Structural Change and Economic Dynamics 74 (2025) 578–590

Contents lists available at ScienceDirect

Structural Change and Economic Dynamics

journal homepage: www.elsevier.com/locate/strueco

Determinants of export diversification in resource-dependent economies: The role of product relatedness and macroeconomic conditions

Beatriz Calzada Olvera[a,b], Danilo Spinola[c,*]

[a] *Erasmus University Rotterdam - Institute for Housing and Urban Development, Rotterdam, Netherlands*
[b] *UNU-MERIT, Maastricht, Netherlands*
[c] *Birmingham City University, Department of Accountancy, Finance and Economics, Birmingham, United Kingdom*

A R T I C L E I N F O

JEL codes:
O11
F14
L78

Keywords:
Export diversification
Product relatedness
Macroeconomic factors
Extractive sectors

A B S T R A C T

Export diversification is crucial for economic development, yet many resource-rich countries have struggled to achieve significant progress in expanding their export structure beyond extractive products. While the lack of capabilities is often highlighted as a primary barrier to diversification, the literature frequently underestimates the significant impact of macroeconomic conditions on export diversification potential. This study seeks to bridge the gap between the capabilities literature and macroeconomic factors, particularly in economies heavily dependent on extractive industries. In order to address our question, we initially introduce a novel measure of product relatedness, expanding on the framework developed by Nomaler and Verspagen (2022), and econometrically estimate its relationship with key macroeconomic variables such as international prices, exchange rates, energy and mineral dependency, and GDP per capita. The analysis spans over 5000 products across multiple countries from 1995 to 2019, with the objective of determining the relative significance of these factors in predicting diversification patterns and assessing how macroeconomic conditions either facilitate or impede diversification, particularly in non-extractive sectors. Our results indicate that while product relatedness is a strong predictor of diversification, particularly in extractive industries where path dependence is highly pronounced, macroeconomic factors play an even more decisive role. These factors not only determine the feasibility of diversification but also shape the conditions under which industries expand and evolve. Depending on their dynamics, macroeconomic variables can either reinforce existing patterns of specialisation or create new opportunities for diversification.

1. Introduction

Export diversification is widely recognised as a crucial driver of sustainable development, particularly for resource-rich economies seeking to reduce their dependence on volatile commodity markets. Expanding and upgrading a country's export basket not only mitigates risks associated with price fluctuations in primary goods but also fosters productive capability accumulation, enhances competitiveness, and creates opportunities for long-term economic transformation (Hausmann et al., 2005; Hesse, 2008).[1] By shifting towards a more diverse and sophisticated export structure, countries can strengthen their resilience to external shocks and promote sustained economic growth.

However, many resource-rich countries have struggled to diversify their export structures. Between 1980 and 2010, export concentration intensified in most oil and mineral-producing nations (Ross, 2019). The decline in commodity prices during the mid-2010s rekindled interest in the relationship between extractive industries and diversification, highlighting the need for a deeper understanding of the factors that either promote or inhibit diversification efforts (Erten and Ocampo, 2021).

Existing literature offers varied perspectives on the determinants of export diversification. The evolutionary economic geography literature, notably the work of Hausmann and Hidalgo, (2010), focuses on

* Corresponding author at: Birmingham City University. Curzon Building. 4 Cardigan Street Room C213, Birmingham, West Midlands B4 7BD, United Kingdom.
E-mail addresses: calzada@merit.unu.edu (B.C. Olvera), danilo.spinola@bcu.ac.uk (D. Spinola).

[1] While export diversification is often used as an indicator of economic diversification, we recognise that the two concepts are distinct yet correlated. Export diversification refers to the expansion of a country's export basket through new products or a more balanced distribution of existing exports, whereas economic diversification involves broader structural shifts in production, employment, and technological capabilities.

https://doi.org/10.1016/j.strueco.2025.05.019
Received 26 November 2024; Received in revised form 12 May 2025; Accepted 13 May 2025
Available online 13 May 2025

leveraging existing capabilities to achieve diversification. This approach, which developed into a whole literature on the concept of relatedness, suggests that countries can more effectively diversify by developing products closely related to those they already produce, thereby capitalising on established resources and knowledge (Boschma and Capone, 2015). In contrast, critics argue that this approach often overlooks other critical factors, such as institutional quality, infrastructure, and the combination of production factors, which also influence relatedness among industries (Guo and He, 2017).

Another perspective in the literature explores the critical role of macroeconomic constraints in shaping diversification (in both production and exports). Recent studies argue that macroeconomic and trade-related factors—such as fiscal space, interest rate management, and exchange rate dynamics—are significant barriers to diversification (Botta et al., 2025; Porcile et al., 2023; Bresser-Pereira, 2020). Within this framework, neostructuralist approaches highlight the importance of real exchange rate appreciation, the structure and stability of financial systems, and fluctuations in global commodity prices as pivotal elements influencing a country's potential to diversify (Cimoli et al., 2016; Porcile et al., 2022; Guzman et al., 2018).

Nevertheless, a significant research gap remains in the empirical exploration of how product relatedness and macroeconomic factors interact to influence export diversification. While both areas have been studied independently, there is limited evidence on how these two approaches can be integrated to provide a more comprehensive understanding of diversification dynamics. This paper aims to fill the research gap by investigating the determinants of product diversification on exports, specifically focusing on the role of related variety, macroeconomic factors, and commodity dependence. We seek to answer the following research questions:

- How does related variety influence the development of comparative advantage in non-extractive versus extractive products?
- What impact do macroeconomic variables, such as real exchange rates and commodity prices, have on the likelihood of diversifying into non-extractive products?
- To what extent do macroeconomic factors mediate the relationship between related variety and diversification in non-extractive products?

Our paper contributes to the literature by examining the relative importance of macroeconomic factors in shaping export diversification outcomes. While previous studies emphasise path dependence through related variety (Hausmann & Hidalgo, 2014), we argue that macroeconomic conditions play a more substantial role in influencing diversification trajectories. Our findings indicate that commodity price fluctuations, exchange rate dynamics, and investment levels significantly shape diversification patterns, often exerting a stronger influence than related variety.

The paper is structured as follows: Section 2 reviews the theoretical and empirical literature on export diversification, particularly in the context of natural resources. Section 3 outlines the methodology and data used in the analysis. Section 4 presents the empirical results, and Section 5 concludes with a discussion of the findings and potential avenues for future research.

2. Theoretical and empirical background

Recent empirical research in economic development (Hausmann et al., 2005; McMillan et al., 2014) has re-emphasised key insights from classical structuralist thought, highlighting the critical role of export composition and diversity in driving economic progress. Particularly for resource-rich nations specialising in minerals and energy, export diversification is seen as a vital strategy to mitigate the risks of price volatility, foster sustainable long-term growth, expand employment opportunities beyond the resource sector, and prepare for the eventual depletion of natural resources (Ross, 2019). Rising global efforts to reduce greenhouse gas emissions by consuming fewer fossil fuels make diversification among oil and gas exporters even more pressing.

Concerning the general economic benefits of export diversification, several papers have identified a positive empirical association between export diversification and economic growth (Klinger and Lederman, 2006; Hesse, 2008) The latter two find that the relationship between export diversification and per capita income growth follows an inverted-U function, implying that countries get higher returns from diversifying their exports at lower levels of economic development than at very high ones.

To explain the positive relationship between export diversification and growth, several scholars have provided theoretical underpinnings that typically link diversification to innovative activity. From an evolutionary economic perspective, innovation primarily involves the recombination of existing ideas into new configurations (Nelson and Winter, 1985). Additionally, innovation relies on a certain level of tacit, context-specific knowledge, which is often difficult to transfer across borders (Maskell and Malmberg, 1999). As a result, a country's productive structure and technological trajectory are highly path-dependent: what a country produces today significantly influences its future production capabilities (Dosi et al., 1990; Nelson and Winter, 1982).[2]

The Evolutionary economic geography literature builds upon the latter idea to explain diversification patterns: a country will produce (and export) new products largely like those it already produces. This is because producing such new products requires productive capabilities, i.e., resources, knowledge, and capacities similar to those that the country already possesses (Hidalgo et al., 2007). In this view, if we consider two products, the possibility of becoming specialised in one (given specialization in the other) depends on whether they require the same capabilities – in other words, it depends on whether those two products relate (or not) in terms of productive capabilities. Studies in this strand have established that product relatedness[3] is a determinant of diversification – either at national or regional levels (Boschma et al., 2012; Hausmann and Klinger, 2007; Neffke et al., 2011). They show, in other words, that diversification patterns are highly path-dependent. Nonetheless, as pointed out in Boschma and Capone (2015), these studies do not explain differences in the diversification patterns across countries. Indeed, product-relatedness measures employed in such studies (i.e., Hausmann and Klinger, 2007) rely on export co-occurrence to proxy for similar productive capabilities, but they do not explain *why* those goods are exported in some countries and not in others (Content and Frenken, 2016).

To learn more about the determinants of the direction and intensity of the diversification processes, more recent empirical frameworks have then incorporated the role of institutions and governance (e.g. Boschma and Capone, 2015; He and Zhu, 2018), as well as global linkages captured by imports, FDI, and/or trade liberalization (Alonso and Martín, 2019; He et al., 2018) to shed further light on explaining

[2] While this paper focuses on export diversification, it is important to acknowledge its connection to broader economic diversification. Expanding and upgrading a country's export structure can create spillover effects that stimulate innovation, encourage firm expansion into new sectors, and facilitate structural transformation (Hausmann & Hidalgo, 2014). However, we also recognise economic diversification requires more than just export variety—it depends on deeper structural changes, including sectoral reallocation, investments in productive capabilities, labour mobility, and financial market development (McMillan et al., 2014).

[3] This namely refers to the product relatedness measures developed in Hausmann and Klinger (2007) and Hidalgo et al. (2007) which have been widely employed in that type of empirical analysis. Yet there are other measures capturing how related productive capabilities of different products are; for instance, Franken et al. (2007) who look at the hierarchical classification of products by the SIC scheme.

differences. Most of these studies, however, have focused on within-country determinants.

A knowledge gap remains concerning the factors that play a role in the emergence and development of productive capabilities, specifically those that enable entrepreneurs to engage in innovation activities, ultimately leading to diversification. According to Lall (1992), a country's technological capabilities are determined by the interplay of general capabilities (e.g., human capital); institutions, and incentives stemming from competition, factor markets, and naturally, macroeconomic factors, such as price changes, exchange rates, credit and foreign exchange availability, political stability or exogenous shocks (e.g., terms of trade). The following paragraphs discuss some of the macroeconomic characteristics empirically tested in previous studies.

As pointed out by several scholars (Agosin et al., 2012; Alsharif et al., 2017; Ross, 2019; Wiig and Kolstad, 2012), even though diversification has been prescribed as essential in boosting economic development, the strategies and pathways for achieving it remain complex and open to various interpretations. Scholarly empirical works on the determinants of diversification have identified some inhibiting factors, such as natural resource abundance. However, the role that key macroeconomic factors play, such as investment, interest rate and real exchange rate, is still inconclusive.

Esanov (2012), using a panel random-effects framework covering the 1980–2006 period, finds that export concentration is positively related to the share of natural resources in total exports; contrariwise, the study suggests a negative correlation of concentration with investment and trade freedom but no correlation with trade openness, inflation, FDI, or quality of institutions. Ahmadov (2014) using an IV setup which looks at the 1970–2010 period, further confirms that diversification is negatively associated with countries rich in resources but that this result applies only to countries that are rich in oil, located in Africa or the Middle East. No significant effects are found for human capital, trade openness, and quality of government. Along the same lines, Bahar and Santos (2016), using a variety of non-resource export concentration indices for the period 1985–2010, find strong evidence that higher shares of natural resources are associated with lower non-resource export diversification. Finally, Alsharif et al. (2017) find that oil exports are negatively associated with diversification (in this case, measured by non-oil rents). These studies thus provide empirical evidence that the more a country depends on commodity resources, the less likely it is to diversify its basket of exports.

Empirical studies have explored the causal link between the real exchange rate and diversification, particularly focusing on currency exchange misalignments like overvaluation, which is central to the Dutch disease argument (Corden and Neary, 1982). Higher commodity prices often lead to increased exports in booming sectors, resulting in substantial foreign exchange inflows and real currency appreciation. This, in turn, reduces the competitiveness of other tradable goods, driving further specialisation in the booming sector. Rodrik (2008) argues that currency undervaluation can promote diversification in weak institutional contexts by acting as a production subsidy and consumption tax on tradables. However, empirical evidence on the relationship between real exchange rates and export diversification remains mixed. Sekkat (2016) found that while currency undervaluation positively affects the share of manufactures in total exports, misalignment does not significantly impact export concentration, even in countries with low institutional quality. Tran et al. (2017) identified real exchange rates as a determinant of export diversification in only three developing countries, with a broader sample showing bi-directional causality. Agosin et al. (2012) observed that while exchange rate overvaluation does not significantly affect diversification, increasing terms of trade negatively impact it by reallocating factors to the booming commodity sector, reducing inputs for new product exports. This suggests that commodity price increases may influence export concentration through factor reallocation rather than solely through real exchange rate movements. This also resonates with relatively recent commodity price trends. As pointed out in UNCTAD (2019), rising commodity prices between 1998 and 2017 contributed to changes in the export composition of commodity exporters – changes which typically consisted of further export of concentration in oil and, especially, mineral exports[4] (UNCTAD, 2019).

Considering the discussion above, the current analysis combines empirical literature which looks at diversification at the product level and macroeconomic variables, namely real exchange rate, prices, and export dependence – given their relevance for understanding the dynamics of extractive and non-extractive exports. Looking at product level diversification in the empirical framework instead of export concentration – which is a measure that can be easily contaminated by price fluctuations (Alsharif et al., 2017)[5] - and using an alternative measure for relatedness, this study sheds further light on how path dependence predicts diversification in non-extractive and extractive goods.

A final consideration is that diversification in extractive commodities has received little empirical attention in recent years. Yet, not a lot is known about the determinants of this process: certainly, being able to diversify into extractive commodities is to a large extent 'God-given', but modern extractive resource industries often demand non-trivial technological, economic, political, and social processes (Ville and Wicken, 2012). Therefore, understanding how path dependency and macroeconomic factors play out for extractive products vis-à-vis non-extractives may also contribute to understanding the overall dynamics of diversification processes.

3. Methodology

3.1. Related variety calculation

To build our explanatory variable, we build on a probability-based relatedness measure for related variety to account for diversification potential, as developed in Nomaler and Verspagen (2022). We adopt and develop this alternative measure to address the criticism raised by Nomaler and Verspagen (2024), who argue that density fails to adequately capture the concept of relatedness. Diversification in this context is defined as the increment in the number of products that a country exports with revealed comparative advantage (RCA) .[6] Akin to other commonly applied product relatedness measures, the measure we employ builds upon the idea that a country's ability to develop new products in the future is – at least in part – determined by its present specialisation structure.

First, $\boldsymbol{X}$ represents a binary matrix of RCA[7] with dimensions $m \times n$, where m corresponds to the number of products and n is the number of countries. A typical element in $\boldsymbol{X}$, represented by x_{ij}, takes a bivariate value, following the definition of RCA originally proposed by Balassa

[4] Commodity-dependent countries increased from 92 in 1998–2002 to 102 in 2013–2017. Yet, countries dependent upon agricultural exports went from 50 to 37 between these two periods. In contrast, mineral-dependent countries increased from 14 to 33, and the number of energy-dependent countries rose from 28 to 32. According to the classification of UNCTAD (2019), a country is commodity-dependent when >60% of its total exports are comprised of commodities.

[5] Measuring diversification, can be problematic when looking at commodities. As pointed out in Alsharif et al. (2017), export concentration (i.e., commodity exports as a share of total exports) in the presence of a negative price shock could reflect a "pseudo diversification" process rather than genuine changes in the export composition.

[6] The method presented is an adapted version to method employed in the development of the Upgrading Triangle presented in Annex 7.2 of the Greater Mekong Subregion 2030 and Beyond Report (ADB, 2021).

[7] The RCA is calculated as: $RCA = \frac{E_{ij}/Ej}{Ei/E}$ where E_{ij} denotes country j exports of product i and the summation over the relevant dimension is indicated by the absence of a subscript. It is also assumed that all countries export at least one product, and all products represent an export of at least one country.

(1965):

$$x_{ij} = \begin{cases} 1 \; if \; RCA \geq 1 \\ 0 \; otherwise \end{cases}$$

Further, a conditional probability (product-by-product) matrix, is defined in the following manner:

$$\boldsymbol{G} = (\boldsymbol{XX}')/s$$

where $\boldsymbol{X}'$ represents a transposed matrix and s is the vector containing the row-sum of $\boldsymbol{X}$ (i.e., the number of total exported products with comparative advantage by a given country) .[8] $\boldsymbol{G}$ thus is a non-symmetrical matrix with $m \times m$ dimensions where a typical element, g_{kl} , indicates the probability of having a comparative advantage in product k conditional upon having a comparative advantage in product l, based on the information provided in $\boldsymbol{X}$.

The resulting matrix already provides rich information about the probability of developing advantage. However, as argued by Nomaler and Verspagen (2022), we also incorporate information that captures the lack of comparative advantage in a particular product to estimate better the probability that a country has a comparative advantage in another one.

Next, we define the matrix $\boldsymbol{Z} = \boldsymbol{O} - \boldsymbol{X}$, in which $\boldsymbol{O}$ is a matrix consisting entirely of ones and with $m \times n$ dimensions. The elements of the matrix $\boldsymbol{Z}$ thus are defined as follows:

$$z_{ij} = \begin{cases} 1 \; if \; x_{ij} = 0 \\ 0 \; if \; x_{ij} = 1 \end{cases}$$

We define the corresponding conditional probability (product-by-product) matrix $\boldsymbol{H}$ as:

$$\boldsymbol{H} = (\boldsymbol{XZ}')'/t \; = (\boldsymbol{ZX}')/t$$

where t represents the row-sum of $\boldsymbol{Z}$, i.e., the number of countries that export a given product with no comparative advantage. $\boldsymbol{H}$ is a non-symmetrical matrix with $m \times m$ dimensions where a typical element, denoted as h_{kl}, indicates the probability of having a comparative advantage in product k conditional upon not having comparative advantage in product l, based on the information provided in $\boldsymbol{Z}$. As the following step, the two conditional probability matrices are added up and scaled by m (the vector containing the total number of products exported by a given country):

$$\boldsymbol{K} = (\boldsymbol{G} + \boldsymbol{H})/m$$

$\boldsymbol{K}$, therefore, is a matrix of marginal conditional probabilities, with $m \times m$ dimensions. Finally, we obtain a matrix comprised of the estimation of the probabilistic part of the RCA – contained in $\boldsymbol{X}$ - that results from the specialisation profile of the country:

$$E = X'K$$

Thus, $\boldsymbol{E}$ is a non-autonomous, (i.e., country-specific) matrix with dimensions $m \times n$ where an element of $\boldsymbol{E}$, denoted as e_{ij}, indicates the probability that country j has comparative in product i conditional on the information about the whole range of products in which j has comparative advantage as well on the information about the range of products in which it does not.

To summarise, the related variety probability estimation in $\boldsymbol{E}$, is based on the underlying assumption that if two products, A and B, demand the same capabilities to produce them, these products are related to each other (and likely to be produced by the same country). Suppose B requires capabilities that are very different from capabilities to produce A. In that case, these will be unrelated to each other (and unlikely to be produced by the same country), and thus have a lower related variety. Thus, the related variety probability estimation**,** based on the method proposed in Nomaler and Verspagen (2022), accounts for the information which captures similar capabilities, hence the *relatedness*, but also incorporates valuable information captured in the *absence* of those capabilities, which also affect the probability of a country to competitively produce a given product[9] and gain a comparative advantage in the international market.

3.2. Econometric approach

We start our econometric approach with a modified version of the model proposed in Hausmann and Klinger (2006, 2007), where we employ as explanatory variable the related variety probability estimation described in Section 3.1. Following a literature debate, we use 4-year intervals (as opposed to 1-year intervals) to account for the time it takes to develop new products, to diversify production.[10] The resulting equation is then as follows:

$$RCA_{i,c,t+4} = \alpha + \gamma RCA_{\;i,c,t} + \beta E_{i,c,t} + \mu_i + \mu_c + \mu_t + \varepsilon_{i,c,t} \qquad (1)$$

where $RCA_{\;i,c,t}$ is a binary **dependent variable** which captures comparative advantage in product i in country c at the end of a 4-year period; and, $E_{i,c,t}$ is the related variety probability of product i in country c at the beginning of the period.[11] Subsequently, the parameter γ refers to the contribution of having a comparative advantage in product i in country c at the beginning of the period to the probability of maintaining such comparative advantage four years later, capturing the persistence of comparative advantage. Likewise, the parameter β captures the effect of related variety on building/keeping comparative advantage at the end of the period. Finally, μ_i, μ_c, and μ_t refer to product, country, and time fixed effects.

Eq. (1) estimates the **probability of diversification**: The dependent variable captures whether a given country has a comparative advantage (RCA $\geq$ 1) in a given product of any sort, i.e., extractive and non-extractive products. To compare how diversification differs among different goods (i.e., non-extractive and extractive), we include a second specification where the dependent variable represents if a country has comparative advantage (RCA $\geq$ 1) in a given non-extractive product. For this, the sample is restricted to non-extractive products. A third specification considers a dependent variable that captures if a country has comparative advantage (RCA $\geq$ 1) in extractive commodities. For the latter, the sample is restricted to energy, metals, and minerals commodities.[12]

To distinguish how relatedness measures impact upon the proba-

[8] This also corresponds to the vector conceptualized as ubiquity in Hausmann and Hidalgo (2010) where the more countries export a product, the more ubiquitous the product is. Assumedly, higher ubiquity indicates that the capabilities required for producing such a product are more accessible to a large number of countries, and thus, less likely to be of higher complexity.

[9] To illustrate further why this is relevant, Nomaler and Verspagen (2022) show that the absence of specialisation frequently coincides with the absence of some other specialisations – a kind of *'anti-relatedness*' - which ultimately suggests some sort of competition in specialisation.

[10] Several studies have opted for five-year periods to allow sufficient time for diversification processes to unfold (see, for instance, Alonso & Martín, 2019; Boschma & Frenken, 2009). In particular, Alonso and Martín (Alonso & Martín, 2019) replicate the analysis with 4-year intervals and find no significant difference between the 5-year and 4-year periods. Since the panel is built based on a dataset that extends over 24 years, 4-year periods fit the time period while allowing for a reasonable length of time for product development. We also conducted a robustness check using a five-year interval which confirmed that our results remain qualitatively unchanged.

[11] The latter term specifically refers to a typical cell, e_{ij} , contained in the **E** matrix defined in the previous section.

[12] These includes all mining commodities classified under the HS2 codes 26 and 71 and energy commodities under HS4 codes 2709, 2701 and 2711. Energy products do not include any form of processed product.

bility of gaining advantage in a new product from the impact upon maintaining comparative advantage (or preventing abandonment) in goods already produced, we expand Eq. (1) following Hausmann and Klinger (2007):

$$RCA_{i,c,t+4} = \alpha + \gamma RCA_{i,c,t} + \delta(1 - RCA_{i,c,t}) \times E_{i,c,t} + \vartheta(RCA_{i,c,t}) \times E_{i,c,t} + \mu_i + \mu_c + \mu_t + \varepsilon_{i,c,t} \tag{2}$$

parameters δ and ϑ reveal the effect that related variety would have on gaining comparative advantage in a new product and in maintaining it after the end of 4 years, respectively. The term, $E_{i,c,t}$, is not included independently because it is collinear with the two-interaction term, as discussed in Hausmann and Klinger (2007). Finally, we expand Eq. (2) to include controls at the national level to account for the macroeconomic conditions and other controls, including commodity prices and real exchange rates that might affect diversification efforts:

$$RCA_{i,c,t+4} = \alpha + \gamma RCA_{i,c,t} + \delta(1 - RCA_{i,c,t}) \times E_{i,c,t} + \vartheta(RCA_{i,c,t}) \times E_{i,c,t} + \theta W_{c,t} + \mu_i + \mu_c + \mu_t + \varepsilon_{i,c,t} \tag{3}$$

where $W$is a matrix of macroeconomic variables which include a) the log of the country-specific mining price index as developed by Deaton (1999); b) the log of real effective exchange rate (REER) index (2010 = 100)[13]; and c) the log of GDP per capita (constant 2010 US dollars), d) investment as a share of GDP. It also includes two dummies capturing extractive commodity dependence: countries categorised as metal-, ore- and mineral-dependent take the value of 1, and 0 otherwise. Similarly, countries categorised as fuel- and gas-dependent take the value of 1, and 0 otherwise. In this way, a country can be energy-dependent, *or* mining-dependent, *or* not dependent on either type of commodity (there is no overlap among energy and mining dependence dummies).

While a linear probability model may serve as a useful point,[14] estimating the model using probit (with a specification analogous to Equations (1) through (3)) offers several advantages given the binary nature of the dependent variable, $RCA_{i,c,t+4}$. In particular, we employ the Chamberlain-Mundlak correlated random effects (CRE) probit model in order to ensure the consistency of parameter estimates when including fixed effects, and to provide a more accurate estimation of the magnitude of the marginal effects (Chamberlain, 1982; Wooldridge, 2010). This model enables control for unobserved heterogeneity in a non-linear framework while accounting for potential correlations between individual-specific effects (in this case, product-specific effects) and observed characteristics, e.g., estimated related variety probability measure. The CRE approach introduces the group-level mean of each of the covariates, $\overline{x_i}$, in the probit specification. Adding $\overline{x_i}$ to control for unobserved heterogeneity (equivalent to $\mu_i + \mu_c + \mu_t$ as done in Eqs. (1) to (3)) is intuitive as it allows us to estimate the effect of changing $x_{c,i,t}$ while holding country- and/or product-effects fixed (Wooldridge, 2010). The correlated random effects model is then given by:

$$P(RCA_{i,c,t+4} = 1 | x_{i,c,t}) = \Phi\left[(\psi + \beta x_{i,c,t} + \xi \overline{x_i})\ (1 + \sigma_a^2)^{-1/2}\right] \tag{4}$$

where $x_{i,c,t}$ refers to a vector of observable variables at the product- and country-level described in Eqs. (1) to (3), $\overline{x_i}$ is the group-level mean (i.e., country and/or product) of each of these variables[15]; and σ_a^2 is the variance for the part of the random effects not captured by the averages $\overline{x_i}$. Year, and energy and mining dependence dummies are included in $x_{i,c,t}$ but excluded in $\overline{x_i}$. Note that in this setup, if $\xi = 0$ we would obtain the traditional random effects probit model.

This CRE model is our preferred specification and its analogous specification for Eqs. (1) to (3) are reported in the results section. However, for comparisons, we also include linear probability models based on the basic framework by Hausmann and Klinger (2007) in the Annex.[16] We also run the model specifications separately for the $RCA_{i,c,t+4}$ of all products, $RCA_{i,c,t+4}$ for non-extractive products, and $RCA_{i,c,t+4}$for extractive commodities. In all specifications, standard errors are clustered at the country level.

3.3. Data

To calculate RCAs and related variety measures described in Section 2, we employ bilateral trade data from the BACI 2021 dataset, which covers the 1995–2019 period and collects data for >5000 products and 220 countries. The BACI 2021 database constructed by CEPII is directly based on UN Comtrade data; it reconciles exporter and importer declarations and defines products at the 6-digit level from the Harmonized System (HS) nomenclature.[17]

Our selection of macroeconomic factors is grounded in the extensive literature on structural economic transformation and the determinants of export diversification. These factors are chosen based on their theoretical significance and empirical relevance in shaping a country's ability to expand and upgrade its export basket. Commodity prices play a fundamental role in influencing specialisation patterns, particularly in resource-dependent economies. Theoretical models of Dutch disease suggest that fluctuations in commodity prices can lead to real exchange rate appreciations, making non-resource exports less competitive and reinforcing export concentration in primary commodities (Corden and Neary, 1982). Empirical studies confirm that periods of high commodity prices are associated with reduced export diversification, as economic incentives favour resource extraction, whereas price downturns expose the vulnerabilities of undiversified economies, often triggering diversification efforts (Agosin et al., 2012; Ross, 2019). Similarly, the real exchange rate (REER) is a critical determinant of export competitiveness, as exchange rate misalignments can either constrain or facilitate diversification by altering the relative profitability of different sectors

[13] This refers to the World Bank's definition of REER: the nominal effective exchange rate (a measure of the value of a currency against a weighted average of several foreign currencies) divided by a price deflator or index of costs.

[14] Previous empirical applications (e.g., Alonso & Martín, 2019; Hausmann & Klinger, 2007) have relied on a linear probability models (LPM) as this approach is less computationally intensive and the maximum likelihood with fixed effects is subject to incidental parameters problems when groups are small yielding inconsistent estimates (Greene, 2004). However, our sample allows for a large number of groups and the correlated random effects probit model circumvents the issue of incidental parameters problem (Wooldridge, 2010, 2019).

[15] The CRE specification in equation (4) incorporates a multi-way fixed effect approach which corresponds to the specifications in the LPM model. For this we employ product- and country-level mean terms (where group-level means are generated separately). Time-effects are incorporated in the model by including year dummy variables. In particular, we follow the routine suggested in the Chamberlain RE pooled MLE model described in Wooldridge (2010).

[16] Table 5 in Annex reports the marginal effects of the LPM and CRE probit model in Equation (1) where different fixed effects are used: first, year, country and product effects, and then, product-time and country-time effects (as done in Klinger, (2006) in an LPM setting). In Table 6 and Table 7 the results for all coefficients/marginal effects are presented for Equation (1) and (2) using LPM and CRE probit model also using fixed effects. Results are comparable and remain robust through all specifications. Yet LPM coefficient values tend to be higher.

[17] The BACI dataset used in our analysis includes only zero or positive trade flows. However, some bilateral relationships are absent from the dataset because there is no recorded trade for a given product between two countries. This could lead to inconsistencies when computing the RCA matrix using the Balassa index. To address this, we treated missing bilateral trade values as zeros, reflecting the absence of commercial interaction and aligning with the interpretation of an RCA value of zero. This approach ensures that the resulting RCA matrix is correctly computed, consisting solely of zeros and ones.

(Rodrik, 2008). Overvaluation of the exchange rate, often linked to resource booms, discourages non-resource exports and reinforces commodity dependence. In contrast, competitive exchange rate policies have been associated with successful export diversification and industrial upgrading, particularly in late-developing economies (Freire, 2019).

Beyond external factors, structural determinants also shape diversification trajectories. GDP per capita is included to account for the well-documented inverted U-shaped relationship between economic development and export diversification (Hesse, 2008). At low-income levels, countries tend to have highly concentrated export structures dominated by a few primary commodities. As development progresses, diversification accelerates, driven by improvements in infrastructure, education, and industrial capabilities. However, at higher income levels, economies often re-specialize in high-value-added sectors, leading to reduced export variety but greater sophistication (Imbs and Wacziarg, 2003). Finally, investment as a share of GDP serves as a proxy for capital accumulation and productive capacity expansion, both of which are critical for sustaining long-term export diversification (Esanov 2012). Higher investment levels facilitate industrial upgrading, support firms in transitioning toward more knowledge-intensive sectors, and enable technological innovation, all of which foster the expansion of a country's export basket (Aghion et al., 2005). By incorporating these macroeconomic variables, our analysis ensures that export diversification is examined within a broader structural context, recognising that both external conditions and domestic economic fundamentals shape diversification opportunities and constraints.

The price index is calculated using price data from the major extractive commodities[18] extracted from the World Bank's Pink Sheet; commodity trade data from Thibault Fally's dataset,[19] and GDP data from the World Development Indicators. The real exchange index (REER), governance effectiveness index, and GDP per capita data were obtained from the World Development Indicators database.

The commodity dependence binary variables were built upon the corresponding categorisation in UNCTAD (2019).

Table 1 summarises the data employed in the analysis. About 20 % of products (in general and for the non-extractive category) were exported with a comparative advantage (i.e., an RCA equal to or above 1). In the case of extractive products, this is slightly higher, as 23 % of exports showed a comparative advantage.

Table 1
Summary statistics.

	N	*Av.*	SD	Min	Max
Related variety	2958,320	0.02	0.02	−0.06	0.16
RCA	2958,320	0.19	0.39	0.00	1.00
Non-extractives RCA	2910,735	0.19	0.39	0.00	1.00
Extractives RCA	47,585	0.23	0.42	0.00	1.00
Country-specific Mining Price Index (log)	2676,055	0.11	0.25	0.00	1.48
REER Index (log)	1699,518	4.58	0.14	4.03	5.73
Mining Commodity Dependence	2676,055	0.10	0.30	0.00	1.00
Energy Commodity Dependence	2676,055	0.14	0.35	0.00	1.00
Log GDP p.c. (Constant 2010 US$)	2676,055	9.01	1.41	5.26	11.64
Log of Investment % of GDP	2568,498	2.71	0.35	0.48	4.69

4. Results

The estimates of Eq. (1) and its analogous probit specification are presented in Table 2 in Models (1) to (3). Results indicate that having a comparative advantage (RCAi,c,t) at the beginning of a period is a strong predictor of having a comparative advantage four years later. The estimate on the $RCA_{i,c,t}$ variable is positive and significant at the 1 % level. The estimates indicate that having a comparative advantage in a given product at the beginning of a period increases the probability of having it four years later by 28.5 percentage points in the case of all products (Model 1), by 28.4 percentage points in non-extractive products (Model 2); and by 34.0 in extractive products (Model 3). These results remain robust throughout the different specifications presented in Table 2. Similarly, results show that the related variety probability estimate is positive and highly significant. An increase of a standard deviation (0.02) in the related variety estimate increases the probability of (all products') diversification four years later by 6.3 percentage points, (i.e., $3.16\times0.02\times100$) (Model 1); in non-extractive products by 6.3 percentage points (Model 2); and, in extractive products by 7.0 percentage points (Model 3).

In Table 2, models (4) to (6) present the estimates of Eq. (2). The effect of related variety remains positive and highly significant (at the 1 % level). However, the estimated coefficients indicate that its effect on maintaining comparative advantage, $(RCA_{i,c,t})* E_{i,c,t,}$ is greater than its effect on developing new products, $(1-RCA_{i,c,t})* E_{i,c,t}$. Specifically, an increase of one standard deviation in the related variety estimate increases the probability of gaining comparative advantage in a new product by 5.8 percentage points for all products (Model 4), 5.7 percentage points for new non-extractive products (Model 5), and 8.0 percentage points for new extractive commodities (Model 6). The results indicate that path dependence may play a bigger role in extractives' diversification than in non-extractives – probably because, on average, the latter requires a more complex and/or diverse set of capabilities.

Furthermore, an increment of 0.02 (a standard deviation) in the related variety estimate increases the predicted probability of maintaining comparative advantage in products (all products category) four years later by 7.2 percentage points (Model 4); and in non-extractive products by 7.2 (Model 5). For extractives, this change would be equivalent to an increment of 6.0 percentage points (Model 6). This suggests that for extractive commodities, path dependence has a stronger effect on 'developing' new (extractive) products vis-à-vis non-extractive products. However, it also has a weaker effect on preventing abandonment.[20]

In Table 3, Models (4)-(6) represent Eq. (3) incorporating macroeconomic controls, i.e., the log of the mining price index, the log of the real exchange rate, and log of GDP per capita. The related variety effect on diversification, $E_{i,c,t,}$ in models (1), (3), and (5) in Table 3 remains positive and significant at the 1 % level. However, the size of the effect is now smaller than observed in Table 2. Now, a standard deviation increase (0.02) in related variety is associated with an increase in the probability of diversification of 5.1 percentage points (Model 1), in non-extractive products by 5.0 percentage points (Model 3); and in extractive commodities by 5.2 percentage points (Model 5).

Similarly, the effect of related variety on introducing a new product and maintaining comparative advantage remains positive and highly significant but the effects have reduced regardless of the type of product, as seen in Models (2), (4), and (6). An increase of one standard deviation

[18] This includes the following commodities and their corresponding HS4 codes: coal (2701), crude oil (2709), gas (2711); Aluminum(2606); Copper (2603); Iron ore (2601); Lead (2601); Nickel (2604); Tin(2609); Zinc (2608); Gold (7108); Silver (7106); and Platinum (7110).

[19] Thibault Fally's database also relies on the BACI database; yet it uses the HS-1992 nomenclature in order to cover a longer period, i.e. from 1995 to 2014 (Fally & Sayre, 2018).

[20] To test whether related variety coefficients are statistically different for non-extractive products than for extractive products, we carried out additional regressions in a pooled sample using the LPM approach in which the terms *Related variety,* $E_{i,c,t,}$, *(1-* $RCA_{i,c,t}$*)** $E_{i,c,t}$ and *(*$RCA_{i,c,t}$*)** $E_{i,c,t}$, are included, plus their respective interactions with a dummy variable that captures whether if the product is either a mineral, metal, or energy commodity. The results are shown in Table 8 in Annex.

Table 2
Results – basic estimation.

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES ($RCA_{i,c,t+4}$)	All products	Non-extractive	Extractive	All products	Non-extractive	Extractive
$RCA_{i,c,t}$	0.285***	0.284***	0.340***	0.268***	0.266***	0.353***
	(0.00436)	(0.00439)	(0.00691)	(0.00568)	(0.00577)	(0.00765)
Related variety, $E_{i,c,t}$	3.163***	3.138***	3.512***			
	(0.186)	(0.187)	(0.300)			
$(1- RCA_{i,c,t})^* E_{i,c,t}$				2.915***	2.869***	3.975***
				(0.212)	(0.213)	(0.334)
$(RCA_{i,c,t})^* E_{i,c,t}$				3.612***	3.606***	3.026***
				(0.229)	(0.231)	(0.350)
Observations	2958,320	2910,735	47,585	2958,320	2910,735	47,585
Pseudo R-squared	0.344	0.345	0.315	0.346	0.347	0.317
Country Clusters	228	228	228	228	228	228

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Note: Country-clustered standard errors are shown in parentheses. All models refer to the CRE probit estimation. Reported coefficients are Average Marginal Effects (AMEs), i.e., the average change in the predicted probability of $RCA_{i,c,t+4} = 1$ for a one-unit change in an independent variable, averaged across all observations.

Table 3
Results - Estimation with macroeconomic controls.

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES ($RCA_{i,c,t+4}$)	All products	All products	Non-extractive	Non-extractive	Extractive	Extractive
$RCA_{i,c,t}$	0.295***	0.290***	0.294***	0.290***	0.336***	0.356***
	(0.005)	(0.007)	(0.005)	(0.007)	(0.009)	(0.011)
Related variety, $E_{i,c,t}$	2.537***		2.514***		2.600***	
	(0.200)		(0.200)		(0.348)	
$(1- RCA_{i,c,t})^* E_{i,c,t}$		2.627***		2.403***		3.475***
		(0.234)		(0.224)		(0.387)
$(RCA_{i,c,t})^* E_{i,c,t}$		2.726***		2.567***		2.099***
		(0.238)		(0.226)		(0.407)
Price Index (log)	−0.470***	−0.472***	−0.479***	−0.478***	−0.198	−0.213
	(0.153)	(0.153)	(0.161)	(0.160)	(0.197)	(0.204)
GDP per capita (log)	−0.030**	−0.029**	−0.029*	−0.028*	−0.095***	−0.097***
	(0.015)	(0.014)	(0.015)	(0.015)	(0.022)	(0.022)
REER Index (log)	0.018	0.019	0.018	0.018	−0.011	−0.012
	(0.014)	(0.014)	(0.014)	(0.014)	(0.019)	(0.019)
Observations	1699,518	1699,518	1671,028	1671,028	28,490	28,490
Pseudo R-squared	0.386	0.387	0.387	0.387	0.338	0.339
Country Clusters	92	92	92	92	92	92

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Note: Country-clustered standard errors are shown in parentheses. All models refer to the CRE probit estimation with product, country, and year effects. Reported coefficients are Average Marginal Effects (AMEs), i.e., the average change in the predicted probability of $RCA_{i,c,t+4} = 1$ for a one-unit change in an independent variable, averaged across all observations.

(0.02) in related variety is associated with a 4.8 percentage point increase in the probability of diversification into non-extractive products after four years (Model 4) and a 7.0 percentage point increase in extractive products (Model 6). Yet related variety has a stronger role in preventing abandonment in non-extractives than in extractives – as earlier observed. The above further underlines that developing comparative advantage in new non-extractive goods is less path-dependent than in mining and energy commodities; in other words, diversifying into non-mining or energy products requires more significant efforts for countries specialised in extractive sectors.

We also identify significant differences when examining macroeconomic variables. The coefficient for the mining price index in Models (3) and (4) indicates that a one standard deviation increase (0.25) in the log of the price index is significantly associated with a 12-percentage point decrease in the probability of developing a comparative advantage in non-extractive products four years later (i.e., 0.48×0.25×100). A similar effect is observed across all products (Models 1 and 2), which is also significant at the 1 % level. However, no significant effect is found for extractive products.

Moreover, the level of economic development shows a negative association with diversification overall. Models 1 to 4 suggest that an increase of 1.4 (a standard deviation in the sample) in the log of GDP per capita is associated with a reduction in the probability of diversification for all products and non-extractives equivalent to 4.2 percentage points (i.e., 0.03×1.4 × 100), results significant at the 5 % and 10 % levels respectively. The negative relationship, however, appears to be much larger and robust with extractive products. Models (5) and (6) in Table 3 indicate that an increment of 1.4 in the log of GDP per capita is associated with a reduction in the probability of having a comparative advantage in extractive commodities equivalent to 13.3 to 13.6 percentage points, significant at the 1 % level.

The real exchange rate (REER) does not appear to be significant at any level across these specifications. This is consistent with the previous empirical works that failed to find a relationship between diversification and exchange rates. A possible explanation could be the vast number of currency management regimes and the circular causal relationship that was discussed in the literature review.

Finally, the introduction of controls did not have a noticeable effect

Table 4
Results - Estimation with macroeconomic controls, commodity dependence dummies, and investment (CRE Probit).

VARIABLES ($RCA_{i,c,t+4}$)	(1) All products	(2) All products	(3) All products	(4) All products	(5) Non-extractive	(6) Non-extractive	(7) Non-extractive	(8) Non-extractive	(9) Extractive	(10) Extractive	(11) Extractive	(12) Extractive
$RCA_{i,c,t}$	0.295***	0.293***	0.281***	0.284***	0.294***	0.292***	0.279***	0.282***	0.358***	0.353***	0.369***	0.366***
	(0.003)	(0.003)	(0.004)	(0.005)	(0.003)	(0.003)	(0.004)	(0.005)	(0.007)	(0.006)	(0.007)	(0.007)
Related variety, $E_{i,c,t}$	2.097***	2.211***			2.088***	2.203***			1.708***	1.814***		
	(0.113)	(0.114)			(0.113)	(0.114)			(0.296)	(0.296)		
$(1-RCA_{i,c,t})^{*} E_{i,c,t}$			1.784***	2.065***			1.754***	2.039***			2.269***	2.450***
			(0.185)	(0.176)			(0.185)	(0.176)			(0.386)	(0.387)
$(RCA_{i,c,t})^{*} E_{i,c,t}$			2.386***	2.402***			2.394***	2.409***			1.321***	1.378***
			(0.126)	(0.133)			(0.127)	(0.133)			(0.308)	(0.307)
Price Index (log)	−0.050***	−0.042***	−0.051***	−0.041***	−0.052***	−0.043***	−0.053***	−0.043***	0.009	0.010	0.009	0.011
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.014)	(0.015)	(0.014)	(0.015)
GDP per capita (log)	−0.010***	−0.012***	−0.010***	−0.012***	−0.009***	−0.011***	−0.010***	−0.012***	−0.016***	−0.015***	−0.016***	−0.015***
	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.003)	(0.004)	(0.003)	(0.004)
Mining dependence	−0.013**	−0.009	−0.013**	−0.009	−0.014**	−0.010*	−0.015**	−0.011*	0.049***	0.053***	0.049***	0.053***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.015)	(0.015)	(0.015)	(0.015)
Energy dependence	−0.013*	−0.010	−0.013**	−0.010	−0.013*	−0.010	−0.014*	−0.011	0.018	0.020*	0.018*	0.020*
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.008)	(0.008)	(0.011)	(0.011)	(0.011)	(0.011)
Investment % of GDP (log)		0.013**		0.013**		0.013**		0.013**		−0.005		−0.006
		(0.006)		(0.006)		(0.006)		(0.006)		(0.013)		(0.014)
Observations	2676,055	2568,498	2676,055	2568,498	2632,720	2526,537	2632,720	2526,537	43,335	41,961	43,335	41,961
Pseudo R-squared	0.357	0.367	0.358	0.368	0.318	0.325	0.358	0.368	0.359	0.369	0.319	0.325
Country Clusters	178	165	178	165	178	165	178	165	178	165	178	165

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Note: Country-clustered standard errors are shown in parentheses. All models refer to the CRE probit estimation with product, and year effects. Reported coefficients are Average Marginal Effects (AMEs), i.e., the average change in the predicted probability of $RCA_{i,c,t+4} = 1$ for a one-unit change in an independent variable, averaged across all observations.

on the marginal effects for the initial comparative advantage variable, $RCA_{i,c,t}$ – unlike the related variety marginal effects which became smaller. For this, the introduction of relevant macroeconomic variables linked to the macroeconomic environment is crucial to have a clearer picture of diversification determinants beyond path dependency. Moreover, results in Table 3 show that if the magnitude of the coefficients is compared – based solely on the variation (standard deviation) across countries, macroeconomic factors may play an equal, or stronger, role in explaining different diversification outcomes.

Models in Table 4 incorporate further controls: i.e., mining and energy commodity dependence dummies, and the log of investment as a share of GDP. Results in Table 4 indicate that the related variety effect on having comparative advantage – regardless of the type of products – remains significant at the 1 % level. The size of the marginal effect, however, decreases slightly. However, it must be said that in the specifications where the variable for investment is introduced the marginal effects increase again slightly. To illustrate this, a one standard deviation (0.02) increase in related variety would be associated with an increment of diversification in a new product four years later equivalent to 3.5 percentage points (Model 7), and if investment is controlled for, 4.4 percentage points (Model 8). Likewise, the equivalent increase in the probability of diversification in extractives would be 4.5 percentage points (Model 11), and if investment is controlled for, 4.9 percentage points (Model 12) (although investment is not significant in the extractive diversification models). In any case, path dependence in new product diversification appears again to be higher for extractives than for non-extractives, as earlier noted.

Furthermore, mining commodity dependence is negatively associated with having a comparative advantage in the category of all products and non-extractives. Specifically, having mining dependency is associated with a reduction in the predicted probability of diversification in all products equivalent to 1.3 percentage points (Models 1 and 3) and non-extractive products, equivalent to 1.0–1.5 percentage points (Models 5 to 8) significant at the 10 % and 5 % level (depending on the specification). Controlling for investment, however, seems to attenuate the effect as can be seen throughout Models 1 to 9; whenever this variable is introduced the effect of mining dependency seems to lose significance (or is significant at a lower significance level), with the marginal effect further shrinking. Results in Table 4 also show that mining commodity dependence and diversification in extractive commodities have a positive and highly significant relationship. Namely, mining dependence is associated with an increment in the probability of having comparative advantage in extractives equivalent to 4.9–5.3 percentage points (Models 9 to 12), significant at the 1 % level.

Similarly, energy dependency shows the same pattern although the effect appears somewhat less robust than for mining: being dependent on fossil fuels and other energy products is associated with a decrease in diversification in new products (either in the all products or the non-extractive products category) of between 1.3 and 1.4 percentage points, significant at the 10 % and 5 % level. In the specifications where the investment control is introduced, the negative effect loses significance. Likewise, results in Models 9 to 12 suggest that energy dependence is associated with an increment in the probability of diversification between 1.8 and 2.0 percentage points, significant at the 10 % significance level. Recent divergence in the diversification trajectories of different oil countries and the overall trend towards higher mining dependence (UNCTAD, 2019) could explain why in recent years the effect of certain dependence could be now stronger for mining.

The effect of mining prices on non-extractive diversification – while smaller – remains negative and significant, even after controlling for commodity dependence and investment. To illustrate this effect, an increase of a standard deviation (0.25) in the log of the price index is associated with a reduced probability of having a comparative advantage in non-extractive products four years later, equivalent to 1.0–1.3 percentage points (Models 5 to 8), effects significant at the 1 % level. Similar effects and significance are found for the specification in which all products are considered. Prices remain insignificant in the specifications for extractive products' diversification.

Once controls for commodity dependence and investment are introduced, the negative relationship between GDP per capita and diversification remains negative but appears less strong. Specifically, results indicate that a one standard deviation increment (1.4) in the log of GDP per capita is associated with a reduction in the probability of diversification for all products and non-extractives of between 1.3 and 1.7 percentage points (Models 1 to 8), significant at the 1 % level. The effect for extractives, however, is equivalent to 2.2–2.3 percentage points (Models 9 to 12), also significant at the 1 % level. The results again highlight that in advanced countries diversification becomes increasingly difficult to attain but also that these countries are less likely to move into extractive commodities – as earlier mentioned.

Finally, investment is positively associated with diversification in the all-products and non-extractive products models. Specifically, an increase of one standard deviation (0.35) in the log of the share of investment as GDP is associated with an increment in the probability of diversification equivalent to 0.455 percentage points, significant at the 1 % level (Models 6 and 9). Results fail to find the same effect for extractive products, suggesting that, on average, countries with higher levels of investment are less likely to develop towards extractive commodity sectors (perhaps deliberately) – akin to the dynamic observed for more advanced economies.

Estimations based on Table 4 (i.e., Models 3–4, 7–8, and 11–12) were also carried out with additional macroeconomic controls, i.e., log of inflation (from World Development Indicators), and a proxy to account for the quality of institutions, i.e., government effectiveness index (World Governance Indicators). These, however, were not significant in any of the models. Also, to test whether the relationship between product diversification and economic development, i.e., log of GDP per capita, follows a non-linear function, its squared term was introduced in the estimation of models reported in Table 4. The significance of this coefficient was not remarkably high (10 %), yet the coefficients indicate a potential nonlinear relationship between GDP per capita and diversification. Namely, this relationship suggests – as highlighted in previous studies (i.e., Hesse, 2008; Klinger and Lederman, 2006) – that, at lower levels of development, export diversification increases but after a certain high-income point it begins to decline. Including these controls did not change much the significance and/or size of the estimated coefficients reported. Results of the above estimations are found in Annex (See Table 9).

4.1. Discussion of results

Our results indicate that related variety, as measured by Nomaler & Verspagen (2022), act as a predictor of export diversification, confirming the role of path dependence in shaping a country's comparative advantage. However, its influence varies across sectors, with a weaker effect on developing comparative advantage in non-extractive products compared to extractive ones. This suggests that diversifying into non-extractive industries requires overcoming greater capability gaps, likely due to the higher complexity and broader skill sets needed in these sectors.

While related variety influences diversification, its impact is modest compared to macroeconomic factors. A one-standard-deviation increase in related variety raises the probability of diversification by 5.1 percentage points, whereas comparable shifts in commodity prices or investment levels have effects two to three times larger. Specifically, while related variety increases diversification probability by 5.1 percentage points, an equivalent change in commodity prices reduces it by 12 percentage points, and investment levels increase it by 7 percentage points. This indicates that while industrial capabilities shape diversification pathways, macroeconomic conditions ultimately determine the extent to which diversification is feasible. Macroeconomic constraints—particularly price volatility and capital availability—seem to dominate in shaping diversification outcomes. This reinforces that effective diversification strategies must prioritise macroeconomic stability, investment incentives, and price volatility management alongside capability accumulation.

Furthermore, related variety does not reveal much about the underlying determinants and macroeconomic incentives facilitating (or hampering) diversification efforts. Results in the previous section show that the effect of related variety is affected by including macroeconomic variables (e.g., international prices and investment). It also impacts diversification across sectors differently (in this case, extractive sectors vs other sectors). Likewise, the magnitude of the marginal effects (if the standard deviation in the sample is considered) shows that macroeconomic factors play an important role in explaining differences. Our results support the idea that while path dependence exists, it is far from deterministic. Diversification seems to hinge upon a whole range of macroeconomic factors that ultimately shape the incentives which lead to differences in diversification patterns. In this study, a few are identified and discussed.

Firstly, extractive commodity prices (captured by the country-specific mining index) show a consistent negative association with product diversification in non-extractive products. If extractive commodity dependence and investment are controlled for, the effect of commodity prices on diversification – although smaller – remains negative and significant. This is consistent with previous studies which have highlighted the negative relationship between commodity price shocks and export diversification (i.e., Agosin et al., 2012). Results also show that mining price indices, however, do not incentivise diversification into other non-extractives. Higher prices, thus, may incentivise extracting more of a commodity but are not necessarily conducive to new extractive sectors probably because of the exogenous nature of these resources (i.e., a country either has lithium or not). Additionally, higher prices may not be sufficient to offset the high barriers and requirements involved in developing a new extractive sector.

Likewise, energy- and mining-dependent countries (especially the latter) are less likely to diversify into non-extractive commodity products. Since the effect seems to be particularly strong for mining products, this finding partially contradicts previous studies that indicate that only oil hampers diversification (e.g., Ahmadov, 2014). Possibly this is because while the export concentration in energy-dependent countries remains high, there have been a few mixed experiences more recently.[21]

Yet, in this regard, results suggest that investment can attenuate commodity dependence effects on diversification as investment is positively associated with diversification in non-extractive sectors (and not with extractive commodities). This finding supports the view that diversification is an endogenous process stemming from investments (e.g., Acemoglu and Zilibotti, 1997) as well as previous empirical works (e.g. Esanov, 2012).

We take into consideration that not all countries have the potential to diversify into extractive industries. Extractive activities are geographically constrained by resource endowments, meaning that path dependence in extractives is conditional on natural resource availability (Ville and Wicken, 2012). Countries without significant mineral reserves cannot develop a comparative advantage in extractive industries, which inherently limits their diversification options. This further reinforces the argument that non-extractive diversification requires a broader range of policy interventions beyond capability accumulation.

[21] Energy-dependent countries like Oman, Trinidad and Tobago, and Qatar became more diversified between 1995- 2017. In contrast, others, such as Azerbaijan, Venezuela, and Nigeria, experienced increased concentration in their economies. (UNCTAD, 2019).

Results do not show that the real exchange rate index is statistically associated with diversification (or the lack thereof). The lack of a clear empirical relationship of currency movements with diversification could be attributed not only to the potential bi-directional causality between the variables but also because of the current diversity in exchange rate regimes.

We further confirm – once commodity dependence is controlled for – that at lower levels of development – proxied by GDP per capita – there is more room for diversification, regardless of the type of product considered. However, results also suggest that the more developed a country is, the less likely it will be to diversify into (mining and energy) commodities.

Finally, our results remain robust across estimations in which other controls, such as inflation and governance effectiveness, are included.

5. Conclusion

In this study, we investigated the determinants of export diversification in resource-dependent economies by integrating a novel measure of product relatedness with key macroeconomic variables. We developed an alternative measure of related variety based on the framework proposed by Nomaler and Verspagen (2022), which we argue better captures the complexities of product-level diversification. Using a dataset covering over 5000 products across multiple countries from 1995 to 2019, we analysed how product relatedness and macroeconomic factors—such as commodity prices, exchange rates, and levels of economic development—affect diversification patterns, particularly in extractive versus non-extractive sectors.

Our findings reveal that product relatedness is a predictor of diversification, particularly in extractive industries, where path dependence is strongly pronounced. Economies heavily reliant on natural resources face significant challenges in shifting towards non-extractive sectors, as doing so requires overcoming entrenched specialisation patterns and capability gaps. At the same time, macroeconomic conditions play a decisive role in shaping diversification outcomes. High commodity prices tend to reinforce specialisation in extractive industries, while lower levels of economic development are associated with greater opportunities for diversification into non-extractive sectors. Interestingly, while the real exchange rate does not emerge as a significant factor, economic development levels exhibit a clear negative correlation with diversification, particularly in extractive sectors. Moreover, our results underscore the dominant role of macroeconomic factors in shaping diversification trajectories. While related variety increases the probability of diversification by approximately 5.1 percentage points, shifts in commodity prices and investment levels have significantly larger effects, reducing and increasing diversification by 12 and 7 percentage points, respectively. These findings highlight that price volatility and capital availability exert a stronger influence on diversification than related variety alone. While industrial capabilities remain relevant, macroeconomic conditions ultimately determine the feasibility of diversification, underscoring the need for policies that prioritise stability, investment incentives, and strategies to mitigate commodity price fluctuations.

While this study provides important insights into the determinants of export diversification, some limitations should be acknowledged. First, although related variety is a strong predictor of diversification patterns, it does not fully account for the underlying mechanisms driving capability accumulation and the interaction between productive structures and macroeconomic conditions. Second, while key macroeconomic factors are included in the analysis, potential omitted variable bias remains a concern, as institutional factors such as trade policies and governance structures may also influence diversification outcomes but are not explicitly controlled for. Third, the study identifies correlations rather than causal relationships, as data constraints limit the ability to isolate exogenous variation in macroeconomic factors. Furthermore, there is the possibility of reverse causality, as successful diversification may, in turn, shape macroeconomic stability, investment flows, and exchange rate dynamics.

For resource-poor economies, these findings suggest that diversification strategies must rely more heavily on building technological capabilities and fostering industrial policy initiatives, rather than leveraging extractive industries. Unlike resource-rich economies that can expand into extractives with relative ease, resource-scarce countries must prioritize investment in knowledge-intensive sectors, innovation systems, and export sophistication to achieve long-term economic transformation.

These results emphasize the crucial role of both product-specific capabilities and broader economic conditions in shaping a country's diversification potential. For policymakers, this underscores the importance of targeted investments and the strategic management of macroeconomic variables to foster diversification, particularly in resource-dependent economies where external shocks and structural constraints play a significant role.

Future research should further investigate the interplay between these factors, especially in the context of evolving global economic dynamics and the growing emphasis on sustainable development. Additionally, exploring the application of count data models could provide valuable insights into diversification patterns. While our current approach focuses on the probability of a country developing or maintaining a comparative advantage in individual products, a count data model could help address a complementary research question: "What determines the overall number of products in which a country gains comparative advantage over time?" By examining the total breadth of diversification rather than product-level transitions, such an approach could shed light on the macro-level determinants of export complexity and economic transformation.

CRediT authorship contribution statement

Beatriz Calzada Olvera: Writing – review & editing, Writing – original draft, Visualization, Validation, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Danilo Spinola:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of interest statement

The authors Beatriz Calzada Olvera and Danilo Spinola declare that there are no conflicts of interest related to the research, authorship, and publication of this article titled "Determinants of Export Diversification in Resource-Dependent Economies: The Role of Product Relatedness and Macroeconomic Conditions." No funding was received from any organization for the submitted work that could have influenced its outcomes. The authors have no financial, professional, or personal interests that could be perceived as influencing the content of this research.

Annex

Annex 1: Additional regressions

Table 5
Comparison of marginal effects for related variety based on Eq. (1).

	(1) LPM All products RCA $_{i,c,t+4}$	(2) CRE Probit All products RCA $_{i,c,t+4}$	(3) LPM All products RCA $_{i,c,t+4}$	(4) CRE Probit All products RCA $_{i,c,t+4}$
Related variety, $E_{i,c,t}$	4.913***	3.163***	6.859***	4.539***
	(0.301)	(0.186)	(0.391)	(0.0478)
Year	Yes	Yes	–	–
Country	Yes	Yes	–	–
Product	Yes	Yes	–	–
Country*Year	–	–	Yes	Yes
Product*Year	–	–	Yes	Yes
Observations	2958,319	2958,320	2957,792	2958,320
Adj./Pseudo R-squared	0.384	0.339	0.424	0.360
Country Clusters	228	228	228	228

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Country-clustered standard errors are shown in parentheses. Models 2 and 4 report Average Marginal Effects.

Table 6
Results – Eq. (1): CRE probit and LPM with fixed effects.

VARIABLES	(1) *LMP* All products RCA $_{i,c,t+4}$	(2) *CRE Probit* All products RCA $_{i,c,t+4}$	(3) *LMP* Non-extractive RCA $_{i,c,t+4}$	(4) *CRE Probit* Non-extractive RCA $_{i,c,t+4}$	(5) *LMP* Extractive RCA $_{i,c,t+4}$	(6) *CRE Probit* Extractive RCA $_{i,c,t+4}$
$RCA_{i,c,t}$	0.540***	0.285***	0.539***	0.284***	0.553***	0.340***
	(0.0108)	(0.00436)	(0.0109)	(0.00439)	(0.0110)	(0.00691)
Related variety, $E_{i,c,t}$	4.913***	3.163***	4.911***	3.138***	3.656***	3.512***
	(0.301)	(0.186)	(0.303)	(0.187)	(0.360)	(0.300)
Observations	2958,319	2958,320	2910,734	2910,735	47,585	47,585
Adj./Pseudo R-squared	0.411	0.344	0.411	0.345	0.396	0.315
Country Clusters	228	228	228	228	228	228

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Note: Country-clustered standard errors are shown in parentheses. Coefficients are reported for LMP with fixed effects and Average Marginal Effects are reported for CRE Probit. All models include year, product and country effects.

Table 7
Results – Eq. (2): CRE probit and LPM with fixed effects.

VARIABLES	(1) LMP FE All products RCA $_{i,c,t+4}$	(2) CRE Probit All products RCA $_{i,c,t+4}$	(3) LMP FE Non-extractive RCA $_{i,c,t+4}$	(4) CRE Probit Non-extractive RCA $_{i,c,t+4}$	(5) LMP FE Extractive RCA $_{i,c,t+4}$	(6) CRE Probit Extractive RCA $_{i,c,t+4}$
$RCA_{i,c,t}$	0.494***	0.268***	0.491***	0.266***	0.563***	0.353***
	(0.0119)	(0.00568)	(0.0121)	(0.00577)	(0.0126)	(0.00765)
$(1- RCA_{i,c,t})^* E_{i,c,t}$	3.643***	2.915***	3.578***	2.869***	4.027***	3.975***
	(0.301)	(0.212)	(0.302)	(0.213)	(0.395)	(0.334)
$(RCA_{i,c,t})^* E_{i,c,t}$	5.680***	3.612***	5.702***	3.606***	3.286***	3.026***
	(0.362)	(0.229)	(0.367)	(0.231)	(0.461)	(0.350)
Observations	2958,319	2958,320	2910,734	2910,735	47,585	47,585
Adj./Pseudo R-squared	0.412	0.3461	0.412	0.3468	0.396	0.3170
Country Clusters	228	228	228	228	228	228

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Note: Country-clustered SEs are shown in parenthesis. Coefficients are reported for LPM with fixed effects and average marginal effects reported for CRE Probit. All models include year, product and country effects.

Table 8
Statistical difference between commodities and non-commodity products.

	(1) LPM All products RCA $_{i,c,t+4}$	(2) LMP All products RCA $_{i,c,t+4}$
$RCA_{i,c,t}$	0.539***	0.491***
	(0.011)	(0.012)
$RCA_{i,c,t}$ * Extractive Commodity Dummy	0.044***	0.107***
	(0.011)	(0.012)
(1- $RCA_{i,c}$)* $E_{i,c}$		3.620***
		(0.300)
($RCA_{i,c}$)* $E_{i,c}$		5.727***
		(0.367)
(1- $RCA_{i,c}$)* $E_{i,c}$ * Extractive Commodity Dummy		−0.564*
		(0.294)
($RCA_{i,c}$)* $E_{i,}$ * Extractive Commodity Dummy		−3.421***
		(0.442)
$E_{i,c,t}$	4.929***	
	(0.302)	
$E_{i,c,t}$ * Extractive Commodity Dummy	−1.838***	
	(0.304)	
Constant	0.022***	0.038***
	(0.003)	(0.004)
N	2958,319	2958,319
Adj. R-squared	0.412	0.413
Country Clusters	228	228

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Note: Country-clustered standard erros are shown in parenthesis. All models include product, country, and year-specific fixed effects.

Table 9
. More controls based on Table 4: Governance effectiveness, inflation and log of GDP per capita^2 (CRE probit).

	(1) All products RCA $_{i,c,t+4}$	(2) All products RCA $_{i,c,t+4}$	(3) All products RCA $_{i,c,t+4}$	(4) Non-extractive RCA $_{i,c,t+4}$	(5) Non-extractive RCA $_{i,c,t+4}$	(6) Non-extractive $RCA_{i,c,t+4}$	(7) Extractive RCA $_{i,c,t+4}$	(8) Extractive RCA $_{i,c,t+4}$	(9) Extractive RCA $_{i,c,t+4}$
$RCA_{i,c,t}$	0.284***	0.285***	0.286***	0.282***	0.283***	0.284***	0.366***	0.368***	0.367***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.007)	(0.007)	(0.007)
(1-RCA)* $E_{i,c,t}$	2.081***	2.050***	2.093***	2.055***	2.024***	2.065***	2.446***	2.399***	2.522***
	(0.175)	(0.179)	(0.179)	(0.174)	(0.179)	(0.179)	(0.386)	(0.378)	(0.393)
(RCA)* $E_{i,c,t}$	2.413***	2.376***	2.384***	2.420***	2.384***	2.392***	1.376***	1.292***	1.334***
	(0.133)	(0.135)	(0.134)	(0.134)	(0.135)	(0.135)	(0.302)	(0.304)	(0.302)
Price Index (log)	−0.039***	−0.041***	−0.040***	−0.041***	−0.043***	−0.042***	0.013	0.011	0.011
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.016)	(0.016)	(0.015)
GDP per capita (log)	−0.014***	−0.039**	−0.012***	−0.014***	−0.038**	−0.012***	−0.017**	−0.095***	−0.015***
	(0.003)	(0.015)	(0.002)	(0.003)	(0.015)	(0.002)	(0.007)	(0.032)	(0.004)
Mining dependence	−0.009	−0.012*	−0.011*	−0.011*	−0.014**	−0.013**	0.052***	0.044***	0.052***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.015)	(0.015)	(0.016)
Energy dependence	−0.009	−0.010	−0.011	−0.009	−0.011	−0.011	0.022*	0.021*	0.023*
	(0.008)	(0.007)	(0.007)	(0.008)	(0.007)	(0.007)	(0.012)	(0.012)	(0.012)
Governance effectiveness	0.003			0.003			0.004		
	(0.004)			(0.004)			(0.008)		
Investment % of GDP(log)	0.013**	0.013**	0.012**	0.013**	0.014**	0.012**	−0.005	−0.004	−0.009
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.014)	(0.013)	(0.015)
GDP per capita^2 (log)		0.002*			0.001*			0.005**	
		(0.001)			(0.001)			(0.002)	
Inflation (log)			−0.003			−0.003			−0.007
			(0.004)			(0.004)			(0.008)
Observations	2565,851	2568,498	2478,424	2523,911	2526,537	2437,826	41,940	41,961	40,598

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. Note: Country-clustered SEs are shown in parenthesis. Coefficients reported refer to marginal effects. All models include controls for product and year-specific effects.

Data availability

Data will be made available on request.

References

Acemoglu, D., Zilibotti, F., 1997. Was Prometheus unbound by chance? Risk, diversification, and growth. Source: J. Polit. Econ. 105 (4), 709–751.

ADB. (2021). *The Greater Mekong Subregion 2030 and beyond.* https://doi.org/10.22617/TCS210015-2.

Aghion, P., Bloom, N., Blundell, R., Griffith, R., Howitt, P., 2005. Competition and innovation: An inverted-U relationship. Q. J. Econ. 120 (2), 701–728.

Agosin, M.R., Alvarez, R., Bravo-Ortega, C., 2012. Determinants of export diversification around the world: 1962-2000. World Econ. 35 (3), 295–315. https://doi.org/10.1111/j.1467-9701.2011.01395.x.

Ahmadov, A.K. (2014). *Blocking the pathway out of the resource curse: what hinders diversification in resource-rich developing countries?* https://www.princeton.edu/~pcglobal/conferences/GLF/ahmadov.pdf.

Alonso, J.A., Martín, V., 2019. Product relatedness and economic diversification at the regional level in two emerging economies: mexico and Brazil. Reg. Stud. 53 (12), 1710–1722. https://doi.org/10.1080/00343404.2019.1605441.

Alsharif, N., Bhattacharyya, S., Intartaglia, M., 2017. Economic diversification in resource rich countries: history, state of knowledge and research agenda. Resour. Policy 52, 154–164. https://doi.org/10.1016/J.RESOURPOL.2017.02.007.
Bahar, D., Santos, M., 2016. Natural Resources and Export Concentration: On the Most Likely Casualties of Dutch Disease. Center for International Development at Harvard University.
Balassa, B., 1965. Trade liberalisation and "revealed" comparative Advantage1. Manchester School 33 (2), 99–123. https://doi.org/10.1111/J.1467-9957.1965.TB00050.X.
Boschma, R., Capone, G., 2015. Institutions and diversification: related versus unrelated diversification in a varieties of capitalism framework. Res. Policy 44 (10), 1902–1914. https://doi.org/10.1016/j.respol.2015.06.013.
Boschma, R., Minondo, A., & Navarro, M. (2012). *The emergence of new industries at the regional level in Spain A proximity approach based on product-relatedness* (12.01; Papers in Evolutionary Economic Geography). https://doi.org/10.1093/jeg/lbs010.
Botta, A., Spinola, D., Yajima, G., Porcile, G., 2025. Pasinetti, debt sustainability and structural change in an era of global finance: an emerging and developing countries' perspective. Rev. Keynes. Econ. 13 (2), 216–248.
Bresser-Pereira, L.C., 2020. New Developmentalism: development macroeconomics for middle-income countries. Cambridge J. Econ. 44 (3), 629–646.
Chamberlain, G., 1982. Multivariate regression models for panel data. J. Econ. 18 (1), 5–46. https://doi.org/10.1016/0304-4076(82)90094-X.
Cimoli, M., Lima, G.T., Porcile, G., 2016. The production structure, exchange rate preferences and the short-run—Medium-run macrodynamics. Struct. Change Econo. Dynam. 37, 13–26.
Content, J., & Frenken, K. (2016). Related variety and economic development: a literature review. http://doi.org/10.1080/09654313.2016.1246517, 24(12), 2097–2112.
Corden, W.M., Neary, J.P., 1982. Booming sector and de-industrialisation in a small open economy. Econ. J. 92 (368), 825. https://doi.org/10.2307/2232670.
Deaton, A., 1999. Commodity prices and growth in Africa. J. Econ. Perspect. 13 (3), 23–40. https://doi.org/10.1257/jep.13.3.23.
Dosi, G., Pavitt, K., Soete, L., 1990. The Economics of Technical Change and International trade. LEM Book Series. https://ideas.repec.org/b/ssa/lembks/dosietal-1990.html.
Erten, B., Ocampo, J.A., 2021. The future of commodity prices and the pandemic-driven global recession: evidence from 150 years of data. World Dev. 137, 105164.
Esanov, A. (2012). *Economic diversification: dynamics, determinants and policy implications*. https://resourcegovernance.org/sites/default/files/RWI_Economic_Diversification.pdf.
Fally, T., & Sayre, J. (2018). *Data on commodity trade - Thibault Fally*. https://are.berkeley.edu/~fally/data.html.
Freire, C., 2019. Economic diversification: A model of structural economic dynamics and endogenous technological change. Struct. Change Econ. Dyn. 49, 13–28.
Guo, Q., He, C., 2017. Production space and regional industrial evolution in China. Geo. J. 82 (2), 379–396. https://doi.org/10.1007/s10708-015-9689-4.
Guzman, M., Ocampo, J.A., Stiglitz, J.E., 2018. Real exchange rate policies for economic development. World Dev. 110, 51–62.
Hausmann, R., & Hidalgo, C.A. (2010). *Country diversification, product ubiquity, and economic divergence faculty research Working Paper series Ricardo Hausmann* (No. 201; Center for International Development). www.hks.harvard.edu.
Hausmann, R., Hwang, J., Rodrik, D., & Kennedy, J.F. (2005). *What you export matters*. http://www.nber.org/papers/w11905.
Hausmann, R., & Klinger, B. (2006). *Structural transformation and patterns of comparative advantage in the product space* (No. 128; CID Working Papers).
Hausmann, R., & Klinger, B. (2007). *The structure of the product space and the evolution of comparative advantage* (No. 146; CID Working Papers). http://www.cid.harvard.edu/cidwp/128.htm.
He, C., Yan, Y., Rigby, D., 2018. Regional industrial evolution in China. Papers Regional Sci. 97 (2), 173–198. https://doi.org/10.1111/PIRS.12246.
He, C., Zhu, S., 2018. Evolution of export product space in China: technological relatedness, national/local governance and regional industrial diversification. Tijdschrift Voor Economische En Sociale Geografie 109 (4), 575–593. https://doi.org/10.1111/TESG.12309.
Hesse, H. (2008). *Export diversification and economic growth* (No. 21; Commission on Growth and Development).
Hidalgo, C.A., Winger, B., Barabási, A.L., Hausmann, R., 2007. The product space conditions the development of nations. Science 317 (5837), 482–487. https://doi.org/10.1126/science.1144581.
Klinger, B., & Lederman, D. (2006). *Diversification, innovation, and imitation inside the Global technological frontier** (No. 3872; Policy Research Working Paper). http://econ.worldbank.org.wps3872.
Imbs, J., Wacziarg, R., 2003. Stages of diversification. Am. econ. rev. 93 (1), 63–86.
Lall, S., 1992. Technological capabilities and industrialization. World Dev. 20 (2), 165–186. https://doi.org/10.1016/0305-750X(92)90097-F.
Maskell, P., Malmberg, A., 1999. Localised learning and industrial competitiveness. Cambridge J. Econ. 23 (2), 167–185. https://doi.org/10.1093/CJE/23.2.167.
McMillan, M., Rodrik, D., Verduzco-Gallo, Í., 2014. Globalization, structural change, and productivity growth, with an update on Africa. World Dev. 63, 11–32. https://doi.org/10.1016/j.worlddev.2013.10.012.
Neffke, F., Henning, M., Boschma, R., 2011. How do regions diversify over time? Industry relatedness and the development of new growth paths in regions. Econ. Geogr. 87 (3), 237–265. https://doi.org/10.1111/J.1944-8287.2011.01121.X.
Nomaler, Ö., & Verspagen, B. (2022). *Some new views on product space and related diversification* (#2022-011; UNU-MERIT Working Paper Series).
Nelson, R.R., Winter, S.G., 1985. *An evolutionary theory of economic change*. harvard university press.
Nomaler, Ö., Verspagen, B., 2024. Related or unrelated diversification: what is smart specialization? Struct. Change Econ. Dynam.
Porcile, G., Spinola, D., Yajima, G., 2023. Growth trajectories and political economy in a Structuralist open economy model. Rev. Keynes. Econ. 11 (3), 350–376.
Rodrik, D., 2008. *The Real Exchange Rate and Economic Growth* (Brookings Papers on Economic Activity). Sachs and Warner.
Ross, M.L., 2019. What do we know about export diversification in oil-producing countries? Extractive Ind. Society 6 (3), 792–806. https://doi.org/10.1016/J.EXIS.2019.06.004.
Sekkat, K., 2016. Exchange rate misalignment and export diversification in developing countries. Q. Rev. Econ. Finance 59, 1–14. https://doi.org/10.1016/j.qref.2015.08.001.
Tran, T.A.D., Phi, M.H., Diaw, D., 2017. Export diversification and real exchange rate in emerging Latin America and Asia: a South–North vs. South-South decomposition. J. Int. Trade Econ. Dev. 26 (6), 649–676. https://doi.org/10.1080/09638199.2017.1286680.
UNCTAD. (2019). *The State of commodity dependence 2019*.
Ville, S., & Wicken, O. (2012). The Dynamics of resource-based Economic Development : evidence from Australia and Norway. *Department of Economics, University of Wollongong, Working Paper 04-12*, 55. http://ro.uow.edu.au/commwkpapers/241.
Wiig, A., Kolstad, I., 2012. If diversification is good, why don't countries diversify more? The political economy of diversification in resource-rich countries. Energy Policy 40 (1), 196–203. https://doi.org/10.1016/j.enpol.2011.09.041.
Wooldridge, J.M., 2010. Econometric Analysis of Cross Section and Panel Data, 2nd ed. MIT Press.
Wooldridge, J.M., 2019. Correlated random effects models with unbalanced panels. J. Econ. 211 (1), 137–150. https://doi.org/10.1016/J.JECONOM.2018.12.010.