0.18	70.95	58.38	0.24	44.53	89.9	0.3	62.69
50th.	59.04	Mongolia	84.96	0.04	81.68	37.22	0.2	29.8	87.62	0.04	84.51
51st.	60.02	Gabon	81.38	0.06	76.88	51.92	0.25	38.91	96.57	0.25	72.28
52nd.	60.36	Saudi Arabia	83.88	0.27	61.45	85.21	0.07	78.96	94.08	0.52	45.33
53rd.	61.31	Brunei Darussalam	97.36	0.05	92.52	86.53	0.13	75.51	97.37	0.66	32.99
54th.	62.97	Timor-Leste	82.92	0.02	81.66	98.93	0.08	91.22	33.52	0	33.52
55th.	64.14	Kuwait	88.96	0.19	72.11	87.55	0.06	82.01	94.3	0.53	44.62
56th.	66.89	Sudan	91.98	0	91.98	48.13	0.09	43.64	80.74	0.08	74.55
57th.	67.81	Chad	93.84	0.06	88.31	44.21	0.16	37.2	94.9	0	94.9
58th.	70.36	Yemen	88.71	0.06	83.59	57.71	0.2	46.25	90.67	0.01	90.09
59th.	73.31	Algeria	98.84	0.09	89.83	65.65	0.21	51.58	95.12	0.11	85.04
60th.	73.78	Libya	97.14	0.11	86.31	90.69	0.2	72.71	97.25	0.34	64
61st.	76.98	Angola	99.07	0.07	92.57	70.35	0.16	59.43	99.36	0.17	82.93
62nd.	81.44	Congo	86.52	0.05	82	80.95	0.16	68.1	98.55	0.02	96.72
63rd.	83.54	Equatorial Guinea	96.37	0.09	87.96	90.59	0.27	66.28	100	0	100
64th.	85.78	Nigeria	93.7	0.09	85.09	99.05	0.18	81.68	90.8	0	90.8
65th	86.74	Iraq	98.52	0.09	90.03	79.99	0.06	74.98	96.67	0	96.67

* = Normalized or transformed values

Figure 5: EDI Results for 2009

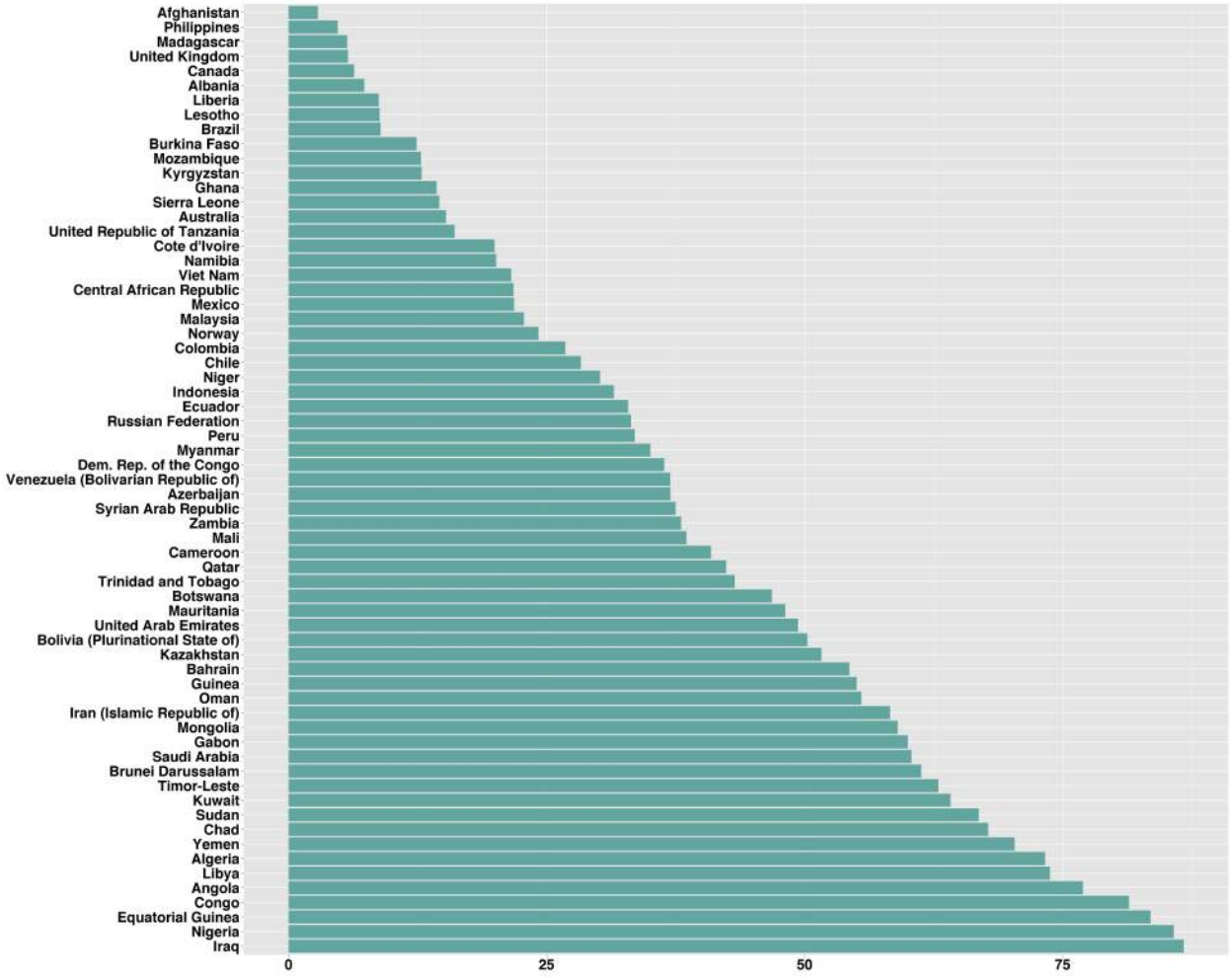


Table 3: EDI Scores (2000-2010)

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1. Afghanistan	--	--	--	--	--	--	--	--	8.94	2.85	2.76
2. Albania	--	--	--	--	--	--	--	--	--	7.35	7.93
3. Algeria	82.15	77.98	75.3	78.04	78.11	79.98	79.49	78.77	78.69	73.31	--
4. Angola	90.61	85.32	84.59	83.94	85.08	85.77	84.99	81.96	80.88	76.98	74.49
5. Australia	--	13.58	12.35	10.79	10.14	11.56	12.28	11.63	13.62	15.26	--
6. Azerbaijan	51.96	45.39	62.47	42.99	53.8	43.23	54.57	55.48	44.81	37.01	34.03
7. Bahrain	58.16	55.87	54.82	54.87	55.73	55.83	55.74	54.53	55.37	54.34	--
8. Bolivia	--	--	--	--	--	--	49.8	49.55	52.56	50.27	--
9. Botswana	67.74	63.35	65.08	63.74	62.38	62.24	62.08	55.07	52.39	46.85	45.92
10. Brazil	7.32	7.3	8.02	9.77	8.97	10.12	11.09	9.86	10.88	8.92	--
11. Brunei Darussalam	58.06	59.2	59.91	59.75	61.66	62.5	63.55	63.2	60.63	61.31	--
12. Burkina Faso	--	--	--	--	--	--	--	--	5.94	12.41	14.25
13. Cameroon	50.74	30.03	18.76	24.94	26.6	27.04	19.54	25.67	27.03	40.95	31.56
14. Canada	--	--	4.53	5	5.35	5.77	6.59	7.12	8.06	6.36	--
15. Central African Republic	--	--	--	--	--	--	20.69	13.41	17.78	21.8	13.93
16. Chad	--	--	--	--	60.48	70.09	79.57	79.07	83.6	67.81	--
17. Chile	18.94	15.56	14.4	19.11	30	32.72	39.95	39.24	33.85	28.33	28.1
18. Colombia	--	--	--	20.5	19.67	20.36	20.79	20.48	23.19	26.82	18.82
19. Congo	81.63	77.39	76.88	77.14	77.82	85.04	85.58	80.66	82.07	81.44	78.39
20. Cote d'Ivoire	--	--	--	7.12	18.39	23.04	15.24	14.72	27.49	19.98	--
21. Dem. Rep. of the Congo	41.18	36.79	53.82	52.49	51.37	56.02	53.5	48.12	45.72	36.41	42.08
22. Ecuador	44.11	37.16	35.05	36.9	41.24	41.24	42.98	41.57	43.23	32.92	--
23. Equatorial Guinea	87.22	79.94	76.77	78.53	82.31	82.37	82.15	81.13	83.86	83.54	--
24. Gabon	--	--	--	--	54.69	68.26	67.23	60.75	63.45	60.02	--
25. Ghana	--	--	--	--	9.64	11.87	12.93	11.61	14.26	14.36	10.25
26. Guinea	52.67	54.19	50.39	43.66	47.91	59.13	55.72	56.37	57.59	55.05	52.22
27. Indonesia	--	34.48	29.99	29.4	30.37	32.31	33.44	29.78	31.45	31.53	26.83
28. Iran	67.18	64.38	69.36	69.35	68.52	67.04	65.8	64.82	62.14	58.29	52.6
29. Iraq	--	--	--	--	92.6	90.43	88.85	88.23	91.39	86.74	82.76
30. Kazakhstan	--	--	40.74	42.5	44.96	37.59	50.94	52.62	56.43	51.65	--
31. Kuwait	--	64.47	63.93	62.01	62.96	59.88	62.01	62.73	64.2	64.14	59.01
32. Kyrgyzstan	--	14.99	15.56	17.81	20.38	17.67	13.74	12.79	13.72	12.9	9.65
33. Lesotho	--	--	--	--	--	5.52	8.56	6.79	17.29	8.82	7.13
34. Liberia	--	--	--	--	--	--	--	--	11.4	8.75	13.19
35. Libya	69.59	71.29	78.79	82.45	79.61	80.83	79.55	76.88	74.89	73.78	71.45
36. Madagascar	--	--	--	--	--	--	--	5.96	6.76	5.68	0
37. Malaysia	15.87	16.56	14.99	15.63	17.82	19.59	21.28	21.49	24.34	22.82	17.89
38. Mali	--	--	--	--	--	--	25.38	39.18	36.2	38.56	31.21
39. Mauritania	31.56	29.47	27.48	--	--	67.74	41.13	47.93	51.62	48.13	--
40. Mexico	18.28	16.77	17.27	19.78	21.3	22.65	23.19	23.03	23.94	21.85	--
41. Mongolia	28.06	21.21	24.72	29.99	36.28	40.68	55.05	60.69	54.42	59.04	--
42. Mozambique	--	--	--	--	--	--	--	--	7.21	12.83	10.15
43. Myanmar	--	--	--	32.72	37.69	38.51	38.29	35.38	36.06	35.06	--
44. Namibia	25.94	28.53	33.44	20.73	22.18	20.37	24.4	24.79	24.06	20.11	17.09

45. Niger	27.55	24.54	21.66	19.86	19.16	15.9	11.64	29.02	43.37	30.19	20.88
46. Nigeria	84.67	82.36	73.75	81.27	83.87	78.52	87.71	86.81	83.69	85.78	--
47. Norway	27.53	27.05	26.47	26.11	25.11	23.87	22.47	21.78	26.02	24.21	--
48. Oman	68.79	63.77	63.06	63.5	64.9	64.44	61.63	57.87	57.43	55.51	--
49. Peru	--	--	--	--	26.69	31.96	35.96	34.24	34.05	33.55	--
50. Philippines	--	--	--	--	--	--	--	4.96	4.34	4.76	2.73
51. Qatar	61.34	57.35	55.92	53.08	46.82	48.57	46.01	44.92	39.91	42.41	37.53
52. Russian Federation	31.46	29.93	28.87	29.22	32.4	36.74	36.62	33.46	33.9	33.18	--
53. Sao Tome and Principe	--	--	--	--	--	7.98	--	10.82	--	--	--
54. Saudi Arabia	64.99	64.13	62.98	64.78	62.73	64.7	64.44	62.84	63.28	60.36	52.8
55. Sierra Leone	9.37	8.59	11.83	12.95	16.36	19.69	20.38	16.95	16.46	14.61	12.4
56. Sudan	--	--	--	--	--	--	--	--	75.6	66.89	51.01
57. Syrian Arab Republic	61.25	65.11	60.2	62.06	54.86	45.85	42.73	38.73	42.63	37.51	--
58. Timor-Leste	--	--	--	24.94	58.89	64.18	52.61	52.14	62.06	62.97	77.63
59. Togo	--	--	--	--	--	--	--	--	--	--	15.12
60. Trinidad and Tobago	36.08	37.92	33.85	40.41	39.21	42.78	46.03	43.24	42.72	43.22	--
61. United Arab Emirates	44.3	45.03	44.14	46.38	47.16	46.74	49.19	50.05	52.69	49.37	46.51
62. United Kingdom	4.21	4.36	4.56	4.31	4.47	5.23	5.25	5.31	6.54	5.76	3.77
63. Tanzania	--	--	--	22.2	3.13	10.51	11.72	11.68	11.39	16.1	17.4
64. Venezuela	56.47	53.13	55.55	59.75	55.48	54.39	53.59	53.25	51.74	37.01	--
65. Viet Nam	33.94	32.24	30.17	30.14	32.07	34.35	33.25	29.11	26.91	21.59	--
66. Yemen	80.44	78.1	76.99	77.57	77.31	80.49	76.61	77.76	79.37	70.36	--
67. Zambia	--	--	--	--	--	11.37	17.83	28.45	36.77	38.04	31.24

Figure 6 shows EDI scores in 2000 against scores in 2009. The figure further demonstrates our examples of the staples thesis with reference to Mongolia, Nigeria and Botswana. As depicted in Figure 6, Mongolia's EDI value in year 2000 was about 29, but in 2009 the value increased to about 59. Hence Mongolia is becoming more dependent on its minerals, before the decline materializes. Nigeria maintains the value of EDI over 85 both in the year 2000 and 2009. Hence Nigeria is not moving along the lines predicted by the staples thesis. In the case of Botswana the EDI declined from 68 to 47 between 2000 and 2009.

Figure 6: Scatterplot of EDI scores (2000 and 2009)

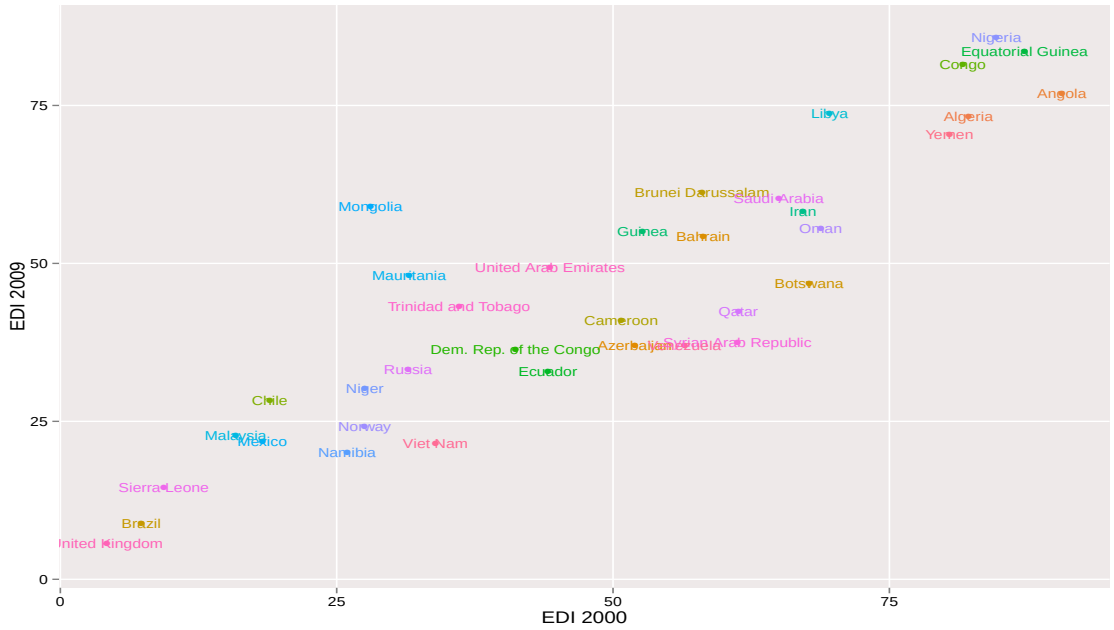


Table 4 compares our EDI results from 2009 and 2010 against resource dependence classifications made by the IMF, the McKinsey Global Institute (MGI) and ICMM.[19] Of the forty-seven countries classified as resource dependent by the IMF, all countries, except Malaysia, have EDI values higher than 21. Because the EDI quantifies resource dependence, it allows for ranking among countries. For instance, while natural resources play an important role in Vietnam and Nigeria, both classified as resource dependent by the IMF, the EDI quantifies the degree of dependence between the two countries. Vietnam is less dependent with an EDI score of 21.59 and Nigeria more dependent with an EDI score of 85.78.

Of the eighty-seven countries classified as resource driven by MGI, the EDI was calculated for 60 of them. The MGI list includes future producers, such as Afghanistan, and countries that meet all three criteria, for example Republic of Congo, Norway, Saudi Arabia and Venezuela.[20] One difference is that our EDI ranks Timor-Leste as a relatively high dependence country (EDI score 77.63); however, the MGI does not include Timor-Leste as a resource driven country. Similar to the IMF classification,

[19] In order to compare ICMM, IMF and MGI lists, we use the most recent data available out of the 2009 and 2010 results. Both ICMM and MGI use 2010 data in their criteria/classification and the IMF classification looks at 2006 to 2010 period.

[20] The three criteria are: resource exports greater than 20% of total exports in 2011; resource revenues more than 20% of government revenue on average from 2006 to 2010; and resource rents[20] greater than 10% of GDP in 2011.

among those countries in the MGI resource driven list, we cannot compare the degree of dependence between countries.

Lastly the ICMM's MCI ranks two hundred and twelve countries on the contribution of the non-fuel minerals to the national economies. Zambia ranks the highest on the MCI with a score of 97.7 while it scores 31.24 on our EDI. Similarly, Australia's MCI score is 87.9 and is ranked 22nd on the MCI. However, Australia's EDI score is 15.26. On both the EDI and MCI, Zambia is ranked higher than Australia but there is a larger difference in scores on our EDI than on the MCI. Both the MCI and EDI capture the importance of the sector, however the EDI also evaluates this importance against the performance of other sectors in the economy. Therefore, while Republic of Congo and Chile rank 12 and 13 on the MCI, their EDI scores are 78.39 and 28.1, respectively. Both Namibia and Tanzania have high mineral exports but the sectors contribution to fiscal revenues and value added are not as high, therefore they rank relatively lower on our EDI with scores less than 20. However, both countries are ranked in the top quartile on the MCI. Lastly, since the MCI looks at only non-fuel minerals, oil rich countries such as Algeria and Nigeria are ranked 103 and 162, respectively while they have EDI scores greater than 70.

Table 4: EDI scores against ICMM, IMF and McKinsey Classification

Country	Index	ICMM	IMF†	McKinsey Global Institute†
Madagascar	1.24	77.1		YES
Philippines	2.73	69.9		
Afghanistan	2.76	40.6		YES
United Kingdom	3.77	52.1		
Canada	6.36	67.1		YES
Lesotho	7.13	43.2		
Albania	7.93	56.5		
Brazil	8.92	79.6		YES
Kyrgyz Republic	9.65	56.9		YES
Mozambique	10.15	49.3		YES
Ghana	10.25	84.9		YES
Sierra Leone	12.4	51.3		YES
Liberia	13.19	89.2		
Central African Republic	13.93	45.5		YES
Burkina Faso	14.25	90.2		YES
Togo	15.12	76.2		YES
Australia	15.26	87.9		YES

Namibia	17.09	86.5		YES
Tanzania	17.4	82.3		YES
Malaysia	17.89	33.4	YES	YES
Colombia	18.82	59.4		YES
Cote	19.98	31.3		YES
Niger	20.88	55.9		YES
Vietnam	21.59	44	YES	YES
Mexico	21.85	55.5	YES	YES
Norway	24.21	37.8	YES	YES
Indonesia	26.83	66.4	YES	YES
Chile	28.1	92.1	YES	YES
Mali	31.21	94.2	YES	YES
Zambia	31.24	97.7	YES	YES
Cameroon	31.56	27.7	YES	YES
Ecuador	32.92	34.5	YES	YES
Russian Federation	33.18	47.6	YES	YES
Peru	33.55	88	YES	YES
Azerbaijan	34.03	13.3	YES	YES
Myanmar	35.06	55.4		YES
Venezuela	37.01	33.6	YES	YES
Syria	37.51	58.5	YES	YES
Qatar	37.53	28.3	YES	YES
Congo, DRC	42.08	93.2	YES	YES
Trinidad and Tobago	43.22	52.4	YES	YES
Botswana	45.92	61.9	YES	YES
United Arab Emirates	46.51	86.6	YES	YES
Mauritania	48.13	95.3	YES	YES
Bolivia	50.27	88	YES	YES
Sudan	51.01	49.4	YES	YES
Kazakhstan	51.65	54	YES	YES
Guinea	52.22	65.3	YES	YES
Iran	52.6	54.7	YES	YES
Saudi Arabia	52.8	23.1	YES	YES
Bahrain	54.34	82.5	YES	YES
Oman	55.51	65.8	YES	YES
Kuwait	59.01	25.5	YES	YES
Mongolia	59.04	93.3	YES	YES
Gabon	60.02	64.2	YES	YES
Brunei Darussalam	61.31	20.3	YES	YES
Chad	67.81	18.4	YES	YES
Yemen, Rep.	70.36	22.9	YES	YES
Libya	71.45	30.4	YES	YES
Algeria	73.31	47.8	YES	YES

Angola	74.49	17.2	YES	YES
Timor-Leste	77.63	14.6	YES	
Congo, Rep	78.39	91.5	YES	YES
Iraq	82.76	29.5	YES	YES
Equatorial Guinea	83.54	34.2	YES	YES
Nigeria	85.78	28.6	YES	YES

† YES indicates that the country is included in the classification and blank if not included

5. Concluding Remarks

Dependence on the oil, gas and mineral industry is often measured by the share of earnings from these commodities in total export earnings and by the tax revenue generated from these commodities as a share of total fiscal revenue.

Alternatively, the composite index we introduced in this paper focuses on adjusted variables consisting of: a) the share of export earnings from extractives in total export earnings; b) the share of revenue from extractives in total fiscal revenue; and c) extractives industry value added in total value added. We adjust these indicators to capture countries' productive capabilities, which determine the presence of alternative sources of export earnings, tax revenues and a diversified industrial sector.

The comparison between Zambia and Norway is instructive. For instance, traditional dependence measures of extractives dependence would not have accounted for Zambia's relatively lower domestic productive capacity. The countries have very similar values for export earnings and revenues from extractives. Thus, under the traditional measures of dependence, without taking into consideration the productive environment under which the extractive sector exists, the two countries would be considered as being equally dependent on the extractive sector.

To a large extent, the EDI reflects the prevailing trends in global commodity prices and does not differentiate between changes in the level of dependence resulting from short-term external shocks or long-term trends. Lower dependence, for instance, could reflect low global prices, as was the case for countries including Angola, Norway, Kuwait, and Nigeria during the economic and financial crisis that started in 2008. Decline in dependence could also reflect decline in global demand for main commodity exports – for instance through fall in revenues from the sector – and not necessarily greater diversification in its manufacturing or tax revenue base.

Nevertheless, at a given point in time and under prevailing economic conditions, the index quantifies how dependent countries are on their oil, gas and mineral reserves.

Annex:

Data and sources

EIX is export revenue from oil, gas, and minerals as a share of total export revenue (Source: UNCTADStat and calculated using SITC product codes 27, 28, 68, 321, 322, 325, 333, 334, 335, 342, 343, 344, 355, 667, and 971.

HTM is export revenue from high-skill and technology intensive manufactures as a share of total export revenue (Source: UNCTADStat using trade products by group. For classification method, see http://www.unctad.info/en/trade-analysis-branch/data-and-statistics/other-databases/).

Rev is revenue generated by the extractive industry as a share of total fiscal revenue (Source: IMF estimates (for methodology see: *Fiscal Regimes for Extractives Industries: Design and Implementation*, Fiscal Affairs Department (International Monetary Fund, 2012) and Extractive Industries Transparency Initiative (EITI))

NIPC is the total non-resource tax revenue from income, profits and capital gains as a share of GDP (Source: International Centre for Tax and Development, IMF Government Financial Statistics and IMF World Economic Outlook). For missing data, mean was imputed using data from 2000 onwards[21]. Due to missing data, instead of NIPC, for Guinea, Iraq, Congo and Cote d'Ivoire total non-resource direct taxes (%GDP) was used; for Qatar and Sudan, non-resource component of corporate income taxes (%GDP) was used; and for Colombia and Indonesia non resource taxes (%GDP) was used.

EVA is extractives industries value added as a share of total value added (Source: UNSD National Accounts Main Aggregates and World Bank African Development Indicators, OECD StatExtracts)

MVA is the per capita manufacturing value added (Source: World Bank World Development Indicators, and African Development Bank Group, Open Data for Africa)

[21] For Guinea, Indonesia and Vietnam, values were imputed using data from 1990 onwards.

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