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Revisiting the Natural Resource 'Curse' in the Context of Trade in Value Added: Enclave or High-development 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, if 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 from scholars sceptical of diversification based on beneficiation from NRI. We then empirically test whether NRI might represent a sufficient "domestic representative demand" à la Linder for backward linked sectors such as Knowledge Intensive Business Services (KIBS) or high tech manufacturing that might provide new opportunities for export diversification led by virtuous pathways of domestic structural change. We find empirical support for this conjecture and discuss some implications that revisit the NRI curse debate.

Keywords: Natural Resource Curse, Backward Linkages, Trade, Value Added, Input-Output

JEL: F14, F63, N50

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1 Introduction

Countries rich in or dependent on Natural Resources (NR)[1] might be 'blessed' or 'cursed', depending on a large number of factors. The literature has copiously analysed these, as effectively summarised in some of the most recent reviews (Badeeb et al. 2017; Havranek et al. 2016; Van Der Ploeg and Poelhekke 2017).

The term 'Natural Resource Curse' was first coined by Auty (Auty 1993, 1987) and is now commonly referenced to, since the publication of a widely cited work by Sachs and Warner (Sachs and Warner 1995, 1997). In a nutshell, the 'curse' thesis argues that countries rich in or dependent on NR experience low and/or stagnant growth performance, with detrimental consequences for their development. The core of the argument has not changed much since (Venables 2016; Harding and Venables 2016).

The theoretical explanations and empirical grounding of the NR curse include a number of arguments. The first is classical one of factors crowding-out, i.e. production inputs that are moved away from non-resources activities; secondly, a worsening of the balance of payment and terms of trade due to the contraction of the non-resources tradable sectors might occur (the well-known Dutch disease, more below) (Corden, 1982, 1984); third, the volatility of commodity[2] prices, which makes resource rents uncertain. Moreover natural resource rich countries will miss the learning-by-doing opportunity, following the lack of a core non-resource (manufacturing mainly) sector (Torvik, 2001). Finally, the scholarship has also shown a negative association of NR dependence with quality of institutions (Mehlum, Moene and Torvik, 2006).

However, natural resources are very diverse (i.e. coal rather than oil or diamonds), entail very different levels of initial investments, quality of institutions and the public management of rents (Havranek, Horvath and Zeynalov, 2016). This makes the

[1] NR is commonly intended to be non-renewable extractive industries such as oil and gas. The renewables, such as forestry, water, land that produce raw material and commodities, usually fall into the primary activities. Here we look at both types of sectors, as detailed below. The literature on the NR 'curse' instead tends to associate NR primarily with extractive industries. Broadly, and based on Venables (2016), countries rich in NR have at least 20% of their export or fiscal revenues coming from NR. For countries dependent on NR, this share is at least 50%.

[2] The term "commodity" generally refers to homogenous goods whose market cannot be easily fragmented. This is often, although not exclusively, the case for the production of both renewable and non-renewable natural resource sectors. Henceforth, we refer to both of these when we use the term commodity.

presence of a 'curse' largely heterogeneous across countries. The literature has identified cases of growth-adverse NR dependence (e.g. RDC, Angola, and many African countries) that are counter-balanced by cases of growth-enhancing ones (e.g. Botswana, Norway, Chile, Australia) (Venables, 2016). Overall, the most recent empirical scholarship has shown large country heterogeneity on the presence of an NR 'curse', that has called for some caution in considering the negative relationship between NR endowment (abundance or dependence) and growth to be conclusive (James, 2015; Badeeb, Lean and Clark, 2017).

One of the arguments contributing to the NR curse debate - of particular interest here - is the link between NR abundance/dependence, domestic structural change, and the trade patterns of NR industries (NRI from now on) versus non-resource industries. For instance, trade scholars have developed the Dutch disease argument by looking at the link between NR and non-resource sector *exports,* with a particular interest in developing countries (Torvik 2001; Harding and Venables 2016). It has been argued that, because NR exports might be detrimental to non-resource tradables, it is difficult to achieve diversification and move away from NR (Harding and Venables 2016; Venables 2016).

The issue of diversification in NR rich countries, traditionally envisaged as moving away from NRI towards an (export-driven) manufacturing sector, calls for more evidence on the role of the structure of the domestic economy. Within this, the importance of the structure of sectoral (backward and forward) linkages, alongside the levels of exports in NR and non-resources industries, has started to become more widely recognised (Baldwin and Venables, 2015; Cust and Poelhekke, 2015).

The case for making good use of backward and forward linkages within development policies is not new, and dates back to the seminal work by development economists such as Hirschman and Rostow (Hirschman, 1958; Rostow, 1960).[3] Hirschman took a remarkably original stand with respect to the mainstream growth theory based on factor endowments. The role of linkages in Hirschman's work serves the purpose of

[3] According to Hirschman (1958), there are different types of externalities, depending on whether activities are related to one another by backward or forward inducement mechanisms, i.e. whether certain sectors, by demanding inputs, induce the growth of supplier industries (input-provision or backward linkage effect) or, rather, by supplying output induce the growth of client industries (output provision or forward linkage effect).

creating new sectors by way of scalable intermediate demand, and therefore represents a useful device to identify strategies of industrial policy that favour diversification of the sectoral composition of economies.

When it comes to the issue of diversifying away from NR, the linkages framework, and specifically the argument of *beneficiation* (that is the development of downstream, forward-linked manufacturing industries that process raw materials and NR) has been criticised despite a substantial paucity of recent specific contributions. Hausmann et al. (2008), for instance, argue that policies aimed at beneficiation are misguided, as diversification should be based on similarity of factor and technological capabilities intensity rather than vertical linkages, most especially when NR is concerned. The argument, within the product space framework (Hausmann, Hwang and Rodrik, 2007; Hidalgo *et al.*, 2007), seems to have been crafted only with respect to beneficiation (i.e. forward-linked industries), rather than to backward-linked ones, that are those that could be demanded by NRI as intermediate inputs.

Building on the Hirschman-Linder Hypothesis put forward in López Gonzáles, Meliciani and Savona (2019) this paper aims to revisit the role of Hirschman linkages, particularly of NR backward-linked business services, to identify whether new patterns of export diversification in NR rich countries can emerge, depending on the revealed comparative advantage in NR of countries, and by distinguishing between extractive industries and agriculture. We aim therefore to contribute to the NR curse debate by offering a novel perspective and empirical evidence that hopefully sparks a whole new set of reflections on how to craft industrial, trade and development policies for NR-rich emerging countries.

We claim that for NR-rich countries, many of which are emerging economies, a specialisation in NRI might not necessarily be a 'curse', provided that it offers opportunities for export diversification in backward-linked sectors à la Hirschman. Such opportunities might be based on virtuous pathways of domestic structural change that do not necessarily involve moving away from NRI, but use them as a platform to sectoral (and technological) upgrade towards directions that have not often been considered, let alone as virtuous ones, such as backward-linked business services.

In previous work (López Gonzáles, Meliciani and Savona, 2019) a Hirschman-Linder conjecture on the determinants of participation in business services (BS) Global Value Chains (GVCs) has been put forward and empirically supported. We have argued that participation in BS GVCs, particularly in emerging countries, depends on the specific domestic structure of backward-linked industries to BS, particularly manufacturing industries. A critical mass of domestic intermediate demand for BS is found to be as important, and in the case of emerging countries even more important, as the foreign demand of (BS) intermediates. There is, therefore, a specific role of backward-linkages and the scale of the intermediate demand for BS that explains the potential for export diversification.

Building upon this conjecture and extending the argument, here we ask whether NRI might represent a sufficient 'domestic representative demand' à la Linder for backward-linked sectors such as Knowledge Intensive Business Services (KIBS)[4]. Should this be the case, there would be an opportunity to spur export diversification in sectors such as KIBS. This would create a whole new narrative around NR and trade and development policy when backward and forward linkage matter (Baldwin and Venables 2015), albeit with a set of sectors so far overlooked.

We empirically test our conjecture within a general method of moments (GMM) dynamic framework, to ascertain whether the domestic intermediate demand arising from the NR sector, distinguishing between extractive industries and agriculture[5], has a positive impact on the export performance of other sectors, in particular KIBS. We use data from the OECD inter-country input output tables (ICIO) to capture domestic intermediate demand as well as value added in exports.

We find empirical support for the Hirschman-Linder conjecture in the case of NRI. We find that countries, particularly those with a revealed comparative advantage in NRI, and particularly agriculture, benefit from a dimensionally important 'representative domestic demand' for KIBS coming from NRI, which favours trade in KIBS value added. This also holds when looking at domestic intermediate demand for high tech manufacturing sectors. These results seem to corroborate the idea that vertical linkages matter in the first place and that the presence of backward linkages

[4] We also test our conjecture by looking at high-tech manufacturing.

[5] In the Appendix we provide a detailed disaggregation of the sectors included in the empirical analysis.

to NRI, particularly when a country has a revealed comparative advantage in agriculture, might be a way of rethinking export diversification strategies that are grounded in NRI, rather than bypassing them. More in general, the NR curse might therefore be reversed, with adequate efforts.

The paper is organised as follows. We first revisit the evolution of the NR curse debate that is relevant to the purpose of this paper (Section 2). We then describe the empirical strategy and the data (Section 3) and present some initial descriptive evidence in support of our main conjecture (Section 4). This is followed by a discussion of the econometric results in order to contribute to the NR curse debate from the perspective of structural change and export diversification (Section 5). We conclude by drawing implications of industrial, trade and development policies (Section 6).

2 Background

In what follows we offer a review of the debate on the NR curse and related topics. As a general background, we first review the seminal NR curse contributions; we then review a second stream of scholarship that has focused on the specialisation in Natural Resource Industries (NRI) and its consequences for export diversification, to which this paper aims to contribute.

2.1 The evolution of the NR curse debate

An abundance of NR and specialisation in NRI have been alternatively regarded as a 'blessing' or a 'curse' for economic development. At first, NR was considered as an opportunity for countries to develop, following a path similar to that of the USA and Australia (Rostow, 1960).

Among the first scholars to question the dominant view of their time, Singer (1950) and Prebisch (1959), considered NR as an inferior specialisation strategy, notably with respect to manufacturing, because of the difference in income-demand elasticity and the deteriorating terms of trade in natural resources. Demand for exports from natural resource industries is, in fact, less elastic than for manufactured goods. This means that as world income grows, demand for commodities from NR will grow less than that for manufactured products. As a consequence, countries exporting NR-based commodities and importing manufactured products will face price to import increases at a faster rate than the price of exports.

The presence of NRI was deemed beneficial only conditionally on the development of a substantial manufacturing sector (Prebisch, 1959), within a balanced development strategy à la Nurkse (1952). The argument was based on the evidence that productivity increases in the NRI would make large parts of the workforce redundant, which, in the absence of a manufacturing sector absorbing this labour, would lead to unemployment, particularly in developing countries (Prebisch, 1959).

The scepticism around economic development ensuing from a large NR endowment and specialisation in NRI became a dominant view in the 1980s, when the Dutch Disease thesis was first coined (Corden, 1982; Auty, 1993). In a nutshell, based on the experience of the Netherlands after the discovery and export of natural gas in the 1960s and 1970s, the Dutch disease implies that the use of production factors in the extraction of NR – assuming full employment – diverts resources from other tradable, (typically manufacturing sectors) and non-tradable sectors (typically services sectors) for which demand (and/or import) increases. The consequence is a worsening of the balance of payments and the terms of trade in the NR rich country. In addition, a contraction of manufacturing exports might reduce opportunities for 'learning by doing' and dynamic efficiency at the macro level (Torvik 2002, 2001).

Apart from the particular argument behind the Dutch Disease, the scholarship has identified a range of negative effects that a large export-oriented natural resource sector would have on the rest of the economy, hindering its overall performance. Because of the exports from the NRI, the country's currency would appreciate making other tradable sectors less competitive (Harding and Venables 2016). Specialisation in NRI would also draw investment and other resources away from other sectors (Sachs and Warner 1997; Matsuyama 1992). By concentrating all the revenues in one sector, the country would become exposed to price volatility of the exported natural resource.

Indeed, over the last decade some scholars have challenged the existence of the NR curse, by reverting to historical examples (Wright and Czelusta 2004). For instance, some scholars have argued that the resource curse would not be inevitable if high-quality institutions were in place, capable of investing and distributing resource revenues in a virtuous way (Brunnschweiler 2008; Boschini et al. 2013; Venables 2016).

Some scholars have also questioned the empirical soundness of the evidence brought in support of the resource curse (see for instance, Stijns 2000; Lederman and Maloney 2006; Brunnschweiler and Bulte 2008). In particular, it has been argued that the empirical evidence in support of the curse thesis, as in the seminal Sachs and Warner (1995), is based on cross-sectional data, which are not fit to capture the evolution over time of both institutions and technology (Robinson et al. 2006; Van Der Ploeg and Poelhekke 2017; James 2015). Also, natural resource *abundance* is often confused with natural resource *dependence* (Brunnschweiler and Bulte 2008); when this is disentangled from natural resource rents, the latter can actually have a positive impact on economic growth (Ding and Field 2005).

Crucially to our purpose here, another reason why the NR sector has been perceived as detrimental for economic development is that it has often been regarded as an enclave (Heeks, 1998), extracting resources from the country, with few linkages with the rest of the domestic economy and most of the profits being shipped away or concentrated in the hands of a few rentiers (Weisskoff and Wolff 1977).

Being an enclave also affects the opportunities in natural resource dependent countries for export diversification (Lederman and Maloney 2006). In this respect, contributions have focused on the chances of diversifying away from NRI (Harding and Venables 2016; Baldwin and Venables 2015). Baldwin and Venables (2015), for instance, model the effects of trade policies aimed at increasing industrialisation in developing – albeit not specifically NR rich – countries. These policies, they argue, should take into account the interactions between backward and forward linkages between *part* and *final* goods; they conclude that, because linkages create a multiplier effect, targeted trade and industrial policies that make sense of the domestic structure of linkages would increase the industrial base and its export performance. The theoretical framework and ensuing argument might well be applied to NR rich countries, although the authors do not go that far.

2.2 Export diversification, NRI and high development linkages

There seems to be a consensus on the importance for countries with a specialisation in NRI to spur the emergence of other sectors in their export portfolio, reducing their dependence on NRI. While such changes may be driven by a variety of factors, it is worth noting that changes in countries' export specialisation are tightly linked to the underlying domestic structure (Hausmann and Klinger 2006; Hausmann et al. 2007), including an increasing number of complex products and services (Hidalgo and Hausmann 2009; Hidalgo 2009; Felipe et al. 2012). Consistent with this view, export diversification has often been a stated policy goal of many commodity dependent countries (Massol and Banal-Estañol 2014).

However, export diversification may be hard to achieve, particularly for countries abundant in NR, when NRI are a traditional enclave lacking significant linkages with the rest of the economy (Hirschman, 1958; Heeks, 1998). Enclave NR sectors, and extractive industries in particular, are typically dominated by large foreign companies, employing a foreign skilled workforce, importing intermediate goods and services, shipping profits back to where they are headquartered, and mainly selling on the international market. For these reasons, NRI has often been regarded as ill-suited to foster the emergence of new sectors through backward or forward linkages (Bloch and Owusu 2012; Heeks 1998).

However, recent qualitative contributions have cast some doubt on the enclave hypothesis about NRI (Bloch and Owusu 2012; Adewuyi and Ademola Oyejide 2012; Marin and 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. For instance, the sector has seen an increase in outsourcing of non-core activities towards local suppliers, which would foster domestic backward linkages (Barnett and Bell 2011; Aragón and Rud 2013).

The debate in the literature around the enclave hypothesis for NRI has also largely hinged upon the role of forward and, to a lesser extent, backward linkages.

Taking a different approach, Hidalgo et al. (2007) and Hausmann and Klinger (2006) have looked at how some products favour the emergence of others in countries' export structure, finding again that NRI is unlikely to lead to the emergence of new industries. Rather than input-output linkages, Hausmann and co-authors look at capabilities requirements, which they infer as using goods' joint probability of being exported by the same country as a measure of proximity (Hidalgo *et al.*, 2007; Hidalgo and Hausmann, 2009). If a pair of products has a high probability of being exported by the same countries, they must require a similar set of capabilities to be produced.

Using this measure of proximity, Hausmann et al. build a 'product space' where some products are more or less connected to others (Hausmann, Hwang and Rodrik, 2007; Hidalgo *et al.*, 2007). While the product space approach does not rely on backward or forward linkages, it yields similar conclusions to the traditional enclave view: within the product space, NRI are shown to be among the least connected products, making it thus particularly hard to diversify starting from a specialisation in such industries.

Policies encouraging export diversification through beneficiation, i.e. fostering forward linkages and trying to move from NRI to downstream manufacturing processing activities, are considered ill-advised for two reasons. First, NRI is a poorly connected sector and, second, export diversification should not be driven by input-output linkages but, rather, by similarity in capability requirements. Hausmann et al. (2008) argue that rather than supporting vertical changes across sectors, industrial policies should focus on enhancing production of goods that lie closer to what countries currently export and therefore to what they have capabilities to produce. In doing so, they join a quite long-standing view in the economic debate that looked with criticism at resource based industrialisation policies (Auty, 1986).

2.3 The Hirschman-Linder hypothesis and NRI: research questions

In this paper we explore the role of backward linkages. We refer in particular to the Hirschman-Linder hypothesis that we have developed in previous work López Gonzáles, Meliciani and Savona (2019).

This conjecture blends the concept of backward linkages à la Hirschman, with the idea of a 'domestic representative' demand à la Linder (Burenstam Linder, 1961). According to this, countries would be able to export a certain good if they attained a benchmark level of domestic demand; this would make domestic producers competitive enough to operate in the international market.

Linder (1961) puts forward this thesis by referring to *final* manufactured products. In López Gonzáles, Meliciani and Savona (2019) we have explored whether *intermediate* domestic demand could be a determinant of countries' GVC participation in KIBS, finding support for this hypothesis concerning domestic backward linkages between the manufacturing sector and KIBS.

Here we explore whether the Hirschman-Linder hypothesis could apply to backward linkages emerging from NRI demand, particularly to KIBS. In particular, we ask:

- What is the NRI's relationship with KIBS domestic *backward* linked sectors, and can this intermediate demand generated by NRI drive the emergence of export by other sectors?
- Does this conjecture apply to high-tech manufacturing too?
- When does specialisation in NRI represent a substantial NRI intermediate demand and affect export of KIBS and high-tech manufacturing?

3 Data and Empirical Strategy

We aim to test our main conjecture, that domestic intermediate demand from the NR sector to KIBS and high-tech manufacturing sectors can be a "representative demand" à la Linder, favouring the emergence of other sectors and ultimately fostering export diversification. Relatedly, we would also expect countries with a specialisation in NRI to be more apt to use such sector as a platform to spur exports in other sectors.

It seems important to distinguish between extractive NRI and renewable ones; the latter are natural resources from soil, such as the agriculture sector. They are, in contrast with extractive activities such as mining, usually considered to be less prone to NR curse effects (Venables, 2016). However, they also yield commodities that may risk making the producing country highly dependent on them, exposed to price volatility and, crucially to our analysis, less likely to diversify due to the lack of inter-sectoral linkages (Vogel 1994; Matsuyama 2008; Hirschman 1958).

For these reasons we include them in our analysis. However, bearing in mind the differences between these two sectors, we present our results separately, looking at the relationship between intermediate domestic demand from these sectors and KIBS. So, our NRI are the two following sectors:

- Agriculture, hunting and fishing (AGR);
- Mining and quarrying (MIN).

In the remainder of the paper when we refer to both AGR and MIN, we will use the general term NRI. When our analysis' results only apply to either sector, we will use the name of the relevant sector. In Appendix A3, Table A3 reports the full list of the sectors used in our analysis and how they are aggregated into KIBS and high-tech manufacturing, following the OECD classification.

3.1 Data

We use the inter-country input-output (ICIO) tables compiled by the OECD, covering 33 sectors in 64 countries for the years 1995-2011. ICIO tables allow observing inter-sectoral linkages, tracing value added flows from the originating to the destination sector, both domestically and across borders[6]. Moreover, a value added approach allows capturing each sector's domestic value added contribution to countries' exports, reallocating value added exported to the sectors from which it has originated (Koopman *et al.*, 2010).

This way we can assess the extent to which the increase of exports from a given sector is driven by domestic productive activity in that sector, as opposed to value added contributions coming from other sectors, either domestic or abroad (i.e. imports).

With 33 sectors, the data are quite aggregate and each sector category includes a wide range of different activities. This means that very diverse activities are included in each sector. We try to mitigate this shortcoming by looking at exports to focus on the share of production that is tradable and meets high enough quality standards to be competitive on the international market (Hidalgo *et al.*, 2007). This choice is also consistent with the literature on the Dutch disease (Corden, 1984; Torvik, 2001), which focuses on the effect of large NRI on exports from other sectors.

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 64 countries, i.e. 128

[6] While a range of inter-country input-output databases are available, we chose the ICIO from the OECD because it ensures the largest coverage of countries, while still being based on statistical information from countries, without using imputation methods (Kowalski *et al.*, 2015).

country-sector combinations, which we refer to as geo-sectors henceforth, over the 1995-2011 period[7]. In the next subsection we detail how we use the ICIO tables to compute the outcome and main explanatory variables.

3.2 Variables

Our literature review has emphasised the importance for countries with large NRI to diversify their export portfolio, which means spurring the exports of other sectors. Consistent with this, we operationalise our conjecture on the importance of NRI's domestic intermediate demand by estimating domestic value added in exports of sectors different from NRI as a result of NRI backward linkages. For simplicity, our discussion here refers to KIBS, although the same variables have been computed for high-tech manufacturing.

Our main outcome variable is domestic value added in exports per capita from the KIBS sector, which we compute as follows: let *VAE* be a c*i x 1 column vector with each country *c* and sector *i* domestic value added embodied in gross export:

$$VAE = V'(I - A)^{-1}E$$

Where V' is a ci x ci diagonal matrix populated with each geo-sector value added share in output, i.e. value added produced by a given geo-sector divided by its total output. $(I\text{-}A)^{-1}$ is the traditional Leontief inverse capturing all inter-sectoral relationships for all sectors and countries. Finally, E is a ci x 1 column vector with each geo-sector export. The elements of *VAE* include all value added that is originated by country *i* but consumed abroad, either through foreign final demand or foreign intermediate demand. We exclude from this measure the value added exported as foreign intermediate demand but then re-imported through country *i*'s own final demand.

From this *VAE* vector we select the elements corresponding to each country's KIBS sectors. We therefore obtain our vector of observations, which we divide by each country's population obtaining *dva_kbs_cap*, i.e. value added in exports per capita in KIBS sector.

[7] The ICIO data provide a balanced panel. However, the World Development Indicators have some missing values, which makes the final panel we are working with unbalanced and forces us to drop some countries from our analysis altogether, such as Brazil, Brunei, Vietnam and the rest of the World compound.

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

Our main explanatory variable, 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:

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

This matrix is computed very much in the same way as *VAE* but we substitute the *ci* x 1 E vector with the *ci* x *ci* matrix F populated with zeros off the diagonal and with each geo-sector final demand on the diagonal. We also use $(I\text{-}A)_d^{-1}$, which is the usual Leontief Inverse, although we extract from it a block-diagonal matrix where the dimensions of the block are the number of sectors, 33 in this case. This matrix will thus only capture the inter-sectoral linkages within the same country.

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 sectors' output. We then aggregate across NR sectors and divide by each country's population and obtain *dd_kbs_nr_cap*.

Finally, both human capital and information and communication technologies (ICT) infrastructure have played a significant role in the expansion of the service sector and its linkages with the rest of the economy (Guerrieri and Meliciani 2005).

For this reason we rely on the World Bank World Development Indicators and use gross enrolment in secondary education to capture human capital and Internet users per thousand inhabitants as a proxy of technological infrastructure, particularly related to ICT.

3.3 Econometric strategy

To test our main conjecture of the Hirschman-Linder hypothesis applied to NR, the general form of our estimated equation is the following:

$$dva\_kbs\_cap_{it} =$$

$$\alpha_0 + \beta_1 dva\_kbs\_cap_{it-1} + \beta_2 dd\_kbs\_nr\_cap_{it} + \beta_3 dd\_kbs\_nr\_cap_{it} * nr\_rca_{ct} + \beta_4 schooling_{ct} + \beta_5 internetaccess_{ct} + \alpha_i + \alpha_t + \varepsilon_{it}$$

In our econometric equation presented above, $dva\_kbs\_cap_{it}$ is the KIBS value added embodied in each geo-sector's *i* gross exports 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 thousand inhabitants and captures countries' technological infrastructure. We also control for geo-sector and year fixed effects (FE) α_i and α_t respectively.

While we test this hypothesis for all countries, we expect that the specialisation in NR sectors of a country may influence the relationship between our outcome and explanatory variables. An additional hypothesis we wish to test is, in fact, whether countries with a specialisation in NRI experience a stronger relationship between backward linkages stemming from NRI and the DVA they export from KIBS and high-tech manufacturing.

To test this, we interact our main explanatory variable with a dummy variable *nr_rca* taking value 1 if the country has a revealed comparative advantage (also measured in value added) in the natural resource sector. This will allow us to explore whether a specialisation in natural resources affects the relationship between exports of value added in KIBS and the intermediate domestic demand generated by the natural resource sector.

Using the revealed comparative advantage to assess countries' specialisation in NRI is a data-driven approach. This has the advantage that our definition of specialisation does not rely on any *ex-ante* and arbitrary definition of how much NRI should represent of a country's GDP or exports.

Two more issues need to be dealt with. First, export of KIBS is likely to be affected by serial correlation, as current levels of exports are often correlated with past ones. Second, the relationship between exports 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, including the lag of the outcome variable on the right-hand side of the equation, $dva\_kbs\_cap_{it-1}$, and use a system GMM, which allows instrumenting with past lags of our endogenous variables.

We also cluster the standard errors by country and perform the robust version of the system GMM with Windmeijer's (2005) correction for finite sample.

All of the variables we have computed with the ICIO tables are per capita measures of DVA flows across sectors (for the explanatory variables), and from one sector to the rest of the world (for the outcome variable). This is to account for countries' differences in size, assuming that population is a good proxy for countries' size. However, this may not necessarily apply to NRI in particular, whose size can be driven by the endowment of natural resources that need not be tightly related to the population of a country. We present in the Appendix a robustness check of our results, accounting for countries' size using Leontief Inverse coefficients[8]. This captures NRI intensity in inputs from KIBS and high-tech manufacturing, which is independent of countries' size and on countries' population.

Before discussing our econometric results in the next section, we present here some descriptive evidence concerning the relationship between intermediate NR-KIBS domestic demand and KIBS domestic value added in exports.

[8] See Tables A8 and A9 in the Appendix

4 Descriptive evidence

In this section we present some preliminary evidence supporting our main conjecture that larger domestic intermediate demand from NRI has a positive effect on DVA export of KIBS.

Figure 1 plots the natural logs of DVA from the KIBS sector and the logs of intermediate demand emanating from the NR sector for KIBS. The dots in blue and green correspond to countries with and without an RCA in NRI, respectively. The same applies for the fitted lines in light blue and dark green, while the fitted line in red is plotted without distinguishing between countries with or without an RCA.

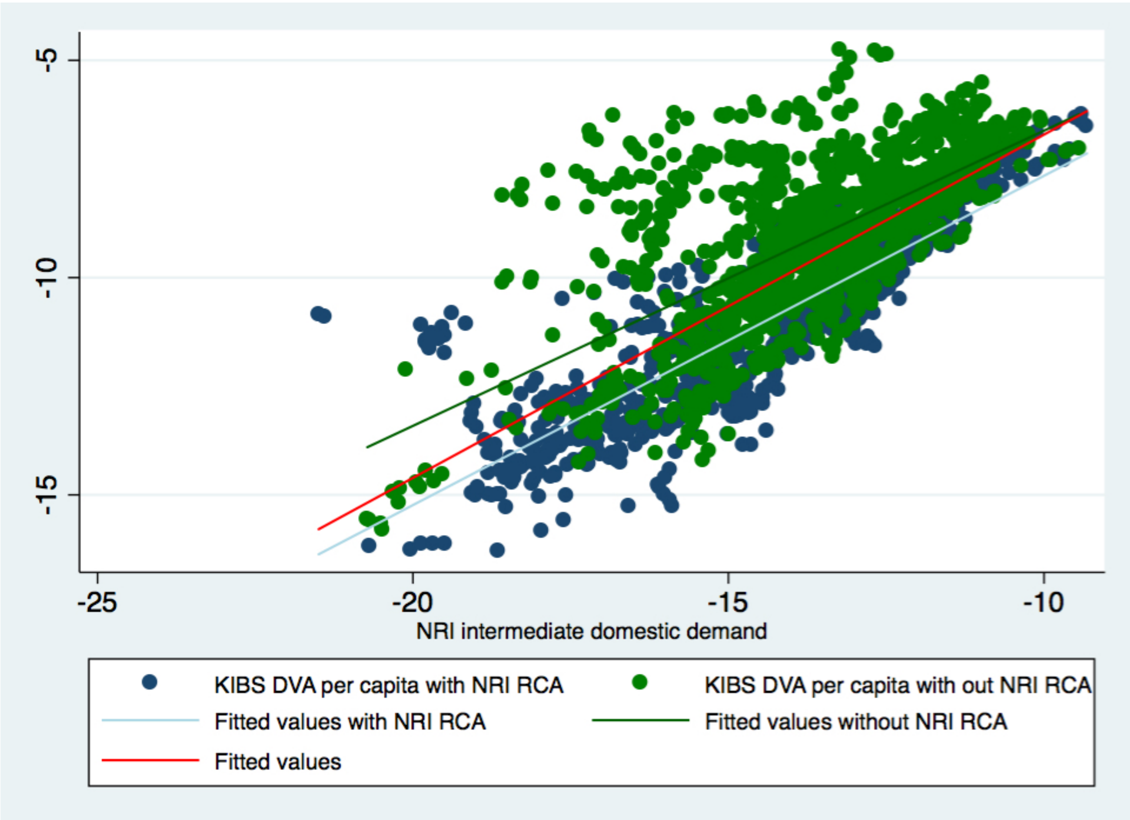

Figure 1: Domestic intermediate demand from NRI and KIBS domestic value added in exports

Source: authors' own calculation with ICIO tables.
Note: figure 1 plots the natural log of intermediate domestic demand per capita from NRI against the natural log of KIBS DVA per capita. These are all negative because the original data from the ICIO tables are measured in millions of USD, which yields values below 1 when divided by the population to obtain per capita measures.

We find a strong and positive relationship between our two variables. We also see that the countries without an RCA in NRI tend to have higher levels of KIBS DVA, although the fitted line has a slightly lower slope; this suggests that the relationship may be less strong. Countries without an RCA in NRI have in fact higher variability of KIBS DVA for similar levels of intermediate demand for KIBS from NRI.

As we mentioned, our econometric analysis will look at AGR and MIN separately, so we now offer some descriptive evidence on the relationship between these two sectors' intermediate demand and DVA in KIBS.

The positive association detected in Figure 1 is borne even more strongly when we look at the AGR sector alone, in Figure 2: the colour legend in this figure is the same for Figure 1. We see again that the countries without an RCA in AGR tend to cluster in the upper-right corner of the graph, which means that they usually have higher levels of both intermediate domestic demand from AGR and KIBS DVA. However, the slope of the fitted line is smaller when compared to the subsample of countries with an RCA in AGR, which suggests that the relationship between intermediate demand from AGR and the export of KIBS DVA may be stronger for countries with an RCA in AGR.

This also brings support to the idea that the relative size of the NR sector may be a factor influencing the relationship between the intermediate domestic demand originating from this sector and the DVA exported by KIBS.

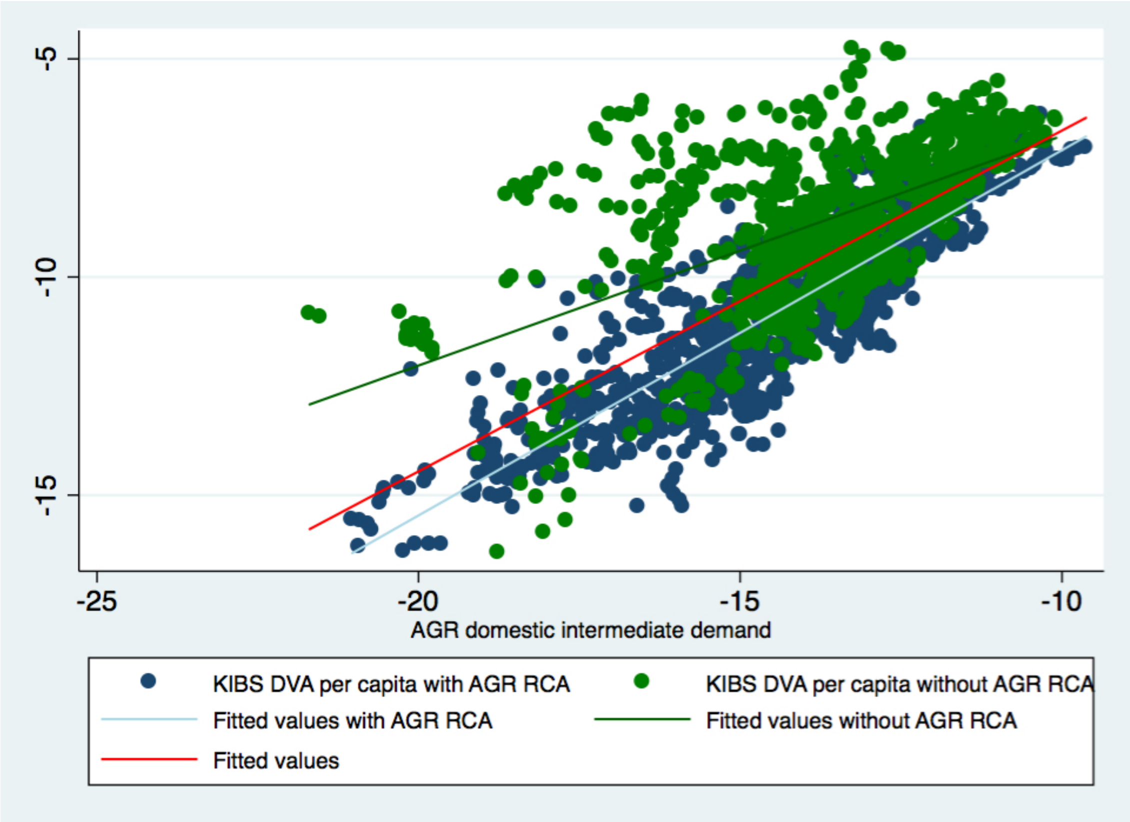

Figure 2: Domestic intermediate demand from AGR and KIBS domestic value added in exports

Source: authors' own calculation with ICIO tables.

Note: figure 2 plots the natural log of intermediate domestic demand per capita from AGR against the natural log of KIBS DVA per capita. These are all negative because the original data from the ICIO tables are measured in millions of USD, which yields values below 1 when divided by the population to obtain per capita measures.

When we turn to the MIN sector in Figure 3, we find once again a positive association between our variables; interestingly we find here that countries without an RCA are located more towards the upper-left quarter of the graph. This hints at the fact that they have rather lower levels of intermediate demand from MIN but higher levels of DVA KIBS. In contrast, countries with an RCA in MIN tend to have lower levels of export of KIBS.

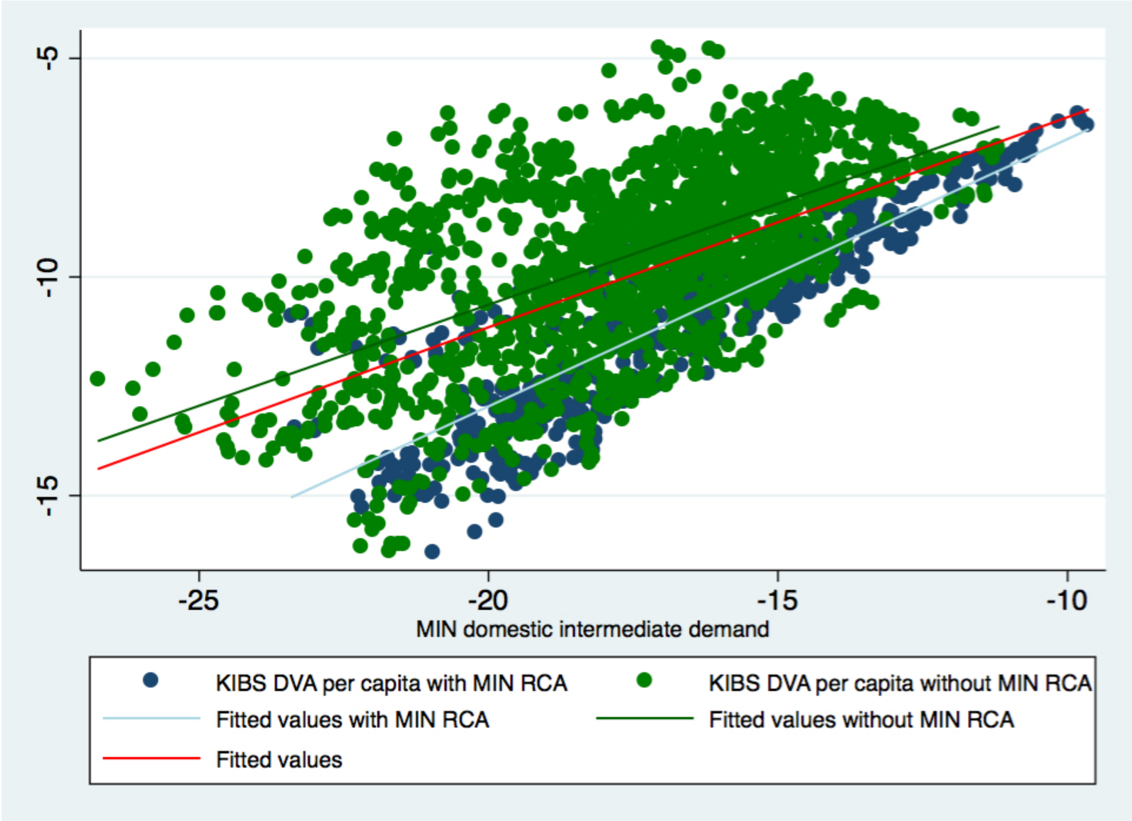

Figure 3: Domestic intermediate demand from MIN and KIBS domestic value added in exports

Source: authors' own calculation with ICIO tables.
Note: figure 3 plots the natural log of intermediate domestic demand per capita from MIN against the natural log of KIBS DVA per capita. These are all negative because the original data from the ICIO tables are measured in millions of USD, which yields values below 1 when divided by the population to obtain per capita measures.

This descriptive analysis provides some preliminary evidence to our main conjecture on the positive effect of NRI intermediate domestic demand and DVA exported by KIBS.

Relating back to Venables' (2016) distinction between renewable (AGR) and extractive industries (MIN), we find some interesting differences. The positive relationship we detect seems to be particularly strong for the AGR sector, rather than MIN. This may suggest that the enclave thesis may apply to backward linkages from extractive NRI more than to renewable NRI. This would lend further support to Venables (2016) conclusion that renewable natural resources may have fewer negative effects on countries' economic performance.

These figures offer *prima facie* evidence about the relationship between intermediate domestic demand and DVA exports of KIBS, which is likely to be riddled with endogeneity, particularly due to reverse causality and simultaneity of the relationship. As discussed above, our econometric approach deals with these issues; we present the main results in the next section.

5 Econometric results

5.1 NRI and backward linked KIBS

In the following tables we present our main results, we also look separately at the two sectors (AGR and MIN) that are included in the NR sector. Re-computing our explanatory variables and RCA accordingly, Table A2 in the appendix summarises the list of relevant variables and the associated acronyms.

In Table 1 we find a positive and significant effect of intermediate demand from NRI on the per capita export of value added of KIBS, both when we look at AGR and MIN. The interacted terms are also significant, which suggests that the positive effect of NRI intermediate demand on the export of KIBS is stronger for countries with an RCA in NRI.

Table 1: The effect of NRI intermediate demand on the DVA of KIBS in export per capita – System GMM estimation

VARIABLES	AGR	MIN
$dva\_kbs\_cap_{t-1}$	0.792***	0.922***
	(0.0778)	(0.0450)
dd_kbs_agr_cap	0.205**	
	(0.0952)	
dd_kbs_agr_cap*agr_rca	0.212**	
schooling	0.00572	0.00304
	(0.00348)	(0.00252)
Internet access	-0.00256	-0.000871
	(0.00256)	(0.00190)
dd_kbs_min_cap		0.0720**
		(0.0363)
dd_kbs_min_cap*min_rca		0.0738**
		(0.0359)
Constant	0	0.0937
	(0)	(0.816)
Observations	1,756	1,756
Number of geo-sectors	122	122
AR(2)	0.289	0.166
Hansen test overidentification	0.529	0.740
Difference-in-Hansen	0.680	0.865

System GMM estimation for the effect of the natural log of intermediate demand per capita of AGR (col. 1) and MIN (col. 2) on the DVA in export per capita of KIBS. The analysis is carried out at the geo-sector level, i.e. for each country-sector combination, where the sectors are two KIBS sectors: Computer and related activities (ITS); R&D and other business services (BZS). The variables agr_rca and min_rca are binary variables taking value 1 if the country has an RCA (in value added terms, rather than gross export) in AGR or MIN, respectively. Schooling is gross enrolment in secondary education and internet access is internet users per thousand inhabitants.

Standard errors in parentheses

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

dva and dd variables in logs

For the AR and Hansen tests the p values are reported.

Source: authors' own calculation on ICIO tables.

These results suggest that intermediate demand from the NR sector exerts a positive effect on the export of KIBS, and even more so in those countries that have an RCA in this sector.

As mentioned above, we chose the RCA index as a measure of specialisation in NRI; however, this has some implications on how these results can be interpreted. The RCA is a measure of relative specialisation: a country with an RCA in NRI above one is a country in which NRI represents a higher proportion in its exports than it does in the world's exports (Balassa, 1965). The underlying idea of the RCA is that countries specialise in sectors whose production requirements they are best equipped to meet (Chor, 2010), which may lead to equating specialisation and competitiveness (Hidalgo *et al.*, 2007).

Competitiveness in a sector is often related to productivity: countries that are more efficient at producing in a given sector will be more likely to be more competitive (and specialise) in this sector (Chor, 2010).

However, a country may develop a specialisation in NRI, which would only be captured by the RCA index because of its endowment in NR and lack of other sectors, regardless of the sector's productivity. This has bearing on the interpretation of our results, depending on the source of RCA in NRI:

- A very productive NR sector allows a country to develop an RCA in NRI, hence requiring more and/or higher quality KIBS inputs, therefore increasing KIBS export performance; there would thus be a 'quality' effect of the intermediate demand stemming from NRI on the export performance of KIBS;
- A very large NR sector, regardless of its productivity, provides a very large intermediate demand and this 'scale' (or quantity) effect improves KIBS export performance.

These two channels are not mutually exclusive, but it is important to disentangle them to understand for which countries our results will be relevant.

On the one hand, if improvements in the export of KIBS are conditional on the 'quality' of the intermediate demand to which they are exposed, countries relying mainly on the size of the NR sectors (which are often developing ones) will be unlikely to see their KIBS sector benefit from NRI domestic intermediate demand.

On the other hand, if the 'scale' effect is at play, countries can exploit the size of the NRI intermediate demand, regardless of its 'quality', to improve KIBS export performance.

In order to ascertain this, we need to control for the 'quality' effect that could drive countries' specialisation in NRI. We proxy the quality of the intermediate demand with an index of productivity of the NR sector[9], which we compute by dividing the domestic value added of the NR sector by its inputs, i.e. its intermediate demand. This is admittedly a crude measure of productivity, but it has the advantage of being readily computable at the sectoral level in our data[10]. It is also close to the idea of productivity as efficiency in production, as it captures how much value added is produced given the input required by the production process.

Part of the intermediate demand of the NR sector is already included in our main explanatory variable; we therefore 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 ($IC_{NR-KIBS}$). Table 2 shows the results of the estimation that includes this additional control.

[9] As above, we refer in the text to NRI in general; naturally, in the empirical analysis, we compute this measure of productivity for AGR and MIN separately.

[10] An alternative approach would have been to compute labour productivity at the sectoral level; however, employment data at the sectoral level for all the countries in our sample is not available. The world input-output tables (WIOT) would have been an alternative source as they include inter-country input-output tables and sectoral levels of employment, but they cover a significantly smaller number of countries, including few developing countries.

Table 2: The effect of NRI intermediate demand on the DVA of KIBS in exports per capita, controlling for NRI productivity – System GMM estimation

VARIABLES	AGR	MIN
$dva\_kbs\_cap_{t-1}$	0.852***	0.925***
	(0.0796)	(0.0443)
dd_kbs_agr_cap	0.206**	
	(0.104)	
dd_kbs_agr_cap*agr_rca	0.213**	
	(0.101)	
schooling	0.00155	0.00155
	(0.00336)	(0.00268)
internetaccess	-0.00470**	-0.000820
	(0.00207)	(0.00171)
vaic_agr	0.0272	
	(0.122)	
dd_kbs_min_cap		0.0520
		(0.0330)
dd_kbs_min_cap*min_rca		0.0595*
		(0.0334)
vaic_min		-0.0721
		(0.0938)
Constant	2.084	0.248
	(1.294)	(0.726)
Observations	1,756	1,756
Number of geo-sectors	122	122
AR(2)	0.665	0.217
Hansen test overidentification	0.845	0.801
Difference-in-Hansen	0.262	0.752

System GMM estimation for the effect of the natural log of intermediate demand per capita of AGR (col. 1) and MIN (col. 2) on the DVA in export per capita of KIBS. The analysis is carried out at the geo-sector level, i.e. for each country-sector combination, where the sectors are two KIBS sectors: Computer and related activities (ITS); R&D and other business services (BZS). The variables agr_rca and min_rca are binary variables taking value 1 if the country has an RCA (in value added terms, rather than gross export) in AGR or MIN, respectively. Schooling is gross enrolment in secondary education and internet access is internet users per thousand inhabitants.

The two additional controls are vaic_agr and vaic_min which are the ratio between AGR and MIN, respectively, total value added divided by their respective total intermediate consumption, excluding the intermediate consumption of KIBS.

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
dva, dd and vaic variables in logs
For the AR and Hansen tests the p values are reported.

Source: authors' own calculation on ICIO tables.

We find our results to be robust, in particular when looking at the agriculture sector. We find that the intermediate domestic demand has a positive effect for all countries and the interaction term is also positive and significant; this suggests that such a relationship is even stronger for countries with an RCA in the AGR sector. For the mining sector, we find significant results, at the 10% level, only for countries with an RCA in NRI.

So, the positive effect between NRI, especially AGR, intermediate domestic demand on KIBS export does not seem to be driven by the 'quality' of the intermediate demand: our results suggest that in countries with a specialisation in NRI, the domestic intermediate demand originating from this sector exerts a positive effect on the export of KIBS, through a scale effect, regardless of productivity. This is also supported by the fact that the productivity measures of either NRI never shows a statistically significant coefficient, suggesting that NRI productivity is unrelated to exports of domestic value added in KIBS.

In conclusion it would appear that, in contrast with a dominant view of natural resources as an enclave sector with weak domestic inter-sectoral linkages with the rest of the economy, domestic intermediate demand emanating from NRI can foster exports for value added in the KIBS sector.

Our empirical results lend support to our initial conjecture relating to the Hirschman-Linder hypothesis. López Gonzáles, Meliciani and Savona (2019) have already shown that manufacturing intermediate demand could foster GVC participation in KIBS; we now find that the same mechanism is also valid for backward linkages from NRI.

It is important to stress, however, that these results should not be interpreted as a rationale for developing a specialisation in NRI, but rather that countries that already have an economic structure in which such industries play a pivotal role should foster the domestic backward linkages to other sectors to spur the emergence of KIBS and achieve economic diversification.

In particular we show that export diversification away from NRI may be possible through backward, rather than the more studied forward linkages, putting forward an interesting alternative to beneficiation policies, which have often proved unsuccessful.

Such policies did not focus on KIBS but on manufacturing. The rationale for this was to allow countries to use the output of their NRI as input for low-tech manufacturing activity, using it to trigger structural change and gradually upgrade to high-tech manufacturing activities. Since these were the ultimate goals of beneficiation policies, we wish to test whether backward linkages from NRI can also provide an avenue for the emergence of exports in high-tech manufacturing, as we see is the case for KIBS.

5.2 NRI and backward linked High-Tech Manufacturing

As emphasised when reviewing the literature, most of the scholarship has looked at the inter-sectoral linkages originating from NRI to *downstream* manufacturing activities, often arguing that these were not a viable path to diversification towards the manufacturing sector (Auty, 1986; Hausmann, B Klinger and Lawrence, 2008). We aim here to explore the potential of *backward* linkages.

We saw in the previous section that such linkages can indeed spur the emergence of KIBS exports. We now wish to test whether this hypothesis applies to high-tech manufacturing and thus whether backward linkages can constitute a path to the emergence of high-tech and knowledge intensive sectors, both in services and manufacturing.

In this section, we define high-tech manufacturing based on the OECD classification[11], and carry out the same empirical analysis as we did for DVA in KIBS in the previous section.

In Table 3, we again find positive and significant effects of domestic intermediate demand on the export of high-tech manufacturing value added, for both AGR and MIN. In both these cases, the interaction terms are positive and significant, corroborating the idea that the positive relationship between NRI intermediate demand and the export of high-tech manufacturing is stronger for countries that have an RCA in NRI.

[11] See Table A1 in the Appendix for a full list of sectors.

Table 3: The effect of NRI intermediate demand on the DVA of high-tech manufacturing in exports per capita – System GMM estimation

VARIABLES	AGR	MIN
$dva\_htm\_cap_{t-1}$	0.884***	0.891***
	(0.0686)	(0.0602)
dd_htm_agr_cap	0.0838***	
	(0.0270)	
dd_htm_agr_cap*agr_rca	0.0799***	
	(0.0276)	
schooling	0.00544	0.00466
	(0.00463)	(0.00437)
internetaccess	-0.000307	0.000230
	(0.00276)	(0.00203)
dd_htm_min_cap		0.0496***
		(0.0190)
dd_htm_min_cap*min_rca		0.0435**
		(0.0198)
Constant	-0.518	-0.633
	(1.486)	(1.213)
Observations	5,268	5,268
Number of geo-sectors	366	366
AR(2)	0.153	0.677
Hansen test overidentification	0.385	0.235
Difference-in-Hansen	0.129	0.458

System GMM estimation for the effect of the natural log of intermediate demand per capita of AGR (col. 1) and MIN (col. 2) on the DVA in export per capita of high-tech manufacturing. The analysis is carried out at the geo-sector level, i.e. for each country-sector combination, where the sectors are six high-tech manufacturing sectors, the full list can be found in the appendix table A1. The variables agr_rca and min_rca are binary variables taking value 1 if the country has an RCA (in value added terms, rather than gross export) in AGR or MIN, respectively. Schooling is gross enrolment in secondary education and internet access is internet users per thousand inhabitants.

Standard errors in parentheses

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

dva and dd variables in logs

For the AR and Hansen tests the p values are reported.

Source: authors' own calculation on ICIO tables.

These results expand the existing debate around beneficiation and NRI forward linkages to manufacturing, suggesting that backward linkages may be a pathway to industrialisation for countries with a specialisation in NRI.

In the previous section, we discussed how an RCA in NRI may arise because the country is very efficient in the production process, or simply because the country is largely endowed and lacks other sectors of comparable size.

For this reason, we now replicate in Table 4 the model from Table 3, adding our measure of productivity of the NR sector as an additional control.

Table 4: The effect of NRI intermediate demand on the DVA of high-tech manufacturing in exports per capita, controlling for NRI productivity – System GMM estimation

VARIABLES	AGR	MIN
$dva\_htm\_cap_{t-1}$	0.955***	0.839***
	(0.0419)	(0.0390)
dd_htm_agr_cap	0.0440	
	(0.0426)	
dd_htm_agr_cap*agr_rca	0.0379	
	(0.0403)	
schooling	0.000789	0.00732***
	(0.00254)	(0.00257)
internetaccess	0.000126	0.00127
	(0.00160)	(0.00182)
vaic_agr	-0.156	
	(0.186)	
dd_htm_min_cap		0.0415***
		(0.0140)
dd_htm_min_cap*min_rca		0.0383**
		(0.0165)
vaic_min		-0.0147
		(0.0324)
Constant	0.287	-1.200
	(0.735)	(0.734)
Observations	5,268	5,268
Number of geo-sectors	366	366
AR(2)	0.016	0.068
Hansen test overidentification	0.213	0.643
Difference-in-Hansen	0.147	0.817

System GMM estimation for the effect of the natural log of intermediate demand per capita of AGR (col. 1) and MIN (col. 2) on the DVA in export per capita of high-tech manufacturing. The analysis is carried out at the geo-sector level, i.e. for each country-sector combination, where the sectors are six high-tech manufacturing sectors, the full list can be found in the appendix table A1.

The variables agr_rca and min_rca are binary variables taking value 1 if the country has an RCA (in value added terms, rather than gross export) in AGR or MIN, respectively. Schooling is gross enrolment in secondary education and internet access is internet users per thousand inhabitants.

The two additional controls are vaic_agr and vaic_min which are the ratio between AGR and MIN, respectively, total value added divided by their respective total intermediate consumption, excluding the intermediate consumption of high-tech manufacturing.

Standard errors in parentheses

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

dva, dd and vaic variables in logs

For the AR and Hansen tests the p values are reported.

Source: authors' own calculation on ICIO tables.

We now find rather different results. In the case of high-tech manufacturing, intermediate backward linkages from the AGR sector do not play any significant role, once we control for the productivity of the AGR sector and thus for the 'quality' of input it demands. This suggests that the previous positive results in Table 3 were picking up an effect related to the productivity of AGR and that, once we account for that, the strength of the intermediate demand becomes irrelevant.

In contrast, we find a positive and significant effect of the intermediate demand from the MIN sector, as well as the interaction terms with the RCA dummy. This suggests that the intermediate demand from the MIN sector does have a positive impact on the DVA export per capita of the high-tech manufacturing and that this effect is stronger for countries with an RCA in MIN.

This is an interesting result, especially when compared to the different results obtained for KIBS. Intermediate demand from the natural resource sector seems to be a successful strategy to develop exports of KIBS, regardless of whether we look at extractive (MIN) or not (AGR) industries. Exports in high-tech manufacturing in contrast seems to be affected by the intermediate demand of only the mining sectors, once we control for the productivity of NRI.

So, in the previous section we find that our Hirschman-Linder hypothesis does apply to NRI-KIBS backward linkages and that this result is robust, even when controlling for productivity in NRI. Concerning high-tech manufacturing we only find support for our Hirschman-Linder hypothesis only for the MIN sector; this is particularly interesting with respect to the well-established literature that has looked with scepticism at resource based industrialisation (RBI) strategies, focusing on forward linkages from NRI (Auty 1986; Hausmann, et al. 2008).

This paper puts forward new evidence suggesting to use backward, rather than forward, linkages to foster exports in high-tech manufacturing. Overall, we propose a novel and alternative way for countries with large NRI to diversify their exports towards manufacturing, relying on NRI's intermediate demand rather than output. We find this path to be viable for export diversification towards KIBS and high-tech manufacturing, though for the mining sector only.

It is also worth pointing out that while our main conjecture is borne out by the evidence concerning KIBS, this appears to be the case only for countries with a specialisation in either AGR or MIN, when we control for the NRI sectors productivity.

This in turn confirms our hypothesis that NRI backward linkages would be a driver of DVA exports in KIBS for countries with a specialisation in NRI.

6 Conclusions

This paper has offered novel empirical evidence to revisit the role of backward and forward linkages à la Hirschman (López-Gonzalez et al. 2015, 2019), in a context of NR abundant or dependent emerging countries that face the opportunities and challenges of having to 'diversify away' from NRI. We aim to contribute to the old-age debate on the NR 'curse', which has been recently revamped by further empirical evidence.

How to better achieve export diversification as a development strategy is of high relevance among academic and policy makers, despite it not being new. We have offered here a new angle in two respects. The first is in revisiting the issue of backward and forward linkage à la Hirschman, alongside some trade scholars (see for instance, Venables et al. 2015), although in a context of NRI specialisation. The second is adding to the debate around diversification via *beneficiation* – that is, the development of downstream, forward linked manufacturing industries that process raw materials and natural resources (Hausmann et al. 2008) – by considering instead diversification by developing backward linkages with KIBS, that have been relatively overlooked in the debate on NRI.

We have looked at whether specialisation in NRI overall, and separately in extractive industries and agriculture, might represent a sizeable and quality 'representative domestic demand' à la Linder that can spur the creation of KIBS and high-tech manufacturing sectors towards export diversification. We explore whether there is a causal link between NRI specialisation and export performance of KIBS and high-tech manufacturing. We find robust evidence in support of our conjectures.

Countries specialised in NR, most especially in agriculture, show a positive impact on KIBS and high tech manufacturing's export performance. This result is stronger for KIBS only, in countries with a revealed comparative advantage in NRI, when we control for NRI's productivity performance.

In the case of high-tech manufacturing, it seems that the positive impact on export performance of manufacturing of the intermediate demand of NRI is absorbed by the productivity of the NR sector itself for the AGR sector, while our results are robust when we look at the intermediate domestic demand of MIN.

Our results seem to support the view that – after all – vertical linkages matter when it comes to identifying patterns of diversification that builds upon extant NRI specialisation rather than trying to move away from it. Looking at backward linked sectors – and especially KIBS - is a first step to rewriting the narrative around NRI, and surely one that contributes to the debate around 'premature deindustrialisation' recently put forward (Rodrik, 2015).

While we do not explicitly provide grounded evidence for specific industrial policy tools, we hope to offer a background narrative that supports new directions and experiments of industrial policy. More in general, it is not straightforward to identify appropriate policy tools that support domestic and trade diversification in emerging countries, that allow 'quality' industrialisation or indeed 'quality' servification, all the more so when countries start from a specialisation in NR.

However, based on our results, we can offer a few general reflections on the importance of a coherent set of industrial policies that aim to support industrial development in NR-based emerging countries.

First, countries, particularly those abundant and/or specialised in NR, could exploit this to identify related backward or forward linked sectors that do not necessarily need to be on the technological frontier but nevertheless represent feasible directions for structural transformation. While this is not, in principle, new, for instance within the product space framework (Hidalgo et al. 2007; Hausmann et al. 2007), we argue that the ability of countries to transition from one set of activities to another one is based on a deliberate policy effort to support technological and sectoral upgrading (Ciarli et al. 2018).

Second, such a deliberate effort would entail a new narrative around the support to international technology transfer, via, for instance, the presence of Multinational Enterprises (MNEs), most especially in NR-based countries. The development of domestic capabilities for upgrading is the result of a patient and long-term process of interaction of foreign and domestic firms, all the more so in a context of international fragmentation of production. Currently there is little reflection, and only from a few scholars, on the link between international technology transfer, export diversification, and domestic technology upgrading as an explicit policy goal that aims to ensure quality directions to structural transformation (Bell 2009; Barrientos et al. 2011; Fu et al. 2011; Pietrobelli et al. 2011). The conjecture and empirical evidence put forward in this paper are aimed to contribute to the narratives that might support furthering of these reflections.

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Appendix A

In this Appendix we present some more detailed information on the data we use, as well as the most relevant robustness checks we have performed to establish the reliability of our results.

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

Table A1: Macro sector groups and ISIC codes

Sectors groups	Sector names	Sector 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.
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

Source: Authors' own classification based on the OECD Technology intensity definition

Note: the ICIO data are an aggregated version of the 2-digits ISIC Rev.3, so we have identified high-tech manufacturing based on the high and medium-high technology intensity as defined by the OECD https://www.oecd.org/sti/ind/48350231.pdf

We also present a table recapitulating the variables used in the paper and the respective abbreviations, as well as a correlation table for our main model.

Table A2: List of variables and acronyms

Variable name	Explanation	Source
dva_kbs_cap	Domestic value added (DVA) exported by KIBS, excluding the portion of DVA exported through exports of NR or AGR or MIN	Authors' own calculations with the OECD ICIO tables
dd_kbs_agr_cap	Domestic intermediate demand from the AGR sector for KIBS	Authors' own calculations with the OECD ICIO tables
dd_kbs_min_cap	Domestic intermediate demand from the MIN sector for KIBS	Authors' own calculations with the OECD ICIO tables
vai_agr	Productivity measure for the AGR sector	Authors' own calculations with the OECD ICIO tables
vaic_min	Productivity measure for the MIN sector	Authors' own calculations with the OECD ICIO tables
dva_htm_cap	DVA exported by high-tech manufacturing (HTM) excluding the portion of DVA exported through export of NR or AGR or MIN.	Authors' own calculations with the OECD ICIO tables
dd_htm_agr_cap	Domestic intermediate demand from the AGR sector for HTM	Authors' own calculations with the OECD ICIO tables
dd_htm_min_cap	Domestic intermediate demand from the MIN sector for HTM	Authors' own calculations with the OECD ICIO tables
agr_rca	Dummy taking value 1 if the country has an RCA in AGR	Authors' own calculations with the OECD ICIO tables
min_rca	Dummy taking value 1 if the country has an RCA in MIN	Authors' own calculations with the OECD ICIO tables
schooling	Gross enrolment in secondary education	World Bank World Development Indicators
internetaccess	Internet users per thousand inhabitants	World Bank World Development Indicators

Source: authors own classification

Below we report a correlation matrix of all the variables included in our econometric analysis.

Table A3: Correlation matrix of main variables

	dva_kbs_cap	dd_kbs_agr	dd_kbs_min	schooling	internetaccess
dva_kbs_cap	1				
dd_kbs_agr	0.7412*	1			
dd_kbs_min	0.6035*	0.7363*	1		
schooling	0.6159*	0.5574*	0.4882*	1	
internetaccess	06293*	0.4270*	0.3737*	0.4765*	1

* = p-value <0.05

All dva and dd variables are in natural logs.

Source: authors' own calculation with the ICIO tables.

Appendix B – Detailed tables of countries with RCAs

We include below three tables, detailing which countries had an RCA in NRI, AGR and MIN in our sample, to give a more complete picture of what observations in our data have the RCA dummy variables taking value 1.

Table A4: Countries with RCA in AGR

Country	Number of Years with RCA	Country	Number of Years with RCA
ARG	17	ISL	17
AUS	17	KHM	17
BGR	17	LTU	15
BRA	17	LVA	17
CAN	10	MAR	17
CHL	17	ME1	3
CHN	17	MYS	17
COL	17	NLD	15
CRI	17	NZL	17
CYP	1	PER	17
CZE	1	PHL	17
DNK	7	POL	5
ESP	16	PRT	12
EST	14	ROU	16
FIN	8	ROW	17
FRA	1	SVK	5
GRC	17	THA	17
HRV	15	TUN	17
HUN	17	TUR	17
IDN	17	VNM	17
IND	17	ZAF	7
IRL	4		

Source: authors' own calculation with the ICIO tables.

Note: the second column of the table reports the number of years in which each country has an RCA in AGR.

Table A5: Countries with RCA in MIN

Country	Number of Years with RCA
ARG	9
AUS	17
BRA	2
BRN	17
CAN	17
CHL	11
CHN	1
COL	17
IDN	17
MAR	6
ME1	17
MYS	17
NOR	17
PER	17
POL	2
ROW	17
RUS	17
SAU	17
TUN	13
VNM	17
ZAF	17

Source: authors' own calculation with the ICIO tables.

Note: the second column of this table reports the number of years in which each country has an RCA in MIN.

Appendix C – Robustness checks

Our main specification relies on per capita measures. This is to take into account different size of countries to make flows of value added across countries comparable. The underlying assumption is that countries with larger populations will also have larger production of KIBS and high-tech manufacturing; they will also have a larger intermediate demand emanating from the NR sector. However, this assumption may not necessarily be true for the NR sector in particular, whose size can be driven by endowment of natural resources that need not be tightly related to the population of a country. The input-output tables allow for another way of accounting for countries' size when looking at intermediate domestic demand. That is, using the coefficients from the Leontief inverse matrix for the two NR sectors, AGR and MIN. These will capture the sector's intensity in KIBS and high-tech manufacturing.

We now present our main models using these coefficients instead of the per capita measures to check for the robustness of our results. Because the intensity of the NR sector is unlikely to be related to the country's size, we use as outcome variables the DVA in exports in absolute terms.

Table A6: The effect of NRI intermediate demand on the DVA of KIBS in exports, using Leontief Inverse coefficients – System GMM estimation

	(2)	(3)
VARIABLES	AGR	MIN
dva_kbs_{t-1}	0.838***	0.989***
	(0.0753)	(0.0583)
dd_kbs_agr	0.155**	
	(0.0787)	
dd_kbs_agr*agr_rca	0.185**	
	(0.0831)	
schooling	0.00314	-0.000914
	(0.00219)	(0.00259)
internetaccess	-0.00280*	-0.00338
	(0.00147)	(0.00232)
dd_kbs_min		0.0700
		(0.0607)
dd_kbs_min*min_rca		0.0996**
		(0.0468)
Constant	2.185***	0.478
	(0.816)	(0.424)
Observations	1,756	1,756
Number of geo-sectors	122	122
AR(2)	0.180	0.346
Hansen test overidentification	0.954	0.470
Difference-in-Hansen	0.792	0.607

System GMM estimation for the effect of Inverse Leontief coefficient of uses of AGR (col. 1) and MIN (col. 2) of KIBS on the DVA in export of KIBS. The analysis is carried out at the geo-sector level, i.e. for each country-sector combination, where the sectors are two KIBS sectors: Computer and related activities (ITS); R&D and other business services (BZS). The variables agr_rca and min_rca are binary variables taking value 1 if the country has an RCA (in value added terms, rather than gross export) in AGR or MIN, respectively. Schooling is gross enrolment in secondary education and internet access is internet users per thousand inhabitants.

Standard errors in parentheses

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

dva and dd variables in logs

For the AR and Hansen tests the p values are reported.

Source: authors' own calculation with the ICIO tables.

We find very robust results, with agriculture intermediate demand having a positive and significant impact on the export of KIBS value added; such effects are even larger for countries with an RCA.

In contrast, mining does not show the same positive relationship we detected in Table 2.1, except for countries with an RCA, in which case the domestic KIBS intensity of the mining sector does have a positive effect on the export of KIBS value added.

Overall these additional results support our conjecture that intermediate domestic demand emanating from the NR sectors can indeed spur the export of KIBS, and that this is particularly true for countries with a specialisation in NRI.

As for KIBS, we now look at our main model for high-tech manufacturing using Leontief Inverse coefficients in Table A8. We find, globally speaking, consistent results with our main model for high-tech manufacturing: intermediate demand, captured here as NRI production's intensity in high-tech manufacturing, has a positive effect on the export of high-tech manufacturing value added.

This effect is even stronger for countries with an RCA in NRI, both for agriculture and mining sectors.

Table A7: The effect of NRI intermediate demand on the DVA of high-tech manufacturing in exports, using Leontief Inverse coefficients – System GMM estimation

	(2)	(3)
VARIABLES	AGR	MIN
dva_htm_{t-1}	0.867***	0.697***
	(0.0702)	(0.169)
dd_htm_agr	0.0609**	
	(0.0275)	
dd_htm_agr*agr_rca	0.0685**	
	(0.0312)	
Schooling	0.00204	0.00851
	(0.00567)	(0.00899)
Internetaccess	-0.000810	0.000361
	(0.00349)	(0.00395)
dd_htm_min		0.0782*
		(0.0463)
dd_htm_min*min_rca		0.0854*
		(0.0472)
Constant	1.170	1.398
	(0.721)	(1.229)
Observations	5,268	5,268
Number of geo-sectors	366	366
AR(2)	0.350	0.634
Hansen test overidentification	0.616	0.499
Difference-in-Hansen	0.482	

System GMM estimation for the effect of Inverse Leontief coefficient of uses of AGR (col. 1) and MIN (col. 2) of high-tech manufacturing on the DVA in export of high-tech manufacturing. The analysis is carried out at the geo-sector level, i.e. for each country-sector combination, where the sectors are six high-tech manufacturing sectors, the full list can be found in the appendix table A1. The variables agr_rca and min_rca are binary variables taking value 1 if the country has an RCA (in value added terms, rather than gross export) in AGR or MIN, respectively. Schooling is gross enrolment in secondary education and internet access is internet users per thousand inhabitants.

dva and dd variables in logs. Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

For the AR and Hansen tests the p values are reported, column two does not report the Hansen-in-Difference test because the estimation relies on the first to fourth lag of the endogenised variables, which is too few instruments of calculate the Hansen-in-Difference test. A set of other lag combinations has been tried but this one was the one passing the other two tests, i.e. second order autocorrelation (AR2) and the Hansen test for overidentification.

Source: authors' own calculation with the ICIO tables.

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