Revisiting the Natural Resource Industries "curse": Beneficiation or Hirschman Backward Linkages?

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Abstract

This paper puts forward and empirically tests the conjecture that specialisation in Natural Resource Industries (NRI) might not necessarily be a "curse" for (developing) countries, to the extent that it provides opportunities for export diversification in backward linked sectors à la Hirschman. We first revisit the evolution of the debate around the NRI "curse", including those views that are skeptical of diversification based on beneficiation from NRI. We then empirically test whether NRI might represent a sufficient "domestic representative demand" for backward linked sectors such as Knowledge Intensive Business Services (KIBS) or high tech manufacturing that might provide new opportunities for export diversification based on virtuous pathways of domestic structural change. We find empirical support to this conjecture and discuss our results as a contribution to a potentially new phase of the NRI curse debate.

Introduction and background

This section first revisits the relevant literatures which have sparked directly or indirectly from the debate on the so-called NRI "curse", that are the evolution of the different views around the notion of "curse" and the opportunities for structural change ensuing from domestic and trade specialisation in NRI.

Second, we derive our main conjecture that specialisation in Natural Resource Industries (NRI) might not necessarily be a "curse" for (developing) countries, to the extent that it provides opportunities for export diversification in backward linked sectors à la Hirschman. We argue that they might provide new opportunities for export diversification based on virtuous pathways of domestic structural change that does not necessarily involves "moving away" from NRI, but uses them as a platform to upgrade in directions that have not often been conceived.

Third, in the following section we empirically test whether NRI might represent a sufficient "domestic representative demand" for backward linked sectors such as Knowledge Intensive Business Services (KIBS). While generally overlooked by these literatures, albeit being the object of a few rich qualitative studies, KIBS are here considered in relation to NRI: we offer a quantitative analysis to test our conjecture. We find empirical support to this conjecture and discuss our results as a contribution to the NRI curse debate from the perspective of structural change and export diversification.

The evolution of the NRI curse debate

Over the last few decades specialisation in natural resources industries (NRI) has been alternatively regarded as a "blessing" or a "curse" for economic development. If we go back in time we find that natural resources had been considered to provide an opportunity for countries to develop, following a path similar to that of the USA and Australia (Rostow 1960).

Among the first to question this dominant view of their time, Singer (1950) and Prebisch (1959) saw development of the primary sector as an inferior specialisation strategy, notably with respect to manufacturing, because of the difference in income-demand elasticity between the two sectors and the deteriorating terms of trade of natural resources. Development of the primary sector was deemed beneficial only conditionally on the development of the manufacturing sector (Prebisch 1959), within a balanced development strategy à la Nurkse (1952).
The argument ran that productivity increases in the primary sector would make large portions of the workforce redundant; this could lead, in the absence of a manufacturing sector capable of absorbing this labour, to large unemployment in developing countries (Prebisch 1959).

The scepticism around economic development ensuing from a large natural resource sector became a dominant view in the 1980s, with the formulation of the Dutch Disease thesis (Corden 1982). A large, capital intensive, high-productivity and export-oriented natural resource sector would have a range of negative effects on the rest of the economy, hindering its overall performance:

- By concentrating all the revenue in one sector, the country would become exposed to price volatility of the exported commodity.
- Because of the export of the commodity the country's currency would appreciate making other sectors' export less competitive (Harding & Venables 2013). The commodity sector would also draw investment and other resources away from other sectors (Sachs & Warner 1997; Matsuyama 1992).

- Crucially to our purpose here, the commodity sector is perceived as an *enclave*, extracting resources from the country for export, with little linkages with the rest of the domestic economy and most of the profits being shipped away (Weisskoff & Wolff 1977).

Along these lines, a larger literature has developed in the 1980s studying the possible channels explaining the association between natural resource abundance and poor economic growth, a paradoxical situation often referred to as resource curse (Sachs & Warner 1997; Auty 1994; Auty 1995). The possible channels usually considered, apart from the Dutch Disease, are the quality of institutions (Torvik 2002; Robinson et al. 2006) and rent-seeking behaviour by economic actors involved in the management of the resources (Auty 2001). Focusing on institutions in particular, some have argued that the resource curse wouldn't be inevitable, if "high-quality" institutions were in place (Brunnschweiler 2008; Boschini et al. 2013).

In the 2000s a new literature has emerged challenging the existence of such a curse, putting forward historical examples (Wright & Czelusta 2004), as well as raising a range of issues questioning the empirical soundness of the evidence on which the resource curse was based (Lederman & Maloney 2006; Stijns 2000; Brunnschweiler & Bulte 2008) in particular:

- The original studies looking at the resource curse (Sachs & Warner 1995) are based on cross sections, which can't capture the evolution over time of both institutions and technology (Van der Ploeg & Poelhekke 2016).
- Natural resource abundance is often confused with natural resource dependence (Brunnschweiler & Bulte 2008) and when this is disentangled from natural resource rents, the latter can actually have a positive impact on economic growht (Ding & Field 2005).
- The real problem with natural resource dependent countries is a lack of export diversification rather than something inherent to natural resources (Lederman & Maloney 2006).

Overall this debate revolves around the effect of natural resource abundance on growth, the potential endogeneity between the capability of countries to extract natural resource and their potential for growth and the role of institutions.

A subset of this literature focuses on the issue of this sector being an enclave hindering economic diversification. It is interesting to ask whether this view is still valid today: this opens up questions on whether backward (and forward) linkages between natural resource and other sectors of the economy could spur export diversification. A proper account of these questions requires enlarging the perspective of the traditional "curse" debate and engage with the scholarship that has dealt with structural change, and the importance of domestic specialisation to change export portfolios of countries. We turn to this attempt in the next section.

NRI, "high development linkages" and export diversification

We have seen in the previous section that the resource curse view has been challenged by a growing literature. Badeeb et al. (2017) provide an interesting review of the literature and Van der Ploeg and Poelhekke (2016) survey the quantitative evidence.

Also some recent qualitative contributions have cast some doubt on the enclave hypothesis about NR (Bloch & Owusu 2012; Adewuyi & Ademola Oyejide 2012; Marin & Stubrin 2015; Marin et al. 2009; Walker 2001). This idea is partly based on important changes the natural resource sector has undergone in recent years, in particular (Marin et al. 2009; Barnett & Bell 2011; Upstill & Hall 2006):

- Increasing outsourcing of non-core activities towards local suppliers (Barnett & Bell 2011).

- Increases in price of commodities has made further innovation economically sustainable (Marin et al. 2009)– this particular rationale doesn't seem to be valid anymore as the boom phase of commodity cycle seems now to be over.
- Increasing attention on the part of the final consumers concerning local development and environmental sustainability of extractive activity (Barnett & Bell 2011).

One of the main drawbacks pointed out by the NR curse literature is that NR are usually *enclave* sectors (Heeks 1998), with little linkages to other sectors and that can even undermine other sectors' competitiveness by causing an appreciation of the exchange rate and by drawing investment and resources away, triggering what the literature often refers to as the Dutch disease (Harding & Venables 2013; Sachs & Warner 1997; Corden 1982).

Why would the characteristics of enclave be detrimental to economic development?

A relatively established fact in the literature on economic development and export structure is that as countries develop, they move from an export portfolio very concentrated on a few commodities, towards more diversified export structures including an increasing number of complex products and services (Hidalgo & Hausmann 2009; Hidalgo 2009; Felipe et al. 2012).

Export diversification seems particularly important for countries rich in natural resources (NR). The influential work of Sachs and Warner (1997) and Auty (1994) has put forward the idea of a natural resource curse, pointing out the fact that countries rich in NR usually experience poor economic performance. Consistently with this view, export diversification has often been a stated policy goal of many commodity dependent countries (Massol & Banal-Estañol 2014).

The importance of intersectoral linkages has been highlighted by Hirschman's (1958) seminal work, arguing that the development of one sector would trigger intermediate demand for inputs produced by other sectors (backward linkages) and provide inputs for other sectors (forward linkages). It is worth pointing out however that Hirschman (1958) saw the NR sector as failing to provide large inter-sectoral linkages, especially towards downstream manufacturgin activities (Vogel 1994).

More recently, a range of contributions, notably by Hidalgo et al. (2007) and Hausmann and Klinger (2006), look at how some products favour the emergence of others in countries' export structure. Rather than input-output linkages Hausmann and co-authors use goods' joint probability of being exported by the same country as a measure of proximity and build a 'product space' where some products are more or less connected to others (Hidalgo et al. 2007; Hausmann et al. 2007). In this framework, economic development can be understood as a process of accumulation of capabilities that leads to the emergence of new and more complex sectors, which require a larger set of capabilities and higher levels of productivity (Hidalgo et al. 2007; Hidalgo & Hausmann 2009; Hausmann et al. 2007).

Within the product space, NR are shown to be among the least complex and, most importantly, among the least connected goods. Consequently, policies encouraging export diversification through beneficiation, i.e. fostering forward linkages and trying to move from NR to more downstream manufacturing processing activities, are argued to be ill-advised.

Hausmann et al. (2008) argue in fact that rather than moving vertically, industrial policies should focus on goods that lie closer in the product space to what they currently export. In doing so, they join a quite long-standing view in the economic debate that looked with criticism at RBI policies (Auty 1986). So, while export diversification is recognised as an important policy goal, especially for NR rich countries, little has been put forward, exploring possible diversification pathways for such countries. Indeed, a good chunk of the literature has looked at forward linkages from NR towards manufacturing, finding little evidence in support of this strategy (Auty 1987; Auty 1986; Adams & Behrman 1981; Hausmann, Klinger, et al. 2008).

This paper offers quantitative evidence suggesting an alternative strategy for countries to diversify their export portfolio: we look at backward linkages spurred by a high specialisation in NRI. This is argued to be a representative domestic demand for knowledge intensive business services (KIBS). This has been much less studied than forward linkages towards manufacturing. However, we also explore the role of backward linkages towards this sector.

From an empirical perspective, we test whether the domestic intermediate demand provided by the NR sector has a positive impact on the export performance of other sectors, in particular KIBS. We test this in a GMM dynamic framework and we present our main results along with some robustness checks.

Data and Empirical Strategy

Data

We use value added flows instead of gross export in order to capture exactly the domestic sector's contribution and to exclude value added imported by other countries or sectors (Koopman et al. 2010). The data we have are quite aggregate and each sector category includes a wide range of different activities. We try to overcome this shortcoming by looking at export to focus on the KIBS that are tradable and meet high enough quality standards to be competitive on the international market.

Our outcome variable captures the domestic value added exported by the KIBS sectors from each country, while our explanatory variable will be the domestic intersectoral linkages between NR and KIBS.
We also split our sample using a range of measures (export and output RCA, rent from the NR sector) to explore whether as the size of the NR sector changes this has an effect on the relationship between backward linkages and export performance of KIBS.

Our main source of data are the ICIO table compiled by the OECD, which we use to compute the backward linkages between NR and KIBS. We consider KIBS the following:

- IT and computer related service (ITS).
- R&D and other business services (BZS).

While NR are:

- Agriculture, Hunt and Fishing (AGR).
- Mining and quarrying (MIN).

In order to maximise the number of observations on which we can rely, we carry out our econometric analysis at the geo-sector level, i.e. looking at each of the two KIBS sectors ITS and BZS in each country. We have thus a panel of 60 countries, i.e. 120 geo-sectors over seven years: 1995, 2000, 2005, 2008-11.

Econometric strategy

Two immediate issues need to be dealt with. First, export of KIBS is likely to be affected by serial correlation, as current levels of export are often correlated with past ones. Second, the relationship between export of KIBS and the domestic intermediate demand coming from NR is likely to go both ways; while we want to test whether increases in the intermediate domestic demand generate increases in the

export of KIBS, it is also possible that the causation's direction may go the other way, through a simultaneous effect.
In order to deal with both these issues, we opt for an autoregressive model and use a system GMM, which allows instrumenting with past lags of our endogenous variables. Our autoregressive specification is thus as follows:

$$dva\_kbs\_cap_{it} = \alpha_0 + \beta_1 dva\_kbs\_cap_{it-1} + \beta_2 dd\_kbs\_nr\_cap_{it} + \beta_3 schooling_{ct} + \beta_4 internetaccess_{ct} + \alpha_i + \alpha_t$$

We present the results of our dynamic model taking the logs of our outcome variable, its lag and our main explanatory variable. We also show the results for our whole sample and a subsample of geo-sectors from countries that have a value added revealed comparative advantage (RCA)[1] in NR.

In our econometric equation presented above $dva\_kbs\_cap_{it}$ is the domestic value added embodied in each geo-sector's *i* gross export per capita in each year *t*, $dd\_kbs\_nr\_cap_{it}$ is the per capita domestic intermediate demand provided by the NR sector to each geo-sector, both these variables are in log. $schooling_{ct}$ captures human capital through years of schooling in each country *c* and year *t*, while $internetaccess_{ct}$ is internet users per thousands of inhabitants and captures countries' technological infrastructure.
Finally, we also control for geo-sector and year fixed effects (FE) α_i and α_t respectively, cluster the standard errors by country and perform the robust version of the system GMM with Windmeijer's (2005) correction for finite sample.

Our outcome variable is computed as follows: let *EXGR_DVA* be a ci x 1 column vector with each country *c* and sector *i* domestic value added embodied in gross export:

$$EXGR\_DVA = V'(I-A)_d^{-1} F_{ex}$$

Where V' is a ci x ci diagonal matrix populated with each geo-sector value added share in output, $(I\text{-}A)^{-1}$ is the traditional Leontief inverse capturing all inter-sectoral relations for all sectors and countries; since we are interested in the *domestic* value added in export we extract from this matrix a *c* x *c* diagonal block matrix $(I\text{-}A)_d^{-1}$ that only includes each country c's *domestic* inter-sectoral relationships. Finally, F_{ex} is a ci x 1 column vector with each geo-sector gross export satisfying foreign final demand.

From this *EXGR_DVA* vector we select only the 120 entries corresponding to each country's two KIBS sectors and we have our vector of observations, which we divide by each country's population obtaining *dva_kbs_cap*.

It is worth pointing out that our outcome variable (value added in export per capita in KIBS sector) includes the KIBS value added that is exported indirectly through NR export. This is also included in our explanatory variable which captures the domestic demand of NR for KIBS. In order to avoid this pitfall, we exclude from our outcome vairable the portion of KIBS value added that is exported through NR. In this way we avoid any mechanical, i.e. by construction, linkage between our two variables of interest.

Domestic intermediate demand for KIBS from the NR sector is computed in a similar way, but we take the ci x ci matrix X_DVA where each entry is populated with each geo-sector value added contribution to each sector's output:

$$X\_DVA = V'(I-A)_d^{-1} F$$

[1] We consider that a country has an RCA in NR if its Balassa index, computed with value added rather than gross export, is above one.

This matrix is computed very much in the same way as EXGR_DVA but we substitute the ci x 1 F_{ex} vector with the *ci* x *ci* matrix F populated with zeros off the diagonal and with each geo-sector final demand on the diagonal.
From the resulting *ci* x *ci* matrix we isolate those entries belonging to KIBS rows and to NR columns that correspond to how much each KIBS geo-sector contributes in value added terms to each of the two NR sector output. We then aggregate across NR sectors and divide by each country's population and obtain *dd_kbs_nr_cap*.

Econometric results

NRI and backward linked KIBS

In the following tables we present our main results for the whole sample and only the countries with an RCA in NR, we also look separately at the two sectors (AGR and MIN) that make up the NR sector.

We first focus on KIBS and detect a strong, positive and significant effect of the NR-KIBS intermediate demand on the export per capita in value added of the KIBS sector only for countries with an RCA in NR (col.2). When we look at the two NR sectors separately we find that the positive effect is essentially driven by the MIN intermediate demand in countries with an RCA in MIN (col. 6).

Tab 1 – NR-KIBS intermediate demand's effect on domestic value added in KIBS export per capita[2].

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	NR	NR RCA	AGR	AGR RCA	MIN	MIN RCA
dva_kbs_cap $_{t-1}$	1.004***	0.287*	0.975***	0.851***	0.965***	0.644***
	(0.0444)	(0.150)	(0.0481)	(0.326)	(0.0661)	(0.103)
dd_kbs_nr_cap	-0.0177	0.448***				
	(0.0486)	(0.159)				
schooling	0.000917	0.0127	0.000269	-0.00028	0.00473	0.0123
	(0.00327)	(0.00808)	(0.00314)	(0.0105)	(0.00474)	(0.00786)
internetaccess	-0.00199	0.00865	-0.00105	0.00286	-7.20e-05	0.000908
	(0.00269)	(0.0150)	(0.00257)	(0.0135)	(0.00406)	(0.00464)
dd_kbs_agr_cap			0.00762	0.0761		
			(0.0426)	(0.191)		
dd_kbs_min_cap					-0.0335	0.221***
					(0.0290)	(0.0390)
AR(2)	-1.85	-1.29	-1.87	-0.93	-1.87	-0.64
Observations	640	262	640	260	640	162
Number of geo-sectors	114	58	114	64	114	36

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

[2] For the Arellano test for auto-correlation, we report the z-value, if no stars are attached to it, then we have failed to reject the null hypothesis of no second order autocorrelation. For space's sake we don't report the number of instruments used, though these have been selected based on the results of the Hansen test for over-identification and the Difference-in-Hansen test of exogeneity of the instruments.

From these results it would seem that intermediate demand from the mining sector exerts a positive effect on the export of KIBS only in those countries that have an RCA in this sector.
In contrast, when we look at the whole sample (col. 1 3 and 5), which mainly includes countries without an RCA in MIN or NR, we find a negative (though insignificant) effect. The intermediate demand from the AGR sector doesn't have a significant effect on either the whole sample or the RCA subsample (col. 3 and 4). This is not surprising as we wouldn't expect very large backward linkages between the agriculture and KIBS sectors to be very strong.

These results suggest that it takes a certain level of either competitiveness or size, which both can drive countries' RCA in NR, for the intermediate demand to exert a positive effect on other sectors' export performance, measured here in terms of domestic value added exported per capita. We have also split our sample with different methods, finding comparable results, we report the most salient in the appendix.

One of the main issues with our approach is how we split the sample and what we capture when doing so.
The RCA is usually considered as a measure of (revealed) competitiveness[3], hence the most intuitive interpretation of our results would be that the positive effect of intermediate demand coming from the NR sector on the export of KIBS applies only to countries who have reached a certain level of competitiveness in the NR sector and hence demand higher quality KIBS input.

However a country can develop an RCA in NR for at least another reason. It could be because of a particularly productive NR sector, or a very large one due to its natural endowments and the absence of other important sectors.
With respect to our main results this leads to two possible explanations.

- A very productive NR sector allows a country to develop an RCA in NR, hence requiring higher quality KIBS inputs and increasing this sector's export performance. The effect of high productivity in the NR sector on our outcome variable may be ambiguous: on the one hand a more productive sector should require more productive inputs and hence improve the export performance of upstream sectors, on the other hand a more productive sector will have a smaller intermediate demand and hence exert a smaller effect on upstream sectors.
- A very large NR sector, regardless of its productivity, provides a very large intermediate demand and this 'scale' effect increases the productivity of the KIBS sector along with its export performance.

In order to look into the first possibility, we include in our econometric equation an index of productivity of the NR sector, which we compute by dividing the domestic value added of the NR sector by its inputs, i.e. its intermediate demand. Of course, part of the intermediate demand of the NR sector is already included in our main explanatory variable, so we exclude this portion of intermediate demand from the calculation of our productivity index.

$$VAIC = \frac{VA}{(IC - IC_{NR-KIBS})}$$

Where VA is domestic value added and the denominator is intermediate consumption (IC) minus the intermediate consumption met by the KIBS sectors ($IC_{NR-KIBS}$). We present the results of our model with this additional control hereunder:

[3] Competitiveness can be a controversial term; here we use it interchangeably with export-led specialisation.

Tab. 2 – NR-KIBS intermediate demand's effect on domestic value added in KIBS export per capita, controlling for NR sector's productivity.

VARIABLES	(1) NR	(2) NR RCA	(3) AGR	(4) AGR RCA	(5) MIN	(6) MIN RCA
dva_kbs_cap $_{t-1}$	0.940***	0.463***	0.947***	0.618*	0.985***	0.717***
	(0.0331)	(0.173)	(0.0351)	(0.318)	(0.0614)	(0.132)
dd_kbs_nr_cap	0.0386*	0.549***				
	(0.0226)	(0.164)				
schooling	0.000590	0.00513	-0.00091	0.0148	0.00212	0.0119
	(0.00324)	(0.00867)	(0.00379)	(0.0112)	(0.00475)	(0.00978)
internetaccess	-0.00150	-0.00239	-0.00091	0.0152	-0.00217	0.000822
	(0.00236)	(0.0132)	(0.00210)	(0.0132)	(0.00303)	(0.00728)
vaic_nr	-0.135**	0.0663				
	(0.0592)	(0.226)				
dd_kbs_agr_cap			0.0366	-0.0285		
			(0.0275)	(0.186)		
vaic_agr			-0.0866	0.161		
			(0.141)	(0.332)		
dd_kbs_min_cap					0.000861	0.166**
					(0.0195)	(0.0741)
lnvaic_min					-0.0642	0.00435
					(0.0541)	(0.484)
AR(2)	-1.95	-1.14	-1.9	-0.77	-1.87	-0.18
Observations	640	262	640	260	640	162
Number of geo-sectors	114	58	114	64	114	36

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Looking at RCA countries, we find that the positive effect of the NR intermediate demand, still driven by MIN, is still strong and significant. In contrast the productivity of the NR sector seems to have no effect on the export performance of KIBS. Only in column 1 we find a negative and significant effect, accompanied by a positive (though weakly significant) effect of the domestic intermediate demand. This would seem to suggest that overall a more productive NR sector has a negative (or insignificant) impact on the export of KIBS. So, countries with a productive NR sector tend to export more of this and less of other sectors, such as KIBS.

Interestingly however this negative effect vanishes when we look at countries with an RCA in NR, while the effect of NR domestic intermediate demand becomes positive and significant again. This would suggest that it's not productivity but rather the size and importance of the NR sector to drive the positive effect of the NR intermediate demand on the export of KIBS.

So, overall a productive NR sector has a negative (or insignificant) impact on the export performance of KIBS and its intermediate demand has no significant effect. However, large NR sectors provide, regardless of their productivity, an intermediate demand large enough to exert a positive effect on the export of KIBS.

We have also tested the model controlling for labour productivity, i.e. value added per worker, the number of worker for the two NR sectors has been retrieved using

ILO data[4], finding quite robust results. This seems to reinforce the idea that the positive effects we find when splitting our sample with the RCA are driven by the size, rather than the productivity of the MIN sector.

NRI and backward linked High- and Low-Tech Manufacturing

In this section we present the results running the same model as before but focusing on the effect of inter-sector domestic intermediate demand, emanating from NRI, on export of manufacturing. We analyse high and low tech separately, we distinguish these based on the OECD classification[5]. We start off with high tech manufacturing and test our main model with the same robustness checks we performed for KIBS, all of which can be found in the appendix. The same tables will also be presented for low tech manufacturing.

In table 2 below we present the results from the main model, which looks at the impact of domestic backward linkages from the NR sector to high tech manufacturing on the domestic value added embodied in export per capita of high tech manufacturing.

We find that NR backward linkages have a positive and significant effect for high tech manufacturing export too, although the size of the coefficient is quite smaller. More importantly, this effect is still significant, despite a further reduction of the coefficient, when we look at the whole sample.

It should be noted that while in our main model we find a positive and significant effect of intermediate demand coming from the mining sector, this result is not robust[6]. It would thus appear that it is the intermediate demand from the AGR sector driving the aggregate result.

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[4] The slight drop in observations when looking at the MIN sector is due to the fact that some countries don't have workers in the MIN sector, according to the ILO data, which means that the productivity measure has some missing values. This is however a very small observation loss and I'm not too concerned about it.

[5] A table with further details can be found in the appendix

[6] See robustness checks in the Appendix

Tab. 3 – Main model for high tech manfuacturing

VARIABLES	(1) NR	(2) NR RCA	(3) AGR	(4) AGR RCA	(5) MIN	(6) MIN RCA
$dva\_htm\_cap_{t-1}$	0.906***	0.566***	0.888***	0.597***	0.884***	0.783***
	(0.0431)	(0.120)	(0.0472)	(0.210)	(0.0397)	(0.255)
dd_htm_nr_cap	0.0808**	0.144***				
	(0.0345)	(0.0385)				
schooling	-0.00325	0.00562	-0.00272	0.0121	-0.00676	-0.00758
	(0.00276)	(0.00846)	(0.00285)	(0.0152)	(0.00612)	(0.0111)
internetaccess	0.000814	0.00614	0.00146	0.000862	0.00182	0.00533
	(0.00225)	(0.00464)	(0.00238)	(0.00508)	(0.00221)	(0.00495)
dd_htm_agr_cap			0.0848**	0.173***		
			(0.0383)	(0.0562)		
dd_htm_min_cap					0.0771**	0.102**
					(0.0346)	(0.0424)
AR(2)	-1.06	0.5	-1.06	-0.51	-1.09	1.14
Observations	1,920	786	1,920	780	1,920	486
Number of geo-sectors	342	174	342	192	342	108

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Interestingly, the fact that for high tech manufacturing coefficients are significant regardless of whether and how we split the data may suggest that high tech manufacturing has indeed a higher propensity to create linkages with other sectors, NR in particular, and to benefit from it. On the other hand the effect of these relationships on the high tech export performance has a smaller magnitude than what we found for KIBS.

As for KIBS, we now wish to control for productivity of the NR sector. In fact one could fear that the effect is actually driven by the productivity of the natural resource sector which would impact of course the intermediate demand and the export of high tech manufacturing.
We control in two ways, using added divided by intermediate consumption excluding the linkages between NR and high tech manufacturing and labour productivity in the NR sectors.

Tab. 4 – High tech manufacturing, controlling for NR sector's productivity

VARIABLES	(1) NR	(2) NR RCA	(3) AGR	(4) AGR RCA	(5) MIN	(6) MIN RCA
$dva\_htm\_cap_{t-1}$	0.849***	0.716***	0.860***	0.585***	0.920***	0.714***
	(0.0327)	(0.161)	(0.0420)	(0.128)	(0.0442)	(0.210)
dd_htm_nr_cap	0.102***	0.147***				
	(0.0283)	(0.0414)				
schooling	-0.00277	-0.00232	-0.00387	0.0114	-0.00141	-0.00380
	(0.00295)	(0.00635)	(0.00291)	(0.00972)	(0.00431)	(0.0124)
internetaccess	0.00261	0.00448	0.00287	0.00450	0.000946	0.00754
	(0.00247)	(0.00669)	(0.00214)	(0.00878)	(0.00215)	(0.00501)
vaic_nr	0.393**	-0.0143				
	(0.200)	(0.734)				
dd_htm_agr_cap			0.0950***	0.160***		
			(0.0283)	(0.0487)		
vaic_agr			0.106	0.462		
			(0.167)	(0.632)		
dd_htm_min_cap					0.0345	0.0859
					(0.0210)	(0.0660)
vaic_min					0.108	0.0743
					(0.0920)	(0.278)
Constant	-0.73	0.54	-0.89	-0.27	-1.16	0.63
Observations	1,920	786	1,920	780	1,920	486
Number of geo-sectors	342	174	342	192	342	108

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The effect of the intermediate demand coming from the MIN sector now loses significance, while the other coefficients remain significant but still quite small compared to our main models for both high tech manufacturing and KIBS.
We have also used labour productivity in the NR sector as a control. This is the same measure discussed above, based on value added computed through the I-O tables at current prices and workforce in each sector as reported by the ILO.
The coefficients we find are comparable in size to what we've seen so far and are all significant except when we look at the MIN sector for the whole sample. As for KIBS, we don't report the results here for space's sake.

We now focus on low tech manufacturing and present the same table we discussed for high tech manufacturing. Table 3 below shows positive and significant effects only for AGR and the whole NR sector. Interestingly the coefficients on the RCA subsample are slightly larger than what we found for high tech manufacturing.

Tab. 5 – Low tech manufacturing, main model.

VARIABLES	(1) NR	(2) NR RCA	(3) AGR	(4) AGR RCA	(5) MIN	(6) MIN RCA
dva_ltm_nonr_cap	0.742***	0.232	0.729***	0.244*	0.894***	0.800***
	(0.0577)	(0.150)	(0.0514)	(0.125)	(0.0485)	(0.229)
dd_ltm_nr_cap	0.0596**	0.350***				
	(0.0241)	(0.0739)				
schooling	0.00330	0.0138**	0.00377	0.0217***	-0.00263	0.00110
	(0.00239)	(0.00656)	(0.00260)	(0.00688)	(0.00579)	(0.00882)
internetaccess	0.00500**	0.00599	0.00498***	0.0110*	0.00132	0.000843
	(0.00222)	(0.00374)	(0.00189)	(0.00568)	(0.00231)	(0.00487)
dd_ltm_agr_cap			0.0738***	0.212*		
			(0.0243)	(0.112)		
dd_ltm_min_cap					0.0286	0.0863
					(0.0197)	(0.0641)
AR(2)	-1.76	-0.14	-1.71	1.05	-1.9	-0.01
Observations	3,200	1,310	3,200	1,300	3,200	810
Number of geo-sectors	570	290	570	320	570	180

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

These results for low tech manufacturing are comparable in interpretation to those for high tech manufacturing.
As we did for high tech manufacturing we now present the results controlling for productivity in the mining sector in order to account for potential spillovers between these sectors. Tables 19 and 20 below control using our measure for productivity in the NR sector and labour productivity, respectively. We find overall significant results that are consistent with what we found in our main model.

Tab. 6 – Low tech manufacturing, controlling for productivity.

VARIABLES	(1) NR	(2) NR RCA	(3) AGR	(4) AGR RCA	(5) MIN	(6) MIN RCA
dva_ltm_cap $_{t-1}$	0.776***	0.297***	0.723***	0.287***	0.848***	0.701***
	(0.0609)	(0.115)	(0.0676)	(0.106)	(0.0665)	(0.248)
dd_ltm_nr_cap	0.0671**	0.284***				
	(0.0333)	(0.0721)				
schooling	0.000215	0.0200***	0.00161	0.0186***	-0.00509	0.00208
	(0.00375)	(0.00632)	(0.00339)	(0.00627)	(0.00555)	(0.00657)
internetaccess	0.00320	0.00671	0.00505*	0.0123*	0.00316	0.00138
	(0.00243)	(0.00561)	(0.00264)	(0.00646)	(0.00343)	(0.00359)
vaic_nr	-0.0852	0.230				
	(0.0578)	(0.303)				
dd_ltm_agr_cap			0.0878***	0.250***		
			(0.0308)	(0.0909)		
vaic_agr			-0.0454	0.0588		
			(0.0959)	(0.273)		
dd_ltm_min_cap					0.0415*	0.113
					(0.0215)	(0.0860)
vaic_min					-0.109	0.127
					(0.0739)	(0.333)
AR(2)	-1.86	0.02	-1.71	1.14	-1.77	0.15
Observations	3,200	1,310	3,200	1,300	3,200	810
Number of geo-sectors	570	290	570	320	570	180

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Overall we find that the mining sector is driving the positive effect we find on the export of KIBS, while the agricultural sector is playing this role for manufacturing.

This is not entirely surprising as one would expect the agricultural sectors to use more manufactured inputs (especially low-tech) as most of the manufacturing going into mining are capital goods, which I-O consider capital formation.
It also makes sense, on the other hand, since KIBS are more intensively used by the mining sector than the agricultural one, that these linkages are driving the positive impact on KIBS export as we've seen in our results.

Final remarks

Our results offer more evidence of the relevance of backward linkages emanating from both the AGR and MIN sector, as potential drivers for export diversification towards either KIBS or manufacturing.

More in general and from a development policy perspective, low tech manufacturing is arguably a less interesting sector to move to. High tech manufacturing on the other hand makes it easier to argue the policy relevance of our results.

On the other hand, both KIBS and high tech manufacturing sectors are unlikely to absorb the largely unskilled workforce of developing countries and fostering low tech manufacturing through NR backward linakages, may have some positive impact on the inequality in these countries.

The fact that coefficients are larger for KIBS than for manufacturing sectors may also be explained by the fact that KIBS value chains are less fragmented and therefore harder to scatter across borders.
This hypothesis is based on the idea that as manufacturing has a more internationally fragmented (and thus longer) value chains, this may have neutralised or reduced the importance of domestic intersectoral linkages “trapping” developing countries in low value added segments that are poorly connected to other sectors.

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Appendix – Robustness checks

In this Appendix we present some more detailed information on the data we use, in particular which sectors are included in our four macro-sectors, as well as the most relevant robustness checks we have performed to establish how reliable our results were.

In table A1 below we present what sectors have been aggregated into the sector groups: Natural resources (NR), low-tech and high-tech manufcturing (LTMF and HTMF respectively).

Tab A1. – Macro sector groups and ISIC codes.

Sector groups	Included sectors	ISIC rev.3 codes
KIBS	Computer and related activities; R&D and other business services.	C72, C73T74.
NR	Agriculture, hunting, forestry and fishing; Mining and quarrying.	C01T05, C10T14.
LTMF	Food products, beverages and tobacco; Textile, textile products, leather and footwear; Wood, products of wood and cork; Pulp, paper and paper product; Coke, refined petrol products and nuclear fuel; Rubber and plastic products; Other non-metallic mineral products; Basic metals; Fabricated metal products; Manufacturing nec and recycling.	C15T16, C17T19, C20, C21T22, C23, C25, C26, C27, C28, C36T37.
HTMF	Chemicals and chemical products; Machinery and equipment; Computer, electric and optical equipment; Electrical machinery and apparatus; Motor vehicles, trailers and semi-trailers; Other transport equipment.	C24, C29, C30T33X, C31 C34 C35

In order to check for the robustness of our results, we have tried splitting our sample using different criteria than the value added RCA. An alternative way of looking at countries domestic structure and the role of the NR sector within this is to compute an RCA based on total output, rather than export.

Tab. A2 – NR-KIBS intermediate demand's effect on domestic value added in KIBS export per capita, using output-based RCA to split our sample.

	(1)	(2)	(3)
VARIABLES	NR RCA	AGR RCA	MIN RCA
dva_kbs_cap $_{t-1}$	0.162	1.065***	0.775**
	(0.274)	(0.166)	(0.304)
dd_kbs_nr_cap	0.505***		
	(0.190)		
schooling	-0.000705	-0.00735	-0.0180
	(0.0126)	(0.0104)	(0.0156)
internetaccess	0.0176	-0.0110	-0.0207
	(0.0143)	(0.00700)	(0.0172)
dd_kbs_agr_cap		0.196	
		(0.205)	
dd_kbs_min_cap			0.440**
			(0.181)
AR(2)	-0.97	-1.58	-0.03
Observations	300	302	152
Number of geo-sectors	80	78	44

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

We find very similar results as those presented in table 1 in the paper. Columns 1, 3 and 5 show very similar coefficients and significance level, though the coefficient of MIN intermediate domand doubles going from 0.221 to 0.440.

A further possible issue is whether using per capita measures could introduce a bias in our analysis.
Domestic value added in export per worker would probably be a better option than using the whole population as it would take into account that not the same proportion of the workforce is employed in the KIBS sector in every country. The consequence of this would be that we might end up comparing countries with similar populations but with different employment shares in the KIBS. Sectoral level employment data for services are however not readily available for all the countries included in our sample.

Having said this, we would also argue that countries with an RCA in NR are unlikely to employ a large share of their population in the KIBS sector.
Therefore dividing domestic value added in export by the whole population will probably underestimate our variables of interest, i.e. domestic value added in export per capita will be smaller than its per worker homologue.
In contrast, the difference between per worker and per capita domestic value added in export will be smaller for countries that are not specialised in NR and/or have already attained a high-income level, as in such countries KIBS employ a large share of the workforce.

It follows that using per capita domestic value added measures may understimate the relationship between our variables of interest in NR abundant countries, which we find however to be strong and significant.
At any rate, we have also run our model without dividing by the countries' population and we found consistent results, despite a reduction in the magnitude of the coefficient on the intermediate demand of MIN.

As a further robustness check we also change our explanatory variable and instead of using the intermediate domestic demand per capita, we use the Leontieff coefficients from our $(I\text{-}A)_d^{-1}$ matrix, which tell us how many dollars of KIBS are needed to produce one dollar of NR.
It is noteworthy that in this alternative setting we use as outcome variable domestic value added in export of KIBS without dividing this by the population, i.e. in absolute terms. This is because the explanatory variable is a coefficient and already deals with countries' different size.

Tab A3 – NR-KIBS Leontieff coefficient's effect on domestic value added in KIBS export, in absolute terms.

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	NR	NR RCA	AGR	AGR RCA	MIN	MIN RCA
dva_kbs_{t-1}	0.998***	0.681***	0.959***	1.063***	0.954***	0.444**
	(0.0289)	(0.175)	(0.0286)	(0.135)	(0.0215)	(0.214)
bd_kbs_nr	0.0474	0.543***				
	(0.0400)	(0.189)				
schooling	-0.00157	0.00881	-0.00046	-0.00410	0.00186	0.00923
	(0.00242)	(0.00955)	(0.00426)	(0.00707)	(0.00285)	(0.00639)
internetaccess	-0.00273	-0.016***	-0.00107	0.00110	-0.00203	0.000212
	(0.00189)	(0.00505)	(0.00155)	(0.00402)	(0.00138)	(0.00517)
bd_kbs_agr			0.0343	-0.0488		
			(0.0437)	(0.125)		
bd_kbs_min					0.0508**	0.583***
					(0.0225)	(0.214)
AR(2)	-1.85	-1	-1.84	-0.3	-1.92	-0.42
Observations	640	262	640	260	640	162
Number of geo-sectors	114	58	114	64	114	36

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

We find in table A3 above results that are broadly consistent with what we find for RCA countries in our main model in table 1. Interestingly, the intermediate demand coming from the MIN sector is now positive and significant in both our whole sample and our RCA sample (col. 5 and 6), though in the latter case the magnitude of the coeffecient decuplicates.

So far we have used countries RCA to split our sample. In the paper's empirical section we have tried to disentangle whether the changes in sign and significance of our coefficients are driven by size or productivity of the NR and MIN sector. We have found evidence pointing at the fact that it's the former to be the main driver.

An alternative way of looking at size of the natural resource and mining sector is by using World Bank's measures of natural resource rents as a share of GDP(Ding &

Field 2005; The World Bank 2010). This is a highly variable measure of the rent that each country is able to extract from its natural resource endowment. While the variability of the measure is driven by prices, we use it to create a dummy variable equal to 1 when the NR rent of a given country in a given year is above the yearly median. The countries for which this dummy takes value one is remarkably stable, which suggests that prices are determined internationally and but that the value our dummy will take actually reflects countries physical endowment[7].

We have been computed rents for the NR sector in total and the mining sector, we report in table 4 below the results, only including countries whose rents are above the median.

Tab. A4 – Countries with higher than the median NR and MIN rents as share of GDP.

	(1)	(2)
VARIABLES	NR	MIN
$dva\_kbs\_cap_{t-1}$	0.703***	1.019***
	(0.120)	(0.150)
dd_kbs_nr_cap	0.0832**	
	(0.0417)	
schooling	-0.00640	-0.0306*
	(0.00395)	(0.0180)
internetaccess	0.0138**	-0.00238
	(0.00705)	(0.0135)
dd_kbs_min_cap		0.157*
		(0.0821)
AR(2)	-1.33	-0.21
Observations	304	320
Number of geo-sectors	68	66

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The results we find are still robust and consistent, however we see a large decrease in the strength of the coefficient when looking at natural resources as a whole. Also the coefficients for the domestic intermediate demand from the mining sector is still significant but only at the 10%.

One should note that the number of observation has increased significantly compared to when we only include countries with an RCA. Interestingly these results seem to suggest it's not just the sheer size of countries' natural endowment, but also whether they are *specialised* in these sectors that drives the positive effect of the sector intermediate domestic demand on the export of KIBS.

So far, we have seen that the intermediate demand provided by the NR and mining sector exert a positive and significant effect on the export, in domestic value added terms, of the KIBS sector. This is however true only for countries with an RCA in either NR or mining sectors.

In the next section we test the robustness of our results for the manufacturing sector, distinguishing between high- and low-tech sectors.

[7] We should probably insert a reference to the appendix where we discuss more at length the stability of the dummy.

High-tech manufacturing.

As we did for KIBS we now use the coefficient of the Leontief inverse matrix, i.e. the intensity of the NR sector in high tech manufacturing. This measure is independent from the size of the country or its population and therefore we use as outcome variable the domestic value added in export in absolute (rather than per capita) terms.

Tab. A5 – High tech manufacturing, using Leontief Inverse

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	NR	NR RCA	AGR	AGR RCA	MIN	MIN RCA
dva_htm $_{t-1}$	0.987***	0.577***	0.929***	0.555**	0.934***	0.927***
	(0.0136)	(0.198)	(0.0289)	(0.224)	(0.0286)	(0.127)
bd_htm_nr	0.00443	0.0143				
	(0.0140)	(0.0696)				
schooling	-0.00186	0.00298	-0.000186	0.00611	-0.000137	-0.0112
	(0.00437)	(0.00766)	(0.00382)	(0.00678)	(0.00339)	(0.0145)
internetaccess	-0.00127	-0.00463	-0.00167	-0.00871	-0.00129	0.00480
	(0.00190)	(0.00612)	(0.00229)	(0.00629)	(0.00197)	(0.00771)
bd_htm_agr			-0.0230	-0.0222		
			(0.0190)	(0.0581)		
bd_htm_min					-0.00747	0.131
					(0.0141)	(0.150)
AR(2)	-1.46	-0.69	-1.64	-0.62	-1.58	0.48
Observations	1,920	786	1,920	780	1,920	486
Number of geo-sectors	342	174	342	192	342	108

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

We find no significant results. As an alternative, though arguably less accurate, way of excluding potential bias introduced by our per capita measures we also run the usual model in absolute terms.

Tab. A6 – High tech manufacturing in absolute terms (i.e. not per capita).

VARIABLES	(1) NR	(2) NR RCA	(3) AGR	(4) AGR RCA	(5) MIN	(6) MIN RCA
dva_htm $_{t-1}$	0.839***	0.772***	0.918***	0.524***	0.961***	0.483*
	(0.0292)	(0.0788)	(0.0328)	(0.131)	(0.0268)	(0.279)
dd_htm_nr	0.135***	0.147***				
	(0.0198)	(0.0304)				
schooling	-0.00283	-0.00169	-0.00403	0.00647	-0.00154	-0.00744
	(0.00301)	(0.00800)	(0.00271)	(0.00640)	(0.00342)	(0.00780)
internetaccess	0.00175	-0.00220	0.000727	-0.00498	-0.00229	0.00618**
	(0.00167)	(0.00464)	(0.00162)	(0.00428)	(0.00194)	(0.00315)
dd_htm_agr			0.0787**	0.251***		
			(0.0322)	(0.0534)		
dd_htm_min					0.0276	0.0499
					(0.0196)	(0.0431)
AR(2)	-1.12	0.63	-0.91	-0.65	-1.37	0.1
Observations	1,920	786	1,920	780	1,920	486
Number of geo-sectors	342	174	342	192	342	108

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In this case we find positive and significant coefficients for both NR and AGR, while MIN is still insignificant. We present our model splitting the data based on the meadian of NR and MIN rents as a share of GDP. We find positive and significant results in line with our main findings.

Tab. A7 – High tech manufacturing splitting our sample using the median of the NR and MIN rent as a share of GDP.

VARIABLES	(1) NR	(2) MIN
dva_htm_cap $_{t-1}$	0.908***	0.615***
	(0.0463)	(0.123)
dd_htm_nr_cap	0.147***	
	(0.0468)	
schooling	-0.0081***	0.00729
	(0.00305)	(0.0106)
internetaccess	0.000570	0.00413
	(0.00394)	(0.00370)
dd_htm_min_cap		0.0960***
		(0.0320)
AR(2)	3.28	0.37
Observations	912	960
Number of geo-sectors	204	198

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In conclusion, based on these results, one could argue that NR backwards linkages do provide countries with opportunities to diversify their economy either towards KIBS or high tech manufacturing.

Low-tech manufacturing.

As we did for high-tech manufacturing, we start with the results using the Leontieff inverse coefficients, also in its version accounting for value added shares across sectors.
In table A8 we look at the “traditional” Leontief inverse and we find broadly speaking robust results with all coefficients significant, except the agricultural intermediate demand for countries with an RCA in this sector.

Tab. A8 – Low tech manufacturing, using Leontief Inverse

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	NR	NR RCA	AGR	AGR RCA	MIN	MIN RCA
dva_ltm $_{t-1}$	0.866***	0.475**	0.843***	0.454**	0.888***	0.834***
	(0.0351)	(0.222)	(0.0345)	(0.204)	(0.0370)	(0.163)
bd_ltm_nr	0.173***	0.353***				
	(0.0267)	(0.123)				
schooling	-0.00049	-0.0005	-0.00239	-0.00091	0.00138	0.00242
	(0.00275)	(0.00508)	(0.00298)	(0.00813)	(0.00208)	(0.0114)
internetaccess	-0.00071	-0.00453	-0.00071	-0.00152	-0.00148	-0.00545
	(0.00157)	(0.00606)	(0.00155)	(0.00319)	(0.00142)	(0.00561)
bd_ltm_agr			0.243***	0.331		
			(0.0332)	(0.204)		
bd_ltm_min					0.108***	0.244*
					(0.0238)	(0.125)
AR(2)	-0.99	0.98	-0.73	1.13	-1.14	0.55
Observations	3,200	1,310	3,200	1,300	3,200	810
Number of geo-sectors	570	290	570	320	570	180

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

When we use our variables in absolute terms we find results consistent with our main model with the MIN intermediate demand insignificant, while the other main explanatory variables are significant and positive.

As a further control, we also split our sample using the NR and MIN rent as a share of GDP, which as we've discussed above is a measure of physical abundance of natural resoruces, here again we find positive and significant results.

Tab. A9 – Low tech manufacturing splitting our sample using the median of the NR and MIN rent as a share of GDP.

VARIABLES	(1) NR	(2) MIN
$dva\_ltm\_cap_{t-1}$	0.761***	0.430***
	(0.0813)	(0.108)
dd_ltm_nr_cap	0.132***	
	(0.0420)	
schooling	0.000706	0.00963*
	(0.00234)	(0.00507)
internetaccess	0.00221	0.00546
	(0.00351)	(0.00419)
dd_ltm_min_cap		0.189***
		(0.0569)
AR(2)	0.39	-1.43
Observations	1,520	1,600
Number of geo-sectors	340	330

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1