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PRODUCTIVITY EFFECTS OF TRADE IN NATURAL RESOURCES - COMPARISON WITH MECHANISMS OF TECHNOLOGICAL SPECIALISATION

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Abstract

This paper compares two alternative growth paths, assessing the effects on productivity of specialisation in natural resources (NR) and in technologically advanced products. The empirical analysis exploits product-level export data for 109 developing and 51 developed economies over the period 1996-2018. We document two distinct types of specialisation, based on exports either of natural resources or of technological products, and compare their role in productivity growth by GMM estimation of a conditional convergence model. In general, reliance on natural resource exports slows growth, but we find that the type of resources exported is important: fuel exports hamper growth while specialisation in metals enhances the catch-up in productivity. Technological specialisation, especially in products typical of the Fourth Industrial Revolution, reinforces productivity growth but does not affect the relationship between resources and productivity growth.

JEL: *O13, O47, O3, Q32*

Keywords: natural resources, technology, specialisation, productivity growth, convergence

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[1] Revised version (September 2022). Previous version of this work was circulated under corresponding author's maiden name - Bazychowska.

1. Introduction

This paper assesses the role played by different types of export specialisation[2] in productivity growth. We simultaneously compare the effects of two forces: 'traditional' mechanisms relating to natural resource endowment and 'modern' specialisation relating to the development of technological capacity.

The wealth of empirical literature on economic growth tends to treat these two development paths separately. Commonly, the role played by natural resources (NR) is analysed from the perspective of the developing countries. The main focus is either on the economic and political distortions produced by resource endowments (the 'resource curse' debate on the failure of many resource-rich countries to benefit from this abundance and the situation where resource-rich countries' performance is notably worse than others': see, amongst many, Gylfason, 2001; Sachs and Warner, 2001; Mehlum et al., 2006; Torvik, 2009; Ross, 2015) or, on the risk-accentuating excessive concentration on a narrow basket of primary products in many low-income countries (the export diversification literature: Basile et al., 2018; Cadot et al., 2011; Parteka and Tamberi, 2013a, 2013b). On the other hand, much attention has recently gone to the potential growth effects of the Fourth Industrial Revolution (4IR) and rapid-fire innovations in digital technology (Aghion et al., 2017, 2021; Foster-McGregor et al., 2019; Venturini, 2022). This literature focuses on the developed world and the discrepancy between the official productivity statistics of many countries and the expectations related to the potential of 4IR technologies (the 'modern productivity paradox': Brynjolfsson et al., 2019, 2021; Syverson, 2017; Byrne et al., 2016; Crafts, 2018; Gal et al., 2019).

However, there are numerous less obvious facts that need to be addressed. First of all, some resource-rich countries have managed to avoid the resource curse, such as Norway and Botswana. Nearly 70% of Norway's exports consists of NR (mostly crude oil and gas), while Botswana relies heavily on diamonds (around 90% of exports),[3] but the two countries' per capita income is very high

[2] Throughout the paper the term 'specialisation' is used to describe a country's export structure in relation to the other countries in the sample, quantified via export shares and revealed comparative advantage in two specific groups of exported products, natural resources and technology.
[3] Export data from CEPII (2021)

($65,000 and $16,000, respectively, in 2018).[4] At the same time, the group of countries that depend heavily on primary commodity exports includes such poor economies as Nigeria and Angola (NR export dependency of 91% and 90%, respectively, and 2018 per capita income of $5,000 and $7,000) or Venezuela, where dependence on oil revenue, combined with economic mismanagement and inappropriate government practices, led to one of the most severe crises in modern history (Bull and Rosales, 2020; John, 2019; Weisbrot and Sachs, 2019). Among the fuel exporters of the Middle East, we might compare Iraq (97% of total exports consisting in fuel and per capita income of $10,500) with Kuwait (87%, $50,500). Secondly, the effects on growth of export concentration in natural resources and modern technologies can be intertwined. There are countries that do both (medium and high tech products make up approximately 15% of Norway's exports), meaning that technological upgrading may be made possible by resource revenues, so the two growth paths need not be mutually exclusive. The question is whether Norway is an isolated case, while most of the developing countries, including resource-rich exporters, are excluded from technology-based growth?

We address this question analysing the process of productivity growth in a large sample of 109 developing and 51 developed economies, from 1996 to 2018. We use product-level trade data to compare the degree of specialisation in NR and in high-tech products. Importantly, unlike other studies, in analysing the growth process we consider the role played by different types of resources (forestry products, fuels, metals, minerals) and different types of technology (comparing broadly defined tech exports to ICT exports and 4IR exports).

The paper is structured as follows. Section 2 reviews the literature, and Section 3 presents the data and some descriptive evidence on the relationship between the two patterns of specialisation. Estimates of the productivity growth model are described in Section 4, and Section 5 concludes.

2. Natural resources and technology as growth determinants – the literature

The early literature on the relationship between natural resources and economic development argued that resource-rich countries, in general, struggle with economic problems and that, almost without exception, they have stagnated since the 1970s (Sachs and Warner, 2001). The phenomenon

[4] Per capita income data from WDI (2022).

has come to be known as the 'resource curse' or 'paradox of plenty'. Now, however, the debate has grown less one-sided. Havranek et al. (2016) show that of 33 resource-curse studies analysed, about 40 per cent find a negative effect, 40 per cent no effect, and 20 per cent a positive effect of natural resources on long-term economic growth. Certainly, the results of different papers depend on multiple factors: the databases used, the time period analysed, the number of developing and developed countries in the sample, and so on (Van der Ploeg, 2011; Badeeb et al., 2017). Nevertheless, there are several possible explanations why natural resources may have an adverse impact on growth in some countries and beneficial effects in others.

Firstly, the quality of institutions and governing bodies is crucial. Torvik (2009) argues that countries of poor institutional quality are more exposed to the risk of a negative impact from NR abundance. An analysis of 40 developing countries by Kim and Lin (2017) finds that natural resources tend to increase per capita income in countries with less government intervention, better protection of property rights and less corruption. Farhadi et al. (2015) contend that it is the quality of institutions that ultimately determines whether the 'curse' of natural resources can be turned into a blessing. Countries with bad institutions may actually suffer a double resource curse when worsening institutional setting reinforces the negative effect of resources (Mehlum et al., 2006). Policies that enable resource rents to be used well can spur economic growth, especially in developing countries (Ben-Salha et al., 2018). Growth- and welfare-enhancing policies can help counter the adverse effects of specialisation in natural resources (Cavalcanti et al., 2011).

Secondly, the relationship between primary commodities and productivity growth may differ with the particular type of resources involved. Cavalcanti et al. (2011) report that oil abundance (in the form of oil rents, production and reserves) doesn't have to be a curse but in fact has beneficial effects on both the level of output and its growth rate. The combination of institutional quality and type of natural resources also proves to be fundamental. According to Torvik (2009), by comparison with NR in general, oil and minerals have a more pronounced negative impact on growth where the quality of institutions is poor. Minerals (diamonds in particular) have the most detrimental effect possible when combined with poor-quality institutions (Boschini et al., 2007; Olsson, 2006).

Another major issue is how resource revenues are spent or saved. Exclusive dependence on these rents obviously carries the risk of price instability. For instance, after the price of oil plunged by almost 50% in 2015, Venezuela was left with the bare minimum of savings during the subsequent economic crisis. It is crucial, that is, for countries to have reserves: according to Torvik (2009), the countries that have escaped the resource curse have higher rates of savings out of resource revenues than those that have not escaped. What is more, the accumulation of physical, human and social capital is inversely correlated with the share of natural resource capital and has a significant effect on the relationship between resources and economic growth (Gyfalson and Zoega, 2006).

Subsequent important factor is how resource exploitation combines with other economic activities. A more complex economy, as measured by the Economic Complexity Index[5] (Hidalgo et al., 2007; Hausmann et al., 2007; Hidalgo and Hausmann, 2009; Hausmann et al., 2014) turns out to diminish the importance of NR rents (Canh et al., 2020) and can drive economic development. The quality and profitability of resource extraction industries can also help to avoid the paradox of plenty. Resource abundance can spur economic growth in countries that succeed in developing strong and efficient resource production industries (Gerelmaa and Kotani, 2016).

The exploitation of natural resources relies on exogenously given endowments, but countries can also base their growth on a completely different factor – technology. Technology is a key component of the production function (Solow, 1957) and technical progress is a factor in many growth models (Romer, 1986, 1990; Lucas, 1988; Aghion and Howitt, 1992). Since the 1980s, the impact of the ICT revolution on growth has been intensively analysed (Jorgenson et al., 2008; Inklaar et al., 2005; Timmer and van Ark, 2005; Oliner et al., 2007; Acemoglu et al., 2014). Recently, a new kind of technological specialisation, related to the advanced 4IR digital technologies, including artificial intelligence (AI), has gained more and more attention (Baruffaldi et al., 2020; Venturini, 2022; Bassetti et al., 2020) but its role in growth process is umbigous.

Aghion et al. (2018), developing the model of economic growth of Zeira (1998), argue that automation (and AI) can increase the economic growth rate either temporarily or permanently,

[5] The Economic Complexity Index (ECI), provided by Harvard Growth Lab, ranks countries by the diversity and complexity of their export baskets.

depending on how they are implemented. The effects of AI and automation depend also on institutions and policies. AI can foster growth but it may also inhibit it if combined with improper competition policy (Aghion et al., 2020). There exists a rich literature on the problem of the recent slowdown in productivity growth in many developed countries, partly dashing the high hopes for the use of digital technologies – a phenomenon dubbed the 'modern productivity paradox' (Brynjolfsson et al., 2019). Inklaar et al. (2020) show that the productivity slowdown of the past decade began well before the 2007-2008 crisis and consequently cannot be considered a simple business cycle effect. Bloom et al. (2020) document that in many technological fields research productivity has been falling, and Nordhaus (2015) finds that the hypothesis of an acceleration of technology-driven growth fails a variety of tests.

Are resource-rich countries excluded from the technology race? The empirical analysis of Fagerberg and Verspagen (2020) shows the wide gap between the countries that specialise in high-tech production and those, lagging behind in terms of technology and income, that specialise in resource-based products. The results of Foster-McGregor et al. (2019) suggest that only the inner circle of the most highly developed countries display a high degree of specialisation in 4IR technologies. However, to the best of our knowledge, none of the studies evaluates simultaneously the role of resources and technology (especially the newest digital solutions) in the growth process. The next section describes the data we use to address this issue.

3. Data and descriptive evidence

3.1 Dataset

The analysis covers a total of 160 countries – 109 developing and 51 developed economies (listed in Table A.1. in Appendix A), from 1996 to 2018. The final choice of countries depend on data availability and representativeness: microstates (with population under 100,000) and countries with limited data on GDP and productivity are excluded. The disaggregated export data (HS96 6-digit)[6] used to compute

[6] The number of HS96 product codes in BACI CEPII diminishes over time, so to hold it constant we delete the product codes that "disappear" between 1996 and 2018 and those that are no longer present in subsequent revisions. The final product-level export database used here contains 4895 product codes.

indices of natural resource (NR) and tech specialisation comes from the BACI CEPII database[7] (CEPII, 2021; Gaulier and Zignago, 2010).

To gauge the importance of NR in countries' exports we use the taxonomy of mining and forestry products based on the WTO International Trade Statistics classification (Bacchetta et al., 2010).[8] We divide products into four groups: forestry products, fuels, metals, and minerals (Appendix A - Table A.4.). To measure technological specialisation, we employ three alternative classifications, denoting technologically advanced products broadly defined (TECH) based on Lall (2000), ICT exports (ICT) from UNCTAD (2021), and 4IR-related products including robots, 3D printers and CAD/CAM machines (4IR) from Parteka et al. (2022)[9] – see Table A.5. (Appendix A). The 4IR and ICT classifications use 6-digit HS96 product level detail. To match the SITC-based taxonomy of Lall (2000) with the HS96 schema in BACI data, we use the SITC (Rev.3) – HS96 correspondence tables from UN Trade Statistics.

3.2 Trends in resources' trade and technological trade

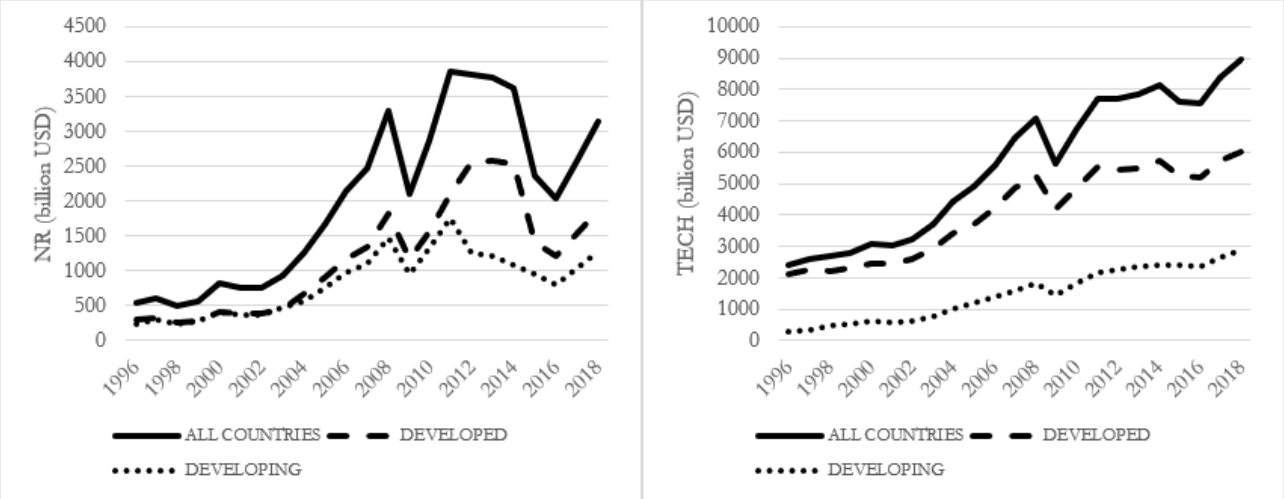
Figure 1 illustrates the growth in the value of NR and TECH exports between 1996 and 2018. Developed countries contribute the greater part of TECH exports, whose total value tripled. The value of developing countries' TECH exports also tripled over these years, but their share of total exports is smaller than in the developed countries. For almost 15 years (1996-2010) the value of NR exports was practically equal in developed and developing countries. Afterward it soared in the developed countries while declining steadily in the developing countries. As of 2018, values of natural resources exports were on an uptrend again.

Figure 2 shows the relative importance of specific NR types in overall NR exports of all the countries in our sample. Unsurprisingly, fuels account for some 70% of all NR exports, and this proportion has basically increased over the years (from 63% in 1996 to a peak of 78% in 2013 before

[7] The BACI database has yearly product-level data on bilateral trade flows; only strictly positive exports are recorded, and trade flows below 1,000 USD do not appear. We aggregate bilateral trade data to the reporter-world dimension.
[8] The WTO classification also comprises fish, raw materials and other semi-manufactures as product groups.
[9] The taxonomy builds upon Domini et al. (2021) and Foster-McGregor et al. (2019).

slipping to 73% in 2018).[10] The export shares of minerals and metals have remained more or less at their original levels, suggesting the persistence of relatively constant demand in various production processes (for example lithium, cobalt and nickel needed to make batteries, or iron for steel production). Given the non-renewable character of these resources, careful and deliberate action in this field is indispensable. On the other hand, the share of forestry in total NR exports has shrunk (from 10% in 1996 to 5% in 2018).

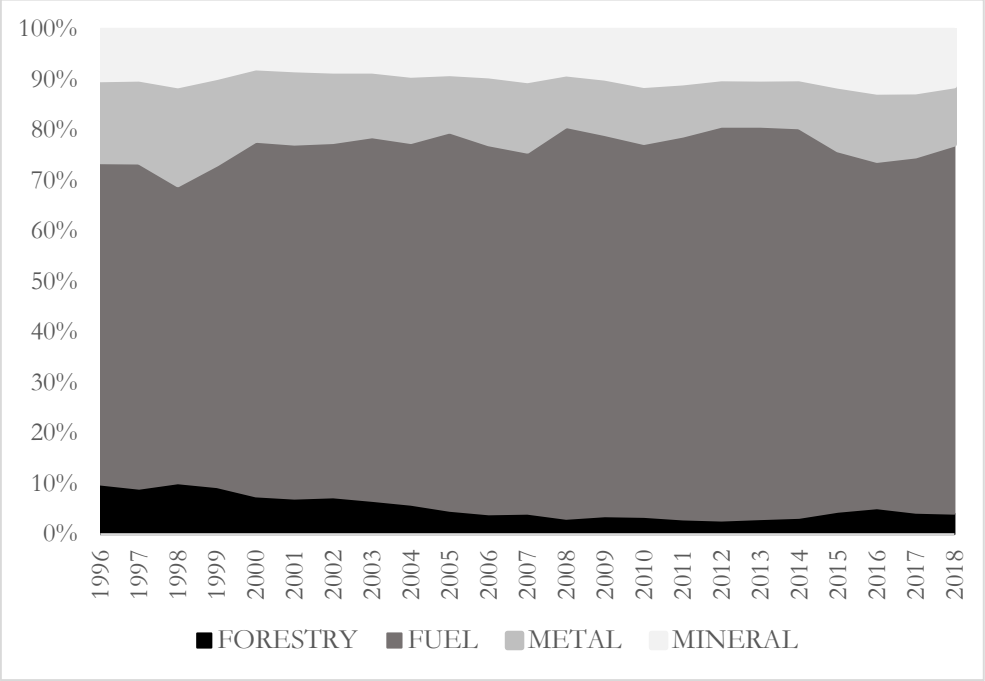
Figure 1. Value of NR exports versus technological exports (sample: 160 countries, 1996-2018)



Note: countries split into developing and developed in Table A.1.
Source: Author's elaboration based on 6-digit HS export data from BACI CEPII (Gaulier and Zignago, 2010), NR product taxonomy from Bacchetta et al. (2010) and TECH export taxonomy from Lall (2000).

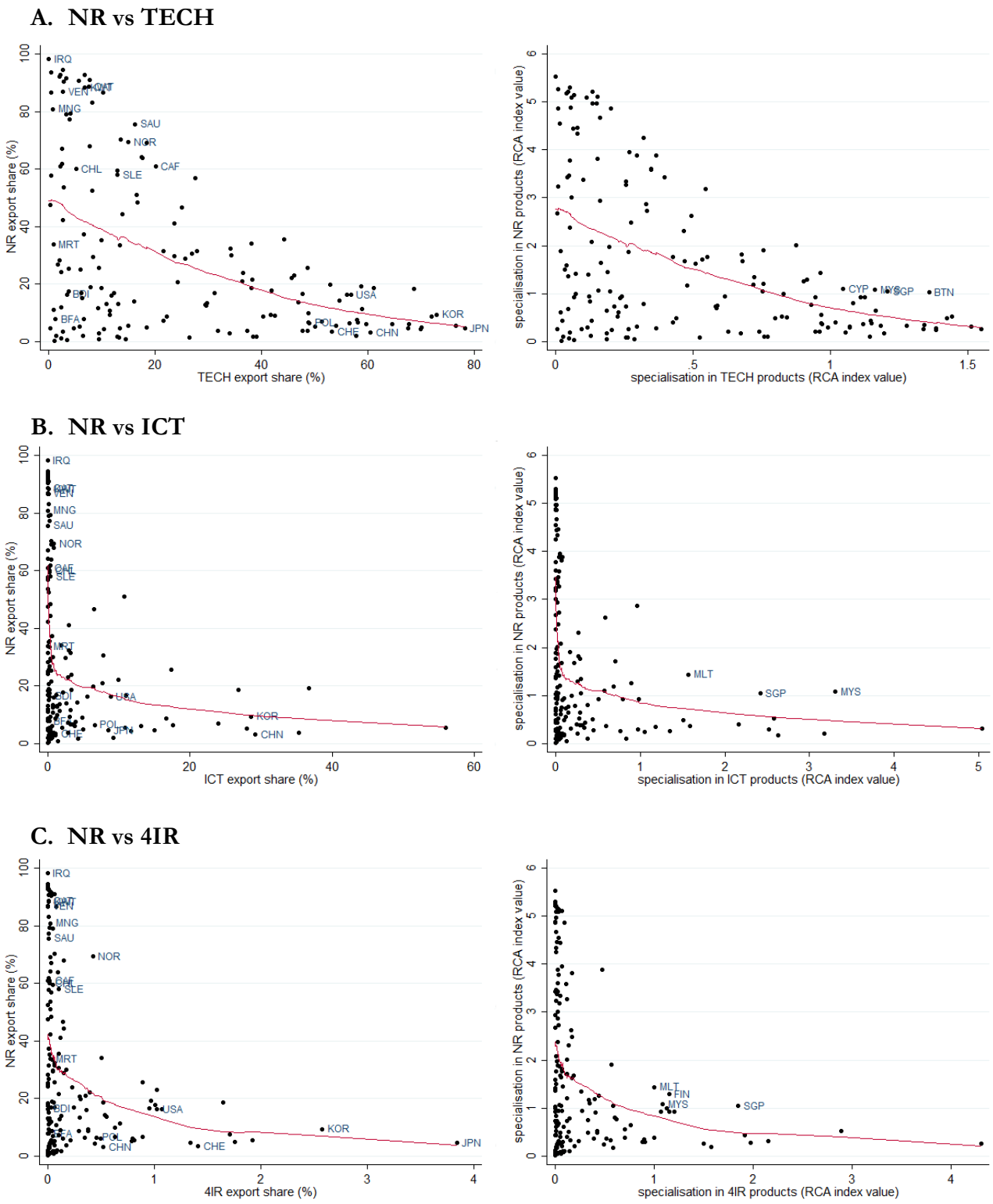
[10] Countries that specialize in the fuels category generally focus on crude and refined petroleum and distillation products (e.g. Qatar, Iraq, Iran, Venezuela and Saudi Arabia). Of course there are also some countries that in addition to petroleum also export natural gas (Russia, Norway) or coal (Indonesia).

Figure 2. The importance of types of natural resources (share in total NR exports), sample: 160 countries, 1996-2018)



Source: Based on 6-digit HS export data from BACI CEPII (CEPII, 2021; Gaulier and Zignago, 2010) and NR products taxonomy from Bacchetta (2010).

Figure 3. Relationship between specialisation in NR and technological specialisation (left: export share; right: RCA index)



Note: sample of 160 countries; year 2018. The scales in the two graphs differ and have various units. For the list of countries, see Appendix, Table A.1. Product classifications in Table A.4. and Table A.5.
Source: Based on 6-digit HS export data from BACI CEPII (CEPII, 2021; Gaulier and Zignago, 2010.)

Figure 3 displays the relative importance of NR and technologically advanced goods in countries' exports. Independently of the type of tech exports (broadly defined TECH; narrow ICT or 4IR), the correlation between NR and technology shares is negative (graphs on the left). This also holds for the Balassa index of revealed comparative advantage, RCA, computed for product groups (graphs on the right).[11] Unsurprisingly, countries with high NR export shares (above 60%) do not export 4IR or ICT products, but some (such as Saudi Arabia, Norway and Central African Republic) supplement their NR exports with middle-tech products within the broad TECH taxonomy (around 20% of total exports). There are a few countries that do have a comparative advantage (i.e. RCA>1) in both NR and technological goods. In the case of 4IR, these are: Finland (RCA in wood, electrical machinery and vehicle parts), Singapore (RCA in refined petroleum, electrical machinery and organic chemicals), Malta (RCA in refined petroleum, electrical machinery and pharmaceuticals) and Malaysia (RCA in refined petroleum and electrical machinery).

Table 1 and Table 2 report the top countries specialising (by Balassa's definition) in technological exports and in NR (by type), in 1996 and in 2018. The position of technological forerunners (countries whose comparative advantage in tech products was already substantial in 1996) has remained more or less unaltered through the years. Japan, South Korea and various European countries still dominate, particularly in 4IR manufacturing. Specialisation in ICT is typical of some Asian countries (Singapore, Malaysia, Philippines, China, Thailand).

When it comes to specialisation in NR, we find many developing countries, both in the past and more recently. However, there have been changes in the RCA indices. Comparing bottom lines of Table 1 and 2, the increase in the number of fuel exporters (from 50 in 1996 to 58 in 2018) might be the reason for the genereally lower values of RCA (FUEL) at the end of the period. Year by year, new oil exporters emerge, while the leading petroleum exporters slowly but steadily shift away from NR and seek alternatives. For forestry products the situation is quite different. The number of countries specialising in lumber exports holds unchanged at 46, but the average magnitude of RCA

[11] The RCA in natural resources is calculated here as the ratio of the share of natural resources (product lines classified as NR in WTO's natural resources classification - WTO, 2010) in the country's total exports to the same ratio at the world level. Similarly, RCA in technology is calculated as the ratio of the share of a technology (broadly defined TECH and by fields: ICT or 4IR – see Table A.5.) in the country's total exports to the same ratio at the world level. RCA in technology corresponds to RTA (Reveled Technological Advantage (Foster-McGregor et al., 2019).

(FORESTRY) doubles. This may be explained by restrictions on lumbering of exotic trees and their reduced availability.

The data confirms the coexistence of different specialisation paths and income-related patterns of specialisation. Low- and middle-income countries specialise in NR exports – in line with the concept of being geographically favoured[12] (Sachs, 2000; Acemoglu et al., 2002) matched with the debate on 'prisoners of geography' (Hausmann, 2001) while high-income countries - in technology. However, specialisation patterns can change (see Figure 4). Egypt, Georgia, Iran, Latvia, Oman and Saudi Arabia show signs of diversifying away from natural resources towards technological production. Petroleum-dependent countries (Egypt, Saudi Arabia, Oman, Iran) increased their technology export shares. The changes did not come overnight and are not always spectacular, but they are nevertheless significant. Latvia, for instance, was once highly specialised in NR exports (wood, crude oil, various metals) but managed to diversify substantially. Latvia's RCA in NR fell from 5.5 in 1996 to around 1 in 2018, as the country turned to electrical machinery and vehicle manufacturing. As a result we observe a scissors-pattern curve, with the tech export share surpassing NR. The same pattern characterises Georgia, where exports of fuels (mostly petroleum) and metals fell while tech exports gained.

[12] Favourable geography refers to the abundance of natural resources that is dependent only on the nature factor; states with proven resource deposits are 'privileged' with respect in comparison to those that are obliged to develop other forms of specialisation.

Table 1. Technological and NR specialisation (RCA index values) - top 10 countries with RCA>1 (1996)

	Technological specialisation						Specialisation in natural resources									
	4IR		ICT		TECH		FUEL		METAL		MINERAL		FORESTRY		TOTAL NR	
	CHE	2,80	SGP	5,36	JPN	1,61	KWT	12,70	ZMB	43,04	GIN	56,81	GNQ	32,33	GAB	8,24
	JPN	2,68	MYS	4,34	SGP	1,49	YEM	12,58	KAZ	18,96	SUR	49,01	CMR	18,75	KWT	8,16
	ITA	2,18	MLT	4,10	MLT	1,29	NGA	12,42	BHR	17,18	MRT	35,09	MMR	17,73	YEM	8,09
	DEU	1,55	PHL	3,77	DEU	1,28	DZA	12,16	CHL	14,37	JAM	34,48	BTN	17,54	NGA	7,99
	USA	1,39	IRL	2,30	USA	1,23	AGO	12,11	PER	11,98	MNG	28,77	LAO	16,64	DZA	7,83
	AUT	1,39	THA	2,08	MYS	1,23	SAU	11,91	KGZ	11,28	GEO	17,12	GAB	13,52	AGO	7,75
	SWE	1,09	JPN	1,97	KOR	1,19	OMN	11,83	TJK	10,92	BOL	14,86	LVA	12,80	SAU	7,66
	CZE	1,07	KOR	1,85	MEX	1,18	QAT	11,71	RUS	8,63	GUY	14,82	CHL	9,00	OMN	7,63
	x	x	HKG	1,79	SWE	1,16	IRQ	11,32	COD	8,28	CHL	13,78	BOL	7,99	GNQ	7,56
	x	x	USA	1,43	CHE	1,14	IRN	11,30	BOL	6,69	PER	11,77	GHA	7,88	QAT	7,52
Number of countries with RCA>1	8		15		15		50		41		65		46		78	

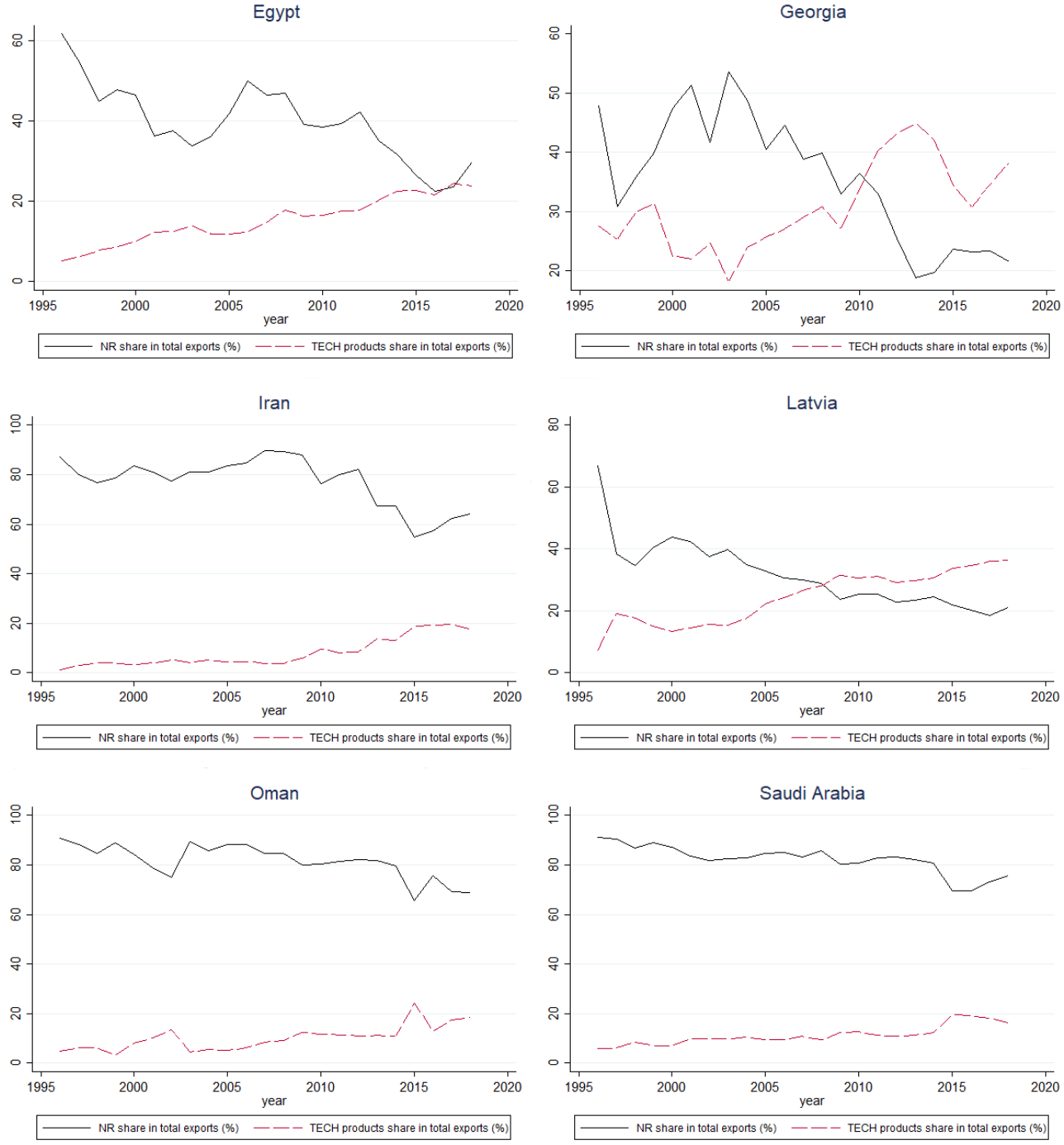
Source: Based on export data from BACI CEPII (CEPII, 2021; Gaulier and Zignago, 2010) and product taxonomies (Table A.4. and Table A.5.). Analysed sample: 160 countries (Appendix A - Table A.1.).

Table 2. Technological and NR specialisation (RCA index values) - top 10 countries with RCA>1 (2018)

	Technological specialisation						Specialisation in natural resources									
	4IR		ICT		TECH		FUEL		METAL		MINERAL		FORESTRY		TOTAL NR	
	JPN	4,30	PHL	5,04	JPN	1,55	IRQ	7,52	ZMB	37,06	JAM	31,70	CAF	75,35	IRQ	5,51
	KOR	2,89	MYS	3,31	PHL	1,51	DZA	7,23	COD	33,52	GIN	22,72	URY	33,53	DZA	5,30
	ITA	2,16	VNM	3,18	KOR	1,44	TKM	7,04	ISL	20,44	SLE	21,01	CMR	25,28	COD	5,25
	DEU	1,97	CHN	2,63	MEX	1,42	AZE	6,97	MOZ	15,74	MNG	18,88	SLE	20,38	TKM	5,20
	AUT	1,92	KOR	2,58	DEU	1,39	BRN	6,93	CHL	11,39	TJK	18,69	GMB	19,66	GNQ	5,20
	SGP	1,85	HKG	2,52	HUN	1,39	AGO	6,88	BHR	9,87	PER	18,62	LVA	15,06	AZE	5,16
	CHE	1,58	SGP	2,42	BTN	1,36	NGA	6,87	MDG	8,82	MRT	16,66	FJI	14,49	NGA	5,14
	CZE	1,50	MAC	2,16	SVK	1,34	KWT	6,73	COG	8,53	CHL	14,57	NZL	13,95	BRN	5,10
	SWE	1,20	THA	1,59	CZE	1,34	GNQ	6,67	TJK	8,49	BOL	13,73	FIN	10,25	GAB	5,08
	USA	1,15	MLT	1,57	MKD	1,28	TCD	6,62	BGR	5,51	AUS	13,64	LAO	10,18	AGO	5,08
Number of countries with RCA>1	16		14		27		58		48		64		46		79	

Source: Based on export data from BACI CEPII (CEPII, 2021; Gaulier and Zignago, 2010) and product taxonomies (Table A.4. and Table A.5.). Analysed sample: 160 countries (Appendix A - Table A.1.).

Figure 4. Share of NR and TECH products in total exports (%) over time – selected countries



Source: Based on 6-digit HS export data from BACI CEPII (CEPII, 2021; Gaulier and Zignago, 2010).

4. The role of NR and tech exports in productivity growth – empirical analysis

4.1 The models

Given these two distinct types of specialisation – either natural resources or technological exports – we now compare their roles in productivity growth. We are particularly interested in countries' relative positions and accordingly apply the empirical model of conditional convergence (based on catching-up theory[13]). The first step is to assess the role of natural resources in the productivity growth process:

$$g(y)_{it} = \alpha + \beta_1 y_{i,t-1} + \beta_2 NR_{i,t-1} + \beta_3 X_{i,t-1} + \delta_t + \varepsilon_{it} \quad (1)$$

where *i* denotes country (*i*=1, …,160), *t* time (*t*=1996, …,2018), and g(*y*) the annual rate of growth in labour productivity (in %). Productivity (*y*) is measured as output per worker (real GDP in constant 2017 USD divided by the number of workers from PWT 10.0, Feenstra et al., 2015). *NR* is the share of NR in total exports. *X* refers to a set of control variables that could potentially affect productivity growth.

Specifically, the extension of model (1) adds the share of technological exports (*T*), to check whether technological specialisation affects the relationship between *NR* and productivity growth:

$$g(y)_{it} = \alpha + \beta_1 y_{i,t-1} + \beta_2 NR_{i,t-1} + \beta_3 T_{i,t-1} + \delta_t + \varepsilon_{it} \quad (2)$$

NR and *T* are computed using 6-digit HS96 product-level trade data from BACI CEPII (Gaulier and Zignago, 2010), matched with product-level taxonomies (*NR* in Table A.3. and *T* in Table A.4.). We consider different types of NR and tech products: *NR*={*FORESTRY, FUEL, METAL, MINERAL*} and *T*={*TECH, ICT, 4IR*} which measures technological exports broadly defined (*TECH*) or ICT and 4IR products. The effects of activities in these fields are not immediate, so *NR* and *T* are lagged.

Other control variables (investment ratio, *INV,*[14] i.e. the share of gross fixed capital formation in GDP, the human capital index, *HCI,*[15] and R&D expenditures as percentage of GDP, *RD*[16]) come from

[13] Convergence theory posits the catch-up effect, whereby poor countries tend to grow faster than rich (Solow, 1957; Barro and Sala-i-Martin, 1992).

[14] Following the World Bank's definition of gross fixed capital formation, this consists in land improvements, plant, machinery, and equipment purchases, construction of roads, railways, schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings (World Bank, 2022). Straub (2008) argues that investment in public infrastructure can enhance productivity; good infrastructure allows time and capital to be invested in more efficient activities, improving productivity.

[15] HCI (range 0–1) proxies for the productivity of future generations of workers and assesses the amount of capital lost due to poor education and health. It is measured by reference to the quality and quantity of education, state of health and

the World Bank's World Development Indicators (WDI) database. Since the productivity effect of the control variables may not be immediate, these too are lagged.

As to primary commodities, there may be problems of simultaneity: the relationship between NR and productivity growth is potentially open to reverse causality and endogeneity (Farhadi et al., 2015), so we use a two-step GMM estimator with a one-year lag of the potentially endogenous variable as instrument. The same applies to the technological variables. Moreover, NR exports tend to be highly persistent[17] (Table A.6. in the Appendix A), so we include time fixed effects to account for the business cycle but not country fixed effects to avoid wiping out all cross-country variability.

4.2 The results

Table 3 reports the basic estimation results of model 1. Separate columns refer to estimates obtained with NR export share measured as a total (column 1) or by type (columns 2-5). In keeping with the convergence theory, the correlation between productivity growth and past productivity level is negative and significant. Natural resources tend to inhibit, weakly, the process of catching up. *Ceteris paribus*, a 1-percentage-point increase in the NR export share is related to a 0.007-p.p. decrease in the productivity growth rate. As the NR share in reality holds relatively fixed, this implies weak but constant negative pressure on productivity growth. Importantly, the subdivision of *NR* into types reveals that not all natural resource endowments act in the same way. While the correlation between fuel exports and productivity growth is negative and significant (column 2), metal exports instead are a positive factor in growth (column 5). This result holds also after adding control variables (*INV*, *RD*, *HCI*) – Table 4.

children's survival. The knowledge and skills of the population are crucial to generating new technologies, hence to productivity gains (Kim & Loayza, 2019).

[16] *RD* gauges spending on basic and applied research and experimental development. This expenditure is divided into four main sectors: business enterprise, government, higher education and private non-profit. Innovation spending has an enormous impact on productivity and leads to the development of more sophisticated activities, products and processes (Kim & Loayza, 2019).

[17] Countries with proven reserves of natural resources usually maintain a constant level of extraction, which tends to result in a relatively constant share of NR in total export value. Situations that can alter such conjunctures are rare and may involve new resource discoveries (increasing the share of NR in total exports), resource depletion (decreasing the NR share) or efforts at export diversification.

Table 3. The relationship between NR exports and productivity growth (estimates of eq. 1)

Dependent variable: $g(y)_{it}$	1	2	3	4	5
	TOTAL NR	*FUEL*	*FORESTRY*	*MINERAL*	*METAL*
$y_{i,t-1}$	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
NRi,t-1	-0.007*	-0.011**	0.046	-0.011	0.022***
	[0.0038]	[0.0045]	[0.0287]	[0.0096]	[0.0061]
No.of obs.	3358	3264	3257	3333	3240
No. of countries	160	160	160	160	160
R^2	0.064	0.068	0.062	0.064	0.073
K-P rk Wald F	76986.240	48571.050	1008.039	3568.880	5792.576
K-P rk LM	1219.286	730.347	86.066	178.083	101.453
K-P rk LM (p-val)	0.000	0.000	0.000	0.000	0.000

Notes: *,**,*** denote significance at the 1%, 5%, and 10% levels respectively; robust standard errors in parentheses; all specifications contain time fixed effects; K-P refers to Kleibergen-Paap test statistics. Instrumented variable: *NR*. Constant included – not reported.
Source: Based on 6-digit HS export data from BACI CEPII (CEPII, 2021; Gaulier and Zignago, 2010).

Table 4. The relationship between NR exports and productivity growth (estimates of eq. 1, with control variables)

Dependent variable: $g(y)_{it}$	1	2	3	4	5
	TOTAL NR	*FUEL*	*FORESTRY*	*MINERAL*	*METAL*
$y_{i,t-1}$	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
NRi,t-1	-0.005	-0.008*	0.049*	-0.011	0.022***
	[0.0042]	[0.0049]	[0.0287]	[0.0096]	[0.0061]
INV	0.039***	0.040***	0.042***	0.035***	0.047***
	[0.0119]	[0.0126]	[0.0121]	[0.0117]	[0.0118]
RD	0.237**	0.194*	0.306***	0.298***	0.333***
	[0.0977]	[0.0993]	[0.0860]	[0.0859]	[0.0845]
HCI	0.632	0.605	0.814	0.687	0.787
	[0.7370]	[0.7380]	[0.7703]	[0.7480]	[0.7440]
No. of obs.	3358	3264	3257	3333	3240
No. of countries	160	160	160	160	160
R^2	0.073	0.077	0.073	0.073	0.088
K-P rk Wald F	63238.359	40326.759	1012.407	3504.070	5781.898
K-P rk LM	1172.695	695.607	86.409	177.908	101.204
K-P rk LM (p-val)	0.000	0.000	0.000	0.000	0.000

Notes: as under Table 3.
Source: Based on 6-digit HS export data from BACI CEPII (CEPII, 2021; Gaulier and Zignago, 2010).

Turning to the importance of technological specialisation (model 2), all three types of tech exports are positively related to productivity growth. The results reported in column 1 in Table 5, Table 6 and Table 7 indicate that, other things being equal, a 1-p.p. increase in the export share of 4IR, ICT, and TECH products generates an increment of 0.4, 0.02 and 0.01 point in the productivity growth rate, respectively. That is, the most economically proficuous technological activity relates to exports of 4IR

products. The magnitude and the significance of the *T* coefficients vary with the type of NR. Most importantly, the inclusion of *T* variables does not alter the benchmark result, namely the adverse effect of fuel exports and the beneficial effect of metal exports (reported in Table 3). This means that even if a country increases the importance of tech exports, the focus on fuels may still slow productivity catch-up.

Table 5. The relationship between NR exports, 4IR exports and productivity growth (estimates of eq. 2)

Dependent variable: $g(y)_{it}$	1	2	3	4	5
	TOTAL NR	*FUEL*	*FORESTRY*	*MINERAL*	*METAL*
$y_{i,t-1}$	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
NRi,t-1	-0.010***	-0.014***	0.021	-0.009	0.022***
	[0.0035]	[0.0042]	[0.0262]	[0.0100]	[0.0060]
Ti,t-1	0.036	-0.021	0.374**	0.331*	0.422**
	[0.1959]	[0.1954]	[0.1693]	[0.1704]	[0.1686]
No.of obs.	3239	3184	3159	3227	3173
No. of countries	160	160	160	160	160
R^2	0.078	0.080	0.074	0.076	0.081
K-P rk Wald F	306.191	307.495	367.245	368.833	368.811
K-P rk LM	163.662	164.382	164.283	164.736	164.428
K-P rk LM (p-val)	0.000	0.000	0.000	0.000	0.000

Notes: *,**,*** denote significance at the 1%, 5%, and 10% levels respectively; robust standard errors in parentheses; all specifications contain time fixed effects; K-P refers to Kleibergen-Paap test statistics. Instrumented variables: *NR, T*. Constant included – not reported.
Source: Based on 6-digit HS export data from BACI CEPII (CEPII, 2021; Gaulier and Zignago, 2010).

Table 6. The relationship between NR exports, ICT exports and productivity growth (estimates of eq. 2)

Dependent variable: $g(y)_{it}$	1	2	3	4	5
	TOTAL NR	*FUEL*	*FORESTRY*	*MINERAL*	*METAL*
$y_{i,t-1}$	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
NRi,t-1	-0.005	-0.010**	0.050*	-0.008	0.024***
	[0.0040]	[0.0047]	[0.0288]	[0.0098]	[0.0062]
Ti,t-1	0.018**	0.015**	0.027***	0.023***	0.029***
	[0.0072]	[0.0069]	[0.0068]	[0.0070]	[0.0068]
No.of obs.	3358	3264	3257	3333	3240
No. of countries	160	160	160	160	160
R^2	0.065	0.069	0.064	0.066	0.076
K-P rk Wald F	9267.795	22237.431	502.887	1836.138	7407.393
K-P rk LM	415.314	858.664	86.677	190.025	291.670
K-P rk LM (p-val)	0.000	0.000	0.000	0.000	0.000

Notes: as under Table 5
Source: Based on 6-digit HS export data from BACI CEPII (CEPII, 2021; Gaulier and Zignago, 2010).

Table 7. The relationship between NR exports, TECH exports and productivity growth (estimates of eq. 2)

Dependent variable: $g(y)_{it}$	1	2	3	4	5
	TOTAL NR	*FUEL*	*FORESTRY*	*MINERAL*	*METAL*
$y_{i,t-1}$	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
NRi,t-1	-0.003	-0.008	0.052*	-0.006	0.027***
	[0.0049]	[0.0053]	[0.0289]	[0.0101]	[0.0065]
Ti,t-1	0.011*	0.008	0.014***	0.013***	0.016***
	[0.0059]	[0.0053]	[0.0044]	[0.0047]	[0.0045]
No.of obs.	3358	3264	3257	3333	3240
No. of countries	160	160	160	160	160
R^2	0.065	0.069	0.064	0.066	0.077
K-P rk Wald F	10541.141	13605.858	507.626	2590.774	15868.519
K-P rk LM	1117.358	1206.426	85.712	298.207	1082.118
K-P rk LM (p-val)	0.000	0.000	0.000	0.000	0.000

Notes: *,**,*** denote significance at the 1%, 5%, and 10% levels respectively; robust standard errors in parentheses; all specifications contain time fixed effects; K-P refers to Kleibergen-Paap test statistics. Instrumented variables: *NR, T*. Constant included – not reported.
Source: Based on 6-digit HS export data from BACI CEPII (CEPII, 2021; Gaulier and Zignago, 2010).

4.3 Extensions and robustness checks

As a first robustness check we run a regression with alternative measures of natural resource endowment (Table B.1. and Table B.2. in Appendix B), replacing the NR export share with the share of NR rents in GDP. This variable comes from the World Development Indicators database and can be described as the difference between the value (at world prices) of the natural resources extracted and their total production cost. The types of commodities (coal, forestry products, oil, gas and minerals) and their total value are largely in line with the NR taxonomy presented in Table A.4. The only discrepancy is the lack of metal rents and the division of fuels into three separate groups (coal, gas and oil). The results show that total NR rents have a negative – but not significant – effect on catching up. There is a positive and statistically significant correlation between coal, gas and mineral rents and productivity growth. Other thins being equal, a 1-p.p. increase in the GDP share of coal/gas/mineral rents results in an increase of 0.573/0.067/0.12 points respectively in the productivity growth rate. The addition of control variables (Table B.2.) confirms the previous results.

To adjust for the possible heterogeneity between developing and developed countries, we split the sample of 160 countries into two groups: 51 developed and 109 developing countries (see Table A.1.). The estimation results are reported in Tables B.3-B.12. In the developed countries (with and without

control variables) all types of NR have a statistically significant impact on productivity growth, but it is positive only for forestry products. *Ceteris paribus*, a 1-p.p. increase in the share of forestry exports corresponds to a 0.14-p.p. increase in the productivity growth rate. For the developed countries, the addition of the technological export shares did not change either the magnitude or the significance of the NR-productivity correlation.

Estimations for the group of developing countries (results in Tables B.5-6 and B.10-12) indicate that the only type of NR exports that can enhance productivity growth in a statistically significant way is metals. Other things being equal, a 1-p.p. increase in the share of metal exports raises the productivity growth rate by 0.029 points. And while the effect is positive and statistically significant, it is still very small. Turning to technological factors, ICT and TECH exports have a positive effect on productivity growth in the developing countries.

Additionally, given that some resource abundant countries report very high shares of NR in exports (nearly 100%), we have also checked the robustness of the results once outliers (defied as observations below 1st and above 99th percentiles of the dependent variable) are excluded. The results are reported in Tables B.13-16 and they stay in compliance with main regression outcomes, both in terms of statistical significance and the magnitude of the relationship.

5. Conclusions

The conventional wisdom, with much of the 'resource curse' literature, holds that the growth of developing countries is hampered by overspecialisation in natural resources, while in the developed world technological advance drives growth. But today's world is considerably more complicated than this simple schema would suggest. Some low-income countries produce advanced technologies, some countries totally escape the resource curse and increase the technological content of their exports, and some economies, finally, have comparative advantages in both commodity-based and technology-intensive goods. In short, the relationship between natural resources and growth is not so obvious or straightforward.

We analyse this issue for a large sample of 160 countries (109 developing and 51 developed economies) from 1996 to 2018. Detailed product level trade data allows us to distinguish various types

of resources and of technologies embodied in exports. Specifically, natural resources may consist in forestry products, fuels, metals, or minerals, and tech exports generically defined are distinguished from newer generation technologies embodying ICT and 4IR solutions.

The GMM estimates of a conditional productivity convergence model confirm that greater total NR exports slow productivity growth and impede, weakly, the catch-up process. However, we find that the type of resources exported matters: fuels hamper productivity growth while metals enhance it (this result applies to the whole sample and is also sustained for the subsample of developing countries). For technological exports too, type matters: the products typical of the Fourth Industrial Revolution, in particular, accelerate productivity growth. However, the magnitude of this effect is small, and in any case it does not affect the relationship between natural resources and productivity growth.

Knowing that oil exporting countries are the ones who were able to initiate the diversification process towards the technological production, possible extension for our work should include division of fuel resources into subsequent three groups - coal, natural gas and oil. This will help in verifying whether all fossil fuels actually hamper productivity growth. Further additions to the empirical model could consist of interaction terms between the share of NR and technological exports and the incorporation of GVC and FDI as control variables.

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Appendix A

Table A.1. List of countries

Group of countries (number of countries)	Countries
Developing (109)	Albania, Algeria, Angola, Argentina, Armenia, Azerbaijan, Bangladesh, Belarus, Belize, Benin, Bhutan, Bolivia, Bosnia Herzegovina, Brazil, Bulgaria, Burkina Faso, Burundi, Cabo Verde, Cambodia, Cameroon, Central African Republic, Chad, China, Colombia, Comoros, Congo, Costa Rica, Côte d'Ivoire, Dem. Rep. of the Congo, Djibouti, Dominican Rep., Ecuador, Egypt, El Salvador, Equatorial Guinea, Ethiopia, Fiji, Gabon, Gambia, Georgia, Ghana, Grenada, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, India, Indonesia, Iran, Iraq, Jamaica, Jordan, Kazakhstan, Kenya, Kyrgyzstan, Laos, Lebanon, Liberia, Macedonia, Madagascar, Malawi, Malaysia, Maldives, Mali, Mauritania, Mauritius, Mexico, Mongolia, Morocco, Mozambique, Myanmar, Nepal, Nicaragua, Niger, Nigeria, Pakistan, Paraguay, Peru, Philippines, Rep. of Moldova, Romania, Russian Federation, Rwanda, Saint Lucia, Saint Vincent and the Grenadines, Sao Tome and Principe, Senegal, Sierra Leone, Sri Lanka, Sudan, Suriname, Syria, Tajikistan, Thailand, Togo, Tunisia, Turkey, Turkmenistan, Uganda, Ukraine, Tanzania, Uzbekistan, Venezuela, Vietnam, Yemen, Zambia, Zimbabwe
Developed (51)	Australia, Austria, Bahamas, Bahrain, Barbados, Belgium and Luxembourg, Brunei, Canada, Chile, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong, Hungary, Iceland, Ireland, Israel, Italy, Japan, Kuwait, Latvia, Lithuania, Macao, Malta, Netherlands, New Zealand, Norway, Oman, Panama, Poland, Portugal, Qatar, Saudi Arabia, Singapore, Slovakia, Slovenia, Spain, South Korea, Sweden, Switzerland, Trinidad and Tobago, USA, United Arab Emirates, United Kingdom, Uruguay

Notes: Belgium and Luxembourg (BELX) stand for joint data for Belgium (BEL) and Luxemburg (LUX); division into developed and developing countries in line with 2018 World Bank's income classification.

Table A.2. Pairwise correlations between explanatory variables

		Expressed as the share in total exports			Expressed as the share in total exports					Expressed as the share of rents in GDP						Control variables		
		4IR	ICT	TECH	TOTAL NR	FUEL	FOREST	MINERAL	METAL	TOTAL NR	OIL	GAS	FORESTRY	COAL	MINERAL	RD	INV	HCI
Expressed as the share in total exports	4IR	1.0000																
	ICT	0.2210*	1.0000															
	TECH	0.3467*	0.6238*	1.0000														
Expressed as the share in total exports	TOTAL NR	-0.1955*	-0.2143*	-0.4014*	1.0000													
	FUEL	-0.1674*	-0.1523*	-0.3061*	0.8451*	1.0000												
	FORESTRY	-0.0467*	-0.0752*	-0.1136*	0.1480*	-0.0159	1.0000											
	MINERAL	-0.0441*	-0.1131*	-0.1738*	0.2524*	-0.1512*	-0.0270	1.0000										
	METAL	-0.0470*	-0.0657*	-0.1311*	0.2777*	-0.0947*	0.0033	0.0421*	1.0000									
Expressed as the share of rents in GDP	TOTAL NR	-0.1878*	-0.1416*	-0.3070*	0.6280*	0.6352*	0.0818*	0.0379*	0.0454*	1.0000								
	OIL	-0.1301*	-0.0886*	-0.2247*	0.6616*	0.7820*	0.0023	-0.1197*	-0.0722*	0.8140*	1.0000							
	GAS	-0.0462*	-0.0227	-0.0669*	0.2168*	0.2621*	-0.0351*	-0.0729*	0.0102	0.4123*	0.2033*	1.0000						
	FORESTRY	-0.1047*	-0.0991*	-0.1512*	-0.0595*	-0.1670*	0.2039*	0.0832*	0.1222*	0.3250*	-0.1321*	-0.0928*	1.0000					
	COAL	0.0045	0.0139	0.0051	0.0978*	0.0199	-0.0398*	0.1960*	0.0238	0.1054*	-0.0198	-0.0014	-0.0622*	1.0000				
	MINERAL	-0.0885*	-0.0801*	-0.1486*	0.1517*	-0.1061*	-0.0217	0.4730*	0.2075*	0.2067*	-0.0789*	-0.0176	0.0681*	0.2945*	1.0000			
Control variables	RD	0.2609*	0.2509*	0.3691*	-0.0816*	-0.0437*	-0.0985*	-0.0859*	-0.0142	-0.1091*	-0.0335*	0.0269	-0.2014*	0.1420*	-0.0460*	1.0000		
	INV	0.0404*	0.0766*	0.0545*	0.1280*	0.0947*	-0.0629*	0.0802*	0.0061	0.0690*	0.1240*	0.0898*	-0.2065*	0.1416*	0.0906*	0.2048*	1.0000	
	HCI	0.0143	0.0364*	0.0667*	-0.0107	-0.0128	-0.0452*	0.0128	-0.0099	-0.0482*	-0.0227	-0.0225	-0.0642*	0.0342*	0.0143	0.0929*	0.0607*	1.0000

Table A.3. Summary statistics of the variables employed in the empirical model (eq.1 and eq.2)

		Sample: Developed and developing countries					Sample: Developed countries					Sample: Developing countries				
	Variable	Obs.	Mean	Std. Dev.	Min	Max	Obs.	Mean	Std. Dev.	Min	Max	Obs.	Mean	Std. Dev.	Min	Max
	$g(y)_{it}$	3520	2,049	5,343	-36,580	91,286	1122	1,297	3,487	-23,275	28,130	2398	2,401	5,986	-36,580	91,286
Expressed as the share in total exports	4IR	3593	0,243	0,448	<0,001	4,440	1173	0,557	0,632	0,001	4,440	2420	0,090	0,184	<0,001	3,660
	ICT	3680	4,152	8,807	0,002	64,659	1173	7,385	9,675	0,014	64,659	2507	2,640	7,932	0,002	62,194
	TECH	3680	23,644	21,848	0,059	86,454	1173	39,921	21,314	0,288	84,570	2507	16,028	17,501	0,059	86,454
Expressed as the share in total exports	TOTAL NR	3679	28,999	29,755	0,002	99,787	1173	25,726	27,420	0,136	97,606	2506	30,531	30,673	0,002	99,787
	FUEL	3611	19,506	28,171	<0,001	99,715	1173	18,744	26,790	0,001	97,184	2438	19,872	28,811	<0,001	99,715
	FORESTRY	3615	1,811	4,598	<0,001	56,032	1172	1,582	3,015	0,000	24,316	2443	1,921	5,185	<0,001	56,032
	MINERAL	3663	4,683	9,994	<0,001	82,305	1173	2,113	4,433	0,015	34,103	2490	5,894	11,538	<0,001	82,305
	METAL	3590	3,495	9,524	<0,001	82,949	1173	3,288	6,696	0,001	42,934	2417	3,595	10,629	<0,001	82,949
Expressed as the share of NR rents in GDP	TOTAL NR	3680	7,430	11,164	0	87,459	1173	4,973	11,195	0	58,983	2507	8,580	10,964	0	87,459
	OIL	3680	3,950	9,619	0	66,564	1173	3,998	10,569	0	58,249	2507	3,928	9,143	0	66,564
	GAS	3680	0,618	2,740	0	68,564	1173	0,555	1,464	0	13,659	2507	0,648	3,165	0	68,564
	FORESTRY	3680	2,022	4,290	0	40,408	1173	0,162	0,340	0	2,832	2507	2,893	4,959	0	40,408
	COAL	3680	0,131	0,780	0	25,965	1173	0,049	0,192	0	2,965	2507	0,170	0,933	0	25,965
	MINERAL	3680	0,713	2,142	0	25,163	1173	0,210	1,192	0	16,767	2507	0,948	2,429	0	25,163
Control variables	RD	3680	0,480	0,846	0	4,941	1173	1,202	1,147	0	4,941	2507	0,142	0,279	0	2,141
	INV	3680	20,395	10,207	0	81,021	1173	21,768	7,776	0	45,326	2507	19,752	11,107	-2,424	81,021
	HCI	3680	0,059	0,185	0	1,455	1173	0,091	0,248	0	1,455	2507	0,045	0,145	0	0,777

Notes: total sample divided into developed (51) and developing countries (109). Variables description in the main text.

Table A.4. Natural resources taxonomy

Segment	Division number	Division description	Group
FORESTRY PRODUCTS	24	Cork and wood	FORESTRY
	25	Pulp and waste paper	FORESTRY
FUELS AND MINING PRODUCTS	27	Crude fertilizers and crude minerals	MINERAL
	28	Metalliferous ores and metal scrap	MINERAL
	32	Coal, coke and briquettes	FUEL
	33	Petroleum, petroleum products and related materials	FUEL
	34	Gas, natural and manufactured	FUEL
	35	Electric current	FUEL
	68	Non-ferrous metals	METAL

Source: Based on the WTO's natural resources classification (WTO, 2010).
Notes: Main natural resource segments from the WTO classification divided into four groups (forestry, mineral, fuel, metal); the list of product codes corresponding to each of the resource groups is provided in file taxononomies.xls (attached in the supplementary materials)

Table A.5. Technological products taxonomies

Abbr.	***Source***	***Number of HS96 6digit product codes***	***Description***
4IR	Parteka et al. (2022)	32	4IR (4th Industrial Revolution) related products
ICT	UNCTAD – OECD (2011)	112	ICT (Information and Communication Technology products)
TECH	UNCTAD - Lall (2000)	1830	medium-tech and high-tech products

Source: Authors' elaboration. 4IR classification is a joint work of Parteka et al. (2022) and builds upon Domini et al. (2021) and Foster-McGregor et al. (2019)
Note: the list of product codes corresponding to each of the classifications is provided in file taxononomies.xls (attached in the supplementary materials)

Table A.6. NR variables – time trend estimates

	$(NR_{it} = \alpha + \beta N_{i,t-1} + \varepsilon_{it})$ where the dep. var. (NR) is:				
	TOTAL NR	*FUEL*	*FORESTRY*	*METAL*	*MINERAL*
$NR_{i,t-1}$	0,9723 [0,0039]	0,9720 [0,0040]	0,9380 [0,0062]	0,9804 [0,0037]	0,9576 [0,0050]
R-squared	0,9465	0,9465	0,8709	0,9531	0,9127
N	3518	3423	3414	3399	3493

Note: constant included, not reported. All coefficient significant at 1% level. Standard errors in parentheses. Sample: 160 countries (1996-2018)

Appendix B. Extensions and robustness checks

Table B.1. The relationship between NR rents and productivity growth (estimates of eq. 1)

Dependent variable: $g(y)_{it}$	1	2	3	4	5	6
	TOTAL NR	*COAL*	*FORESTRY*	*OIL*	*GAS*	*MINERAL*
$y_{i,t-1}$	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
NRi,t-1	-0.010	0.573***	-0.036	-0.022	0.067**	0.120***
	[0.0122]	[0.1748]	[0.0289]	[0.0146]	[0.0304]	[0.0433]
No.of obs.	3360	3360	3360	3360	3360	3360
No. of countries	160	160	160	160	160	160
R^2	0.064	0.070	0.064	0.065	0.064	0.066
K-P rk Wald F	4454.147	20.926	2224.404	4077.568	138.666	760.651
K-P rk LM	423.718	7.700	193.399	293.651	19.084	92.387
K-P rk LM (p-val)	0.000	0.000	0.000	0.000	0.000	0.000

Notes: *,**,*** denote significance at the 1%, 5% and 10% levels respectively; robust standard errors in parentheses; all specifications contain time fixed effects; K-P refers to Kleibergen-Paap test statistics. Instrumented variable: *NR*. Constant included – not reported. *NRi,t-1* is the natural resources rents share (total, coal, forestry, oil, gas and mineral) in GDP (%). Source: Based on 6-digit HS export data from BACI CEPII (CEPII, 2021; Gaulier and Zignago, 2010).

Table B.2. The relationship between NR rents and productivity growth (estimates of eq. 1, with control variables)

Dependent variable: $g(y)_{it}$	1	2	3	4	5	6
	TOTAL NR	*COAL*	*FORESTRY*	*OIL*	*GAS*	*MINERAL*
$y_{i,t-1}$	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
NRi,t-1	0.000	0.500***	-0.013	-0.013	0.076**	0.118***
	[0.0134]	[0.1756]	[0.0291]	[0.0161]	[0.0322]	[0.0441]
INV	0.039***	0.034***	0.038***	0.039***	0.038***	0.037***
	[0.0117]	[0.0121]	[0.0117]	[0.0117]	[0.0117]	[0.0118]
RD	0.304***	0.299***	0.303***	0.247**	0.341***	0.328***
	[0.1016]	[0.0844]	[0.0850]	[0.1016]	[0.0869]	[0.0861]
HCI	0.671	0.700	0.667	0.656	0.712	0.778
	[0.7461]	[0.7235]	[0.7464]	[0.7413]	[0.7451]	[0.7404]
No.of obs.	3360	3360	3360	3360	3360	3360
No. of countries	160	160	160	160	160	160
R^2	0.073	0.079	0.073	0.074	0.074	0.076
K-P rk Wald F	3802.505	20.643	2209.574	3508.037	135.784	767.702
K-P rk LM	429.314	7.789	207.626	293.566	18.794	93.096
K-P rk LM (p-val)	0.000	0.000	0.000	0.000	0.000	0.000

Notes: *,**,*** denote significance at the 1%, 5% and 10% levels respectively; robust standard errors in parentheses; all specifications contain time fixed effects; K-P refers to Kleibergen-Paap test statistics. Instrumented variable: *NR*. Constant included – not reported. *NRi,t-1* is the natural resources rents share (total, coal, forestry, oil, gas and mineral) in GDP (%). Source: Based on 6-digit HS export data from BACI CEPII (CEPII, 2021; Gaulier and Zignago, 2010).

Table B.3. The relationship between NR exports and productivity growth – <u>developed countries</u> (estimates of eq. 1)

Dependent variable: $g(y)_{it}$	1	2	3	4	5
	TOTAL NR	*FUEL*	*FORESTRY*	*MINERAL*	*METAL*
$y_{i,t-1}$	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
NRi,t-1	-0.022***	-0.024***	0.140***	-0.030*	-0.026**
	[0.0053]	[0.0063]	[0.0275]	[0.0156]	[0.0121]
No.of obs.	1071	1071	1069	1071	1071
No. of countries	51	51	51	51	51
R^2	0.226	0.228	0.214	0.204	0.206
K-P rk Wald F	17613.910	11560.278	2329.853	2046.408	3550.803
K-P rk LM	394.947	282.428	67.006	39.775	62.721
K-P rk LM (p-val)	0.000	0.000	0.000	0.000	0.000

Notes: *,**,*** denote significance at the 1%, 5% and 10% levels respectively; robust standard errors in parentheses; all specifications contain time fixed effects; K-P refers to Kleibergen-Paap test statistics. Instrumented variable: *NR*. Constant included – not reported. Sample: 51 developed countries; in compliance with 2018 World Bank income classification.
Source: Based on 6-digit HS export data from BACI CEPII (CEPII, 2021; Gaulier and Zignago, 2010).

Table B.4. The relationship between NR exports and productivity growth – <u>developed countries</u> (estimates of eq. 1, with control variables)

Dependent variable: $g(y)_{it}$	1	2	3	4	5
	TOTAL NR	*FUEL*	*FORESTRY*	*MINERAL*	*METAL*
$y_{i,t-1}$	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
NRi,t-1	-0.024***	-0.027***	0.143***	-0.024	-0.025**
	[0.0074]	[0.0088]	[0.0276]	[0.0156]	[0.0121]
INV	-0.017	-0.023	-0.004	0.001	0.000
	[0.0156]	[0.0161]	[0.0156]	[0.0156]	[0.0155]
RD	-0.043	-0.031	0.207***	0.165**	0.169**
	[0.1164]	[0.1156]	[0.0796]	[0.0815]	[0.0806]
HCI	1.664	1.402	1.888	2.181	2.217
	[1.3544]	[1.3277]	[1.3598]	[1.4172]	[1.4193]
No.of obs.	1071	1071	1069	1071	1071
No. of countries	51	51	51	51	51
R^2	0.228	0.231	0.221	0.210	0.212
K-P rk Wald F	14496.107	9232.430	2355.729	2026.068	3541.062
K-P rk LM	322.816	231.006	68.147	40.643	62.709
K-P rk LM (p-val)	0.000	0.000	0.000	0.000	0.000

Notes: *,**,*** denote significance at the 1%, 5% and 10% levels respectively; robust standard errors in parentheses; all specifications contain time fixed effects; K-P refers to Kleibergen-Paap test statistics. Instrumented variable: *NR*. Constant included – not reported. Sample: 51 developed countries; in compliance with 2018 World Bank income classification.
Source: Based on 6-digit HS export data from BACI CEPII (CEPII, 2021; Gaulier and Zignago, 2010).

Table B.5. The relationship between NR exports and productivity growth – <u>developing countries</u> (estimates of eq. 1)

Dependent variable: $g(y)_{it}$	1	2	3	4	5
	TOTAL NR	*FUEL*	*FORESTRY*	*MINERAL*	*METAL*
$y_{i,t-1}$	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
NRi,t-1	-0.002	-0.007	0.029	-0.009	0.029***
	[0.0048]	[0.0058]	[0.0330]	[0.0102]	[0.0068]
No.of obs.	2287	2193	2188	2262	2169
No. of countries	109	109	109	109	109
R^2	0.039	0.043	0.038	0.040	0.054
K-P rk Wald F	45627.288	27200.363	767.734	3179.164	4280.456
K-P rk LM	900.073	500.182	65.964	159.669	75.887
K-P rk LM (p-val)	0.000	0.000	0.000	0.000	0.000

Notes: *,**,*** denote significance at the 1%, 5% and 10% levels respectively; robust standard errors in parentheses; all specifications contain time fixed effects; K-P refers to Kleibergen-Paap test statistics. Instrumented variable: *NR*. Constant included – not reported. Sample: 109 developing countries; in compliance with 2018 World Bank income classification.
Source: Based on 6-digit HS export data from BACI CEPII (CEPII, 2021; Gaulier and Zignago, 2010).

Table B.6. The relationship between NR exports and productivity growth – <u>developing countries</u> (estimates of eq. 1, with control variables)

Dependent variable: $g(y)_{it}$	1	2	3	4	5
	TOTAL NR	*FUEL*	*FORESTRY*	*MINERAL*	*METAL*
$y_{i,t-1}$	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
NRi,t-1	-0.002	-0.006	0.043	-0.009	0.027***
	[0.0049]	[0.0058]	[0.0333]	[0.0102]	[0.0068]
INV	0.043***	0.048***	0.047***	0.039***	0.055***
	[0.0145]	[0.0155]	[0.0146]	[0.0139]	[0.0141]
RD	1.811***	1.745***	1.950***	1.828***	2.051***
	[0.3127]	[0.3121]	[0.3216]	[0.3232]	[0.3096]
HCI	-0.274	-0.335	0.069	-0.239	-0.005
	[1.1453]	[1.1515]	[1.2008]	[1.1574]	[1.1544]
No.of obs.	2287	2193	2188	2262	2169
No. of countries	109	109	109	109	109
R^2	0.058	0.062	0.059	0.056	0.082
K-P rk Wald F	43178.128	26178.260	765.601	3143.829	4278.375
K-P rk LM	887.355	506.781	66.312	161.480	75.621
K-P rk LM (p-val)	0.000	0.000	0.000	0.000	0.000

Notes: *,**,*** denote significance at the 1%, 5% and 10% levels respectively; robust standard errors in parentheses; all specifications contain time fixed effects; K-P refers to Kleibergen-Paap test statistics. Instrumented variable: *NR*. Constant included – not reported. Sample: 109 developing countries; in compliance with 2018 World Bank income classification.
Source: Based on 6-digit HS export data from BACI CEPII (CEPII, 2021; Gaulier and Zignago, 2010).

Table B.7. The relationship between NR exports, 4IR exports and productivity growth – <u>developed countries</u> (estimates of eq. 2)

Dependent variable: $g(y)_{it}$	1	2	3	4	5
	TOTAL NR	*FUEL*	*FORESTRY*	*MINERAL*	*METAL*
$y_{i,t-1}$	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
NRi,t-1	-0.028***	-0.028***	0.144***	-0.028*	-0.025**
	[0.0071]	[0.0079]	[0.0277]	[0.0162]	[0.0126]
Ti,t-1	-0.466**	-0.383**	0.169	0.077	0.070
	[0.1939]	[0.1830]	[0.1219]	[0.1258]	[0.1265]
No.of obs.	1071	1071	1069	1071	1071
No. of countries	51	51	51	51	51
R^2	0.231	0.232	0.215	0.204	0.206
K-P rk Wald F	860.655	939.223	1185.964	1416.255	1167.878
K-P rk LM	154.313	161.907	152.432	178.249	147.575
K-P rk LM (p-val)	0.000	0.000	0.000	0.000	0.000

Notes: *,**,*** denote significance at the 1%, 5% and 10% levels respectively; robust standard errors in parentheses; all specifications contain time fixed effects; K-P refers to Kleibergen-Paap test statistics. Instrumented variables: *NR, T*. Constant included – not reported. Sample: 51 developed countries; in compliance with 2018 World Bank income classification.

Source: Based on 6-digit HS export data from BACI CEPII (CEPII, 2021; Gaulier and Zignago, 2010).

Table B.8. The relationship between NR exports, ICT exports and productivity growth – <u>developed countries</u> (estimates of eq. 2)

Dependent variable: $g(y)_{it}$	1	2	3	4	5
	TOTAL NR	*FUEL*	*FORESTRY*	*MINERAL*	*METAL*
$y_{i,t-1}$	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
NRi,t-1	-0.020***	-0.022***	0.165***	-0.019	-0.018
	[0.0058]	[0.0066]	[0.0287]	[0.0164]	[0.0127]
Ti,t-1	0.009	0.014	0.039***	0.029***	0.027***
	[0.0103]	[0.0097]	[0.0103]	[0.0102]	[0.0102]
No.of obs.	1071	1071	1069	1071	1071
No. of countries	51	51	51	51	51
R^2	0.227	0.230	0.228	0.212	0.213
K-P rk Wald F	1931.382	2110.511	2386.246	2502.047	2055.986
K-P rk LM	109.359	114.124	147.874	139.429	114.604
K-P rk LM (p-val)	0.000	0.000	0.000	0.000	0.000

Notes: *,**,*** denote significance at the 1%, 5% and 10% levels respectively; robust standard errors in parentheses; all specifications contain time fixed effects; K-P refers to Kleibergen-Paap test statistics. Instrumented variables: *NR, T*. Constant included – not reported. Sample: 51 developed countries; in compliance with 2018 World Bank income classification.

Source: Based on 6-digit HS export data from BACI CEPII (CEPII, 2021; Gaulier and Zignago, 2010).

Table B.9. The relationship between NR exports, TECH exports and productivity growth – <u>developed countries</u> (estimates of eq. 2)

Dependent variable: $g(y)_{it}$	1	2	3	4	5
	TOTAL NR	*FUEL*	*FORESTRY*	*MINERAL*	*METAL*
$y_{i,t-1}$	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
NRi,t-1	-0.037***	-0.029***	0.180***	-0.015	-0.017
	[0.0103]	[0.0086]	[0.0318]	[0.0199]	[0.0145]
Ti,t-1	-0.023**	-0.009	0.018***	0.010*	0.009
	[0.0101]	[0.0067]	[0.0052]	[0.0055]	[0.0054]
No.of obs.	1071	1071	1069	1071	1071
No. of countries	51	51	51	51	51
R^2	0.232	0.229	0.225	0.208	0.209
K-P rk Wald F	10021.675	14506.162	4329.181	2132.410	9839.606
K-P rk LM	229.126	590.045	308.884	123.879	480.170
K-P rk LM (p-val)	0.000	0.000	0.000	0.000	0.000

Notes: *,**,*** denote significance at the 1%, 5% and 10% levels respectively; robust standard errors in parentheses; all specifications contain time fixed effects; K-P refers to Kleibergen-Paap test statistics. Instrumented variables: *NR, T*. Constant included – not reported. Sample: 51 developed countries; in compliance with 2018 World Bank income classification.

Source: Based on 6-digit HS export data from BACI CEPII (CEPII, 2021; Gaulier and Zignago, 2010).

Table B.10. The relationship between NR exports, 4IR exports and productivity growth – <u>developing countries</u> (estimates of eq. 2)

Dependent variable: $g(y)_{it}$	1	2	3	4	5
	TOTAL NR	*FUEL*	*FORESTRY*	*MINERAL*	*METAL*
$y_{i,t-1}$	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
NRi,t-1	-0.005	-0.009	-0.003	-0.008	0.029***
	[0.0046]	[0.0055]	[0.0299]	[0.0106]	[0.0069]
Ti,t-1	0.973	0.852	1.868	1.549	2.076
	[1.8498]	[1.8514]	[1.6871]	[1.7009]	[1.7233]
No.of obs.	2168	2113	2090	2156	2102
No. of countries	109	109	109	109	109
R^2	0.054	0.056	0.052	0.054	0.061
K-P rk Wald F	6.879	6.619	7.407	7.581	7.466
K-P rk LM	26.432	25.912	30.837	30.696	30.028
K-P rk LM (p-val)	0.000	0.000	0.000	0.000	0.000

Notes: *,**,*** denote significance at the 1%, 5% and 10% levels respectively; robust standard errors in parentheses; all specifications contain time fixed effects; K-P refers to Kleibergen-Paap test statistics. Instrumented variables: *NR, T*. Constant included – not reported. Sample: 109 developing countries; in compliance with 2018 World Bank income classification.

Source: Based on 6-digit HS export data from BACI CEPII (CEPII, 2021; Gaulier and Zignago, 2010).

Table B.11. The relationship between NR exports, ICT exports and productivity growth – developing countries (estimates of eq. 2)

Dependent variable: $g(y)_{it}$	1	2	3	4	5
	TOTAL NR	*FUEL*	*FORESTRY*	*MINERAL*	*METAL*
$y_{i,t-1}$	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
NRi,t-1	-0.001	-0.006	0.031	-0.008	0.030***
	[0.0049]	[0.0058]	[0.0330]	[0.0104]	[0.0069]
Ti,t-1	0.016*	0.013	0.020**	0.016*	0.025***
	[0.0091]	[0.0089]	[0.0090]	[0.0092]	[0.0087]
No.of obs.	2287	2193	2188	2262	2169
No. of countries	109	109	109	109	109
R^2	0.040	0.043	0.039	0.040	0.055
K-P rk Wald F	6375.823	13878.672	382.555	1636.339	4610.466
K-P rk LM	245.349	551.901	66.244	169.619	151.716
K-P rk LM (p-val)	0.000	0.000	0.000	0.000	0.000

Notes: *,**,*** denote significance at the 1%, 5% and 10% levels respectively; robust standard errors in parentheses; all specifications contain time fixed effects; K-P refers to Kleibergen-Paap test statistics. Instrumented variables: *NR, T*. Constant included – not reported. Sample: 109 developing countries; in compliance with 2018 World Bank income classification.

Source: Based on 6-digit HS export data from BACI CEPII (CEPII, 2021; Gaulier and Zignago, 2010).

Table B.12. The relationship between NR exports, TECH exports and productivity growth – <u>developing countries</u> (estimates of eq. 2)

Dependent variable: $g(y)_{it}$	1	2	3	4	5
	TOTAL NR	*FUEL*	*FORESTRY*	*MINERAL*	*METAL*
$y_{i,t-1}$	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
NRi,t-1	0.002	-0.003	0.034	-0.006	0.032***
	[0.0054]	[0.0062]	[0.0332]	[0.0106]	[0.0072]
Ti,t-1	0.017*	0.014	0.014*	0.014*	0.020**
	[0.0094]	[0.0091]	[0.0082]	[0.0087]	[0.0085]
No.of obs.	2287	2193	2188	2262	2169
No. of countries	109	109	109	109	109
R^2	0.041	0.044	0.039	0.041	0.055
K-P rk Wald F	2865.737	3215.853	1085.407	3458.299	3258.929
K-P rk LM	396.472	389.854	135.700	439.290	398.281
K-P rk LM (p-val)	0.000	0.000	0.000	0.000	0.000

Notes: *,**,*** denote significance at the 1%, 5% and 10% levels respectively; robust standard errors in parentheses; all specifications contain time fixed effects; K-P refers to Kleibergen-Paap test statistics. Instrumented variables: *NR, T*. Constant included – not reported. Sample: 109 developing countries; in compliance with 2018 World Bank income classification.

Source: Based on 6-digit HS export data from BACI CEPII (CEPII, 2021; Gaulier and Zignago, 2010).

Table B.13. The relationship between NR exports and productivity growth – <u>sample excluding outliers</u> (estimates of eq. 1)

Dependent variable: $g(y)_{it}$	1	2	3	4	5
	TOTAL NR	*FUEL*	*FORESTRY*	*MINERAL*	*METAL*
$y_{i,t-1}$	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
NRi,t-1	-0.004*	-0.007**	0.053***	-0.010	0.017***
	[0.0025]	[0.0029]	[0.0159]	[0.0065]	[0.0054]
No.of obs.	3293	3202	3195	3271	3182
No. of countries	160	160	160	160	160
R^2	0.089	0.092	0.092	0.090	0.099
K-P rk Wald F	79456.681	51482.635	968.737	3437.230	5773.726
K-P rk LM	1171.216	691.419	82.183	177.347	100.950
K-P rk LM (p-val)	0.000	0.000	0.000	0.000	0.000

Notes: *,**,*** denote significance at the 1%, 5% and 10% levels respectively; robust standard errors in parentheses; all specifications contain time fixed effects; K-P refers to Kleibergen-Paap test statistics. Instrumented variable: *NR*. Constant included – not reported. Outliers defined as observations below 1st and above 99th percentiles of the dependent variable.
Source: Based on 6-digit HS export data from BACI CEPII (CEPII, 2021; Gaulier and Zignago, 2010).

Table B.14. The relationship between NR exports and productivity growth – <u>sample excluding outliers</u> (estimates of eq. 1, with control variables)

Dependent variable: $g(y)_{it}$	1	2	3	4	5
	TOTAL NR	*FUEL*	*FORESTRY*	*MINERAL*	*METAL*
$y_{i,t-1}$	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
NRi,t-1	-0.002	-0.005	0.055***	-0.011	0.017***
	[0.0027]	[0.0031]	[0.0161]	[0.0065]	[0.0055]
INV	0.034***	0.037***	0.039***	0.034***	0.035***
	[0.0077]	[0.0081]	[0.0080]	[0.0078]	[0.0079]
RD	0.243***	0.210***	0.267***	0.260***	0.294***
	[0.0736]	[0.0743]	[0.0691]	[0.0689]	[0.0680]
HCI	-0.004	-0.063	0.158	0.017	0.143
	[0.5565]	[0.5601]	[0.5728]	[0.5586]	[0.5529]
No.of obs.	3293	3202	3195	3271	3182
No. of countries	160	160	160	160	160
R^2	0.101	0.104	0.108	0.102	0.114
K-P rk Wald F	65659.785	42403.814	973.030	3368.549	5769.388
K-P rk LM	1129.380	658.925	82.518	177.564	100.837
K-P rk LM (p-val)	0.000	0.000	0.000	0.000	0.000

Notes: *,**,*** denote significance at the 1%, 5% and 10% levels respectively; robust standard errors in parentheses; all specifications contain time fixed effects; K-P refers to Kleibergen-Paap test statistics. Instrumented variable: *NR*. Constant included – not reported. Outliers defined as observations below 1st and above 99th percentiles of the dependent variable. Source: Based on 6-digit HS export data from BACI CEPII (CEPII, 2021; Gaulier and Zignago, 2010).

Table B.15. The relationship between NR exports, 4IR exports and productivity growth – <u>sample excluding outliers</u> (estimates of eq. 2)

Dependent variable: $g(y)_{it}$	1	2	3	4	5
	TOTAL NR	*FUEL*	*FORESTRY*	*MINERAL*	*METAL*
$y_{i,t-1}$	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
NRi,t-1	-0.004	-0.007**	0.047***	-0.009	0.017***
	[0.0027]	[0.0031]	[0.0152]	[0.0067]	[0.0055]
Ti,t-1	0.097	0.045	0.251*	0.208	0.288*
	[0.1645]	[0.1629]	[0.1477]	[0.1490]	[0.1479]
No.of obs.	3183	3129	3106	3173	3120
No. of countries	160	160	160	160	160
R^2	0.097	0.099	0.098	0.098	0.105
K-P rk Wald F	300.013	301.198	361.013	362.736	362.869
K-P rk LM	162.238	163.183	162.970	163.392	163.257
K-P rk LM (p-val)	0.000	0.000	0.000	0.000	0.000

Notes: *,**,*** denote significance at the 1%, 5% and 10% levels respectively; robust standard errors in parentheses; all specifications contain time fixed effects; K-P refers to Kleibergen-Paap test statistics. Instrumented variables: *NR, T*. Constant included – not reported. Outliers defined as observations below 1st and above 99th percentiles of the dependent variable.

Source: Based on 6-digit HS export data from BACI CEPII (CEPII, 2021; Gaulier and Zignago, 2010).

Table B.16. The relationship between NR exports, ICT exports and productivity growth – sample excluding outliers (estimates of eq. 2)

Dependent variable: $g(y)_{it}$	1	2	3	4	5
	TOTAL NR	*FUEL*	*FORESTRY*	*MINERAL*	*METAL*
$y_{i,t-1}$	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
NRi,t-1	-0.002	-0.006*	0.057***	-0.007	0.020***
	[0.0026]	[0.0030]	[0.0161]	[0.0066]	[0.0055]
Ti,t-1	0.022***	0.020***	0.028***	0.024***	0.028***
	[0.0065]	[0.0063]	[0.0062]	[0.0062]	[0.0062]
No.of obs.	3293	3202	3195	3271	3182
No. of countries	160	160	160	160	160
R^2	0.092	0.095	0.098	0.094	0.104
K-P rk Wald F	9890.181	22905.089	482.736	1765.742	7369.909
K-P rk LM	436.535	821.789	82.655	189.585	289.173
K-P rk LM (p-val)	0.000	0.000	0.000	0.000	0.000

Notes: *,**,*** denote significance at the 1%, 5% and 10% levels respectively; robust standard errors in parentheses; all specifications contain time fixed effects; K-P refers to Kleibergen-Paap test statistics. Instrumented variables: *NR, T*. Constant included – not reported. Outliers defined as observations below 1st and above 99th percentiles of the dependent variable.

Source: Based on 6-digit HS export data from BACI CEPII (CEPII, 2021; Gaulier and Zignago, 2010).

Table B.16. The relationship between NR exports, TECH exports and productivity growth – sample excluding outliers (estimates of eq. 2)

Dependent variable: $g(y)_{it}$	1	2	3	4	5
	TOTAL NR	*FUEL*	*FORESTRY*	*MINERAL*	*METAL*
$y_{i,t-1}$	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
NRi,t-1	-0.001	-0.005	0.058***	-0.006	0.021***
	[0.0032]	[0.0034]	[0.0161]	[0.0068]	[0.0056]
Ti,t-1	0.009**	0.007**	0.012***	0.009***	0.011***
	[0.0039]	[0.0035]	[0.0030]	[0.0031]	[0.0030]
No.of obs.	3293	3202	3195	3271	3182
No. of countries	160	160	160	160	160
R^2	0.092	0.093	0.097	0.093	0.103
K-P rk Wald F	11493.702	14864.007	488.383	2400.140	16978.847
K-P rk LM	1111.554	1188.451	81.795	285.423	1060.873
K-P rk LM (p-val)	0.000	0.000	0.000	0.000	0.000

Notes: *,**,*** denote significance at the 1%, 5% and 10% levels respectively; robust standard errors in parentheses; all specifications contain time fixed effects; K-P refers to Kleibergen-Paap test statistics. Instrumented variables: *NR, T*. Constant included – not reported. Outliers defined as observations below 1st and above 99th percentiles of the dependent variable.

Source: Based on 6-digit HS export data from BACI CEPII (CEPII, 2021; Gaulier and Zignago, 2010).

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