Long-term effects of real exchange rate volatility and institutional quality on economic complexity

Rafael Moraes de Sousa and Michele Polline Veríssimo

Received: 15/06/2023
Accepted: 12/08/2024

Abstract

This article analyses whether real exchange rate volatility and institutional quality, combined as conditioning variables of the productive specialization of economies, can have a negative impact on a country's ability to achieve greater economic sophistication, especially in countries with a commodity-dominated and natural resource-based export basket. The methodology used consists of panel cointegration estimation (pooled mean group) using data from 1995 to 2018 for a sample of 54 countries. The results indicate that real exchange rate volatility is indeed an obstacle to the implementation of structural measures aimed at diversification and sophistication of a country's productive fabric, while the quality of its institutions has a positive effect on its economic complexity and increases the possibilities for developing local capabilities.

Key words

Foreign exchange markets, commodities, natural resources, international trade, production, economic research

JEL classification

F14, O13

Authors

Rafael Moraes de Sousa is a professor in the Faculty of Economics at the Federal University of Pará, Brazil. Email: rafaelmsousa1@hotmail.com.

Michele Polline Veríssimo is a professor in the postgraduate economics programme at the Institute of Economics and International Relations of the Federal University of Uberlândia, Brazil. Email: micheleverissimo@ufu.br.

I. Introduction

Based on the argument that the key to economic prosperity lies in the efficiency of a country or region in bringing together a variety of capabilities that enable it to diversify its productive and export structure, Hidalgo and Hausmann (2009) developed the concept of economic complexity, which has gained wide acceptance in different currents of thought in the economic literature. This methodology aims to measure the complexity and diversity of the economy in a location and is based on the identification, using international trade data, of the products with the largest share of the export profile of that location that make it possible to achieve a greater degree of diversity (number of products that the country or region exports with a comparative advantage) and less ubiquity (number of countries or regions that export a given product with a comparative advantage), and defines the kinds of skills that are necessary to achieve a certain productive profile. To that end, the economic complexity index has been extensively applied as an analytical tool in studies on international trade and structural changes from different perspectives, including as a proxy for the acquisition of productive capabilities; in the analysis of the factors that determine the complexity of economies with a low level of productive sophistication; and in explaining the growth of economies at varying levels of development.

Given the wide range of applications of this methodology, the aim of this article is to discuss two approaches that link international trade to the productive specialization profile of economies and to the potential for economic growth in the long term. The first approach consists of the economic complexity methodology (Hidalgo and Hausmann, 2009), which correlates economic growth with the development of local capabilities that enable diversification and sophistication of the production and export structure. The second approach concerns the literature on the "curse of natural resources", which assumes a negative relationship between a country's natural resource specialization and its economic growth (Sachs and Warner, 1995), observed mainly in oil and mineral exporting economies with low institutional quality.

The purpose of this study is to examine the effects of two transmission channels of the resource curse associated with structural changes in economies —real effective exchange rate volatility and institutional quality— on the level of economic complexity that a country can achieve. It is hypothesized that real exchange rate volatility and low institutional quality have a negative effect on countries whose productive and export structure is centred on commodities and on low-technology manufactures, since these channels become long-term obstacles to reorienting the economy towards a more complex production structure. This is because they hinder efforts to implement and propagate capabilities in the productive fabric with the aim of establishing a more sophisticated production and export structure.

The methodology used consists of cointegration analysis with panel data (pooled mean group) for a sample of 54 countries over the period 1995–2018. The models are estimated taking into consideration the economic complexity index of the Observatory of Economic Complexity, exchange rate volatility based on the autoregressive conditional heteroskedasticity (ARCH) and generalized autoregressive conditional heteroskedasticity (GARCH) models using data from the Bank for International Settlements (BIS), and institutional quality indicators provided by the World Bank, in addition to other control variables related to the characteristics of the countries analysed.

The article contributes to the literature by providing evidence that the economic complexity and resource curse theories have complementary aspects and may represent an interesting research agenda for discussion of the obstacles to long-term economic growth in countries with natural resource-based economies. In addition, as a new development, using measures of exchange rate volatility and proxies to measure institutional quality, the article empirically analyses the impact of variables that may help to drive structural changes that affect the economic complexity level.

This article is divided in five sections, including the introduction and concluding remarks. Section II systematizes the theories unpinning the development of the estimated econometric model. Section III presents the empirical strategies adopted, and section IV explores the results obtained.

II. Economic complexity, exchange rate, institutions and economic growth

One of the major questions that dominates economic thinking concerns the factors behind the income disparity between economies and the influence of international trade on economic growth. The debate also touches on the role of exports as a source of external demand in the determination of output (Kaldor, 1957; Thirlwall, 1979), as well as the importance of the specialization profile of the production and export structure (Krugman, 1994; Sachs and Warner, 1995; Rodrik, 2009).

An analytical tool has been developed relatively recently that is widely used by scholars of the relationships between economic growth, structural changes and international trade, namely the theory of economic complexity proposed by Hidalgo and Hausmann (2009). These authors hypothesize that the productive structure of an economy is determined by the set of capabilities that are necessary to produce a given good. The more complex these capabilities are, that is, the more diverse and exclusive they are, the more likely it is that the economy will develop new products from them (product space).

A country's economic growth is thus affected in different ways depending on its productive specialization, since some products have a dense network of connections, which helps the country or region to develop diverse capabilities, while others do not have that effect. Based on the assumption that comparative advantages reveal the level of productive specialization, Hidalgo and Hausmann (2009) note that if an economy is able to export a given product with a comparative advantage, it is because it has the capabilities necessary for its production. That country's economic complexity is therefore related to the complexity of the products it exports.

Given that, despite the benefits of trade relations, income disparity between economies has continued to grow over time, it is reasonable to assume that certain characteristics influence a country's economic performance that cannot be imported but must be developed internally, such as infrastructure, regulation and special workforce skills. A country's performance is thus assumed to be directly related to its efficiency in diversifying its non-tradable local capabilities, and therefore cross-country differences in income can be explained by differences in economic complexity, as measured by the diversity of capabilities present in a country and their interactions (Hidalgo and Hausmann, 2009, p. 10.570).

The great contribution of this view is the creation of a mathematical tool called the method of reflections, which makes it possible to derive the economic complexity index from international trade data. According to the Observatory of Economic Complexity (2021), economic complexity is estimated by measuring the complexity of the location (country, region or city) and that of the activities present in it (products, industries or technologies). It is assumed that the activities produced in or exported from a particular location contain information on the complexity of that location, while the locations where a given activity is present contain information on the complexity required to perform that activity.

Based on the adjacency matrix Mcp, which represents the activities (p) present in a location (c), the method of reflections consists of iteratively calculating the average value of a node's neighbours, that is, it produces a simultaneous interaction between the international trade data (exports and imports) of the related countries of the matrix, such that the method produces a symmetrical set of variables for the two types of nodes in the network: countries and products. Consideration is given only to products for which the country has a revealed comparative advantage, represented by $RCA_{cp} = (Xcp^{local}/Xc^{local})/(Xp^{world}/X^{world})$, where Xcp^{local} represents the local exports of activity p at location c; Xc^{local}, the total exports in location c; Xp^{world}, global exports of activity p; and X^{world}, total global exports.

The matrix $Mcp = 1$ when local production of an activity is higher than expected for a location of the same size and an activity with the same total production. Thus, the two measurements of interest can be obtained:

$$K_c = \frac{1}{M_c}\sum_p M_{cp}K_p \tag{1}$$

$$K_p = \frac{1}{M_p}\sum_p M_{cp}K_c \tag{2}$$

where K_c is the complexity of the location and K_p is the complexity of the product. Substituting (2) for (1) is equivalent to diagonalizing the following matrix:

$$\widetilde{M}_{cc} = \sum_p \frac{M_{cp}M_{c'p}}{M_c M_p} \tag{3}$$

where $M_c = \sum_p M_{cp}$ represents the number of activities (diversity) of the location, and $M_p = \sum_p M_{cp}$ expresses the ubiquity of an activity.

Hidalgo and Hausmann (2009) note that complex products are the result of a combination of diverse and exclusive capabilities. Diversity is measured by the number of products exported by a country, assuming that the more products exported, the greater the diversity of available capabilities. Exclusivity is measured by the number of countries exporting the same product: the fewer the countries, the more exclusive the available capabilities will be. Product complexity is therefore obtained from the interaction between the measures of diversity and exclusivity.

The economic complexity index is calculated based on the share of complex products in the export profile. We therefore obtain:

$$PCI = \frac{K_p - \tilde{k}_p}{\sigma(K_p)} \tag{4}$$

$$ECI = \frac{K_c - \tilde{k}_c}{\sigma(K_c)} \tag{5}$$

where PCI is the product complexity index; ECI is the economic complexity index; $\tilde{k}_p$ and $\tilde{k}_c$ are averages; and $\sigma(K_c)$ and $\sigma(K_p)$ represent the standard deviation.

The authors ascribe a predictive nature to indicators of economic complexity, meaning that a country or region's productive sophistication is correlated with its income level and deviations from this relationship are predictors of its future economic growth. This suggests that countries and regions tend to converge towards an income level associated with available local capabilities (Hidalgo and others, 2007; Hidalgo and Hausmann, 2009). However, this methodology measures the availability of capabilities in a given location but does not discuss the process required to achieve sophistication in terms of the trajectory taken, the obstacles overcome and how those capabilities were accumulated. The indicator represents a measure of results for a given period of time, taking into account the diversity and exclusivity of the products exported and intuiting the skill level required for their production. In empirical studies, therefore, the economic complexity index is typically used as a proxy for characteristics such as structural changes, the acquisition of productive sophistication, the impact on income disparity and the path to more sustainable production.

The analysis of the circumstances and factors that can hinder the realization of more dynamic and sophisticated productive structures creates a space for dialogue between discussions on economic complexity and the literature on the effects of productive and export specialization on economic growth. Of particular note is the literature on the resource curse, whose central proposition is that there is a negative relationship between natural resource abundance (specialization) and long-term economic growth (Sachs and Warner, 1995).

Given that an economy's export profile reflects the orientation of its production structure and the concentration of its local capabilities (e.g. knowledge, technological intensity and innovation systems), the resource curse theory identifies factors linking natural resource-based production structures and low economic growth through transmission channels. These include the long-term decline in commodity prices, barriers to the development of the industrial sector, the effects of Dutch disease and weak institutions (Frankel, 2010; Van der Ploeg, 2011).

The literature on the resource curse associates low growth in natural resource-based economies with the Prebisch-Singer hypothesis of low value added and commodity price volatility, which lead to declining terms of trade for commodities relative to manufactured goods. This results in an unequal distribution of the gains from trade, which translates into unequal labour remuneration in the centre and the periphery. That in turn reinforces the disparity in income between countries specializing in commodities (periphery) and industrialized countries (centre).

The literature on the resource curse also indicates that terms-of-trade improvements or the discovery of new resource deposits can hinder industrial development by shifting the means of production (capital and labour) to the primary sectors (Sachs and Warner, 1997), paving the way for Dutch disease and deindustrialization. Dutch disease occurs when an increase in commodity exports —driven by the discovery of new resource deposits or rising prices— leads to higher foreign currency inflows and, in turn, an overvaluation of the real exchange rate such that the export of manufactured goods ceases to be profitable, since they have no comparative advantage in the international market and require a more competitive exchange rate to ensure profitability for their producers (Corden and Neary, 1982; Bresser-Pereira, 2009).

Reorientation of exports towards commodities, primary goods or low value-added manufactures, together with the effects of Dutch disease, is seen as a negative process that can ultimately lead to deindustrialization of the country, in other words, a fall in the share of industry in employment and output (Oreiro and Feijó, 2010). Given the Kaldorian assumptions that the industrial sector has higher income elasticity of exports, greater economies of scale and greater technology spillover to other sectors of the economy, commodity specialization contributes to lower economic growth rates in the long term.

The weakening of the industrial sector due to Dutch disease has structural effects seen in significant changes in the real exchange rate, so instability in this macroeconomic price can be a barrier to any strategy for sustained growth. In this regard, exchange rate variations can lead to non-negligible changes in exports, whereby real devaluation stimulates the entry of new sectors in the export profile, and can also create opportunities to exploit economies of scale, promote productivity growth and enable permanent transformations in the international specialization profile. In contrast, appreciation of the real exchange rate may contribute to the shrinking of some activities, the downgrading of technical capacities, lost externalities, decreased productivity and reduced competitiveness in some sectors. Exchange rate volatility also generates balance-of-payment instability in countries with natural resource-based economies, making it difficult to obtain foreign currency to finance imports (Oreiro and Feijó, 2010).

The effects of the level, misalignment and volatility of the real exchange rate on economic growth have been examined in several empirical studies. Razin and Collins (1997), for example, using a sample of 93 countries over the period 1975–1992, demonstrated that only significant exchange-rate appreciation is associated with slower economic growth, while moderate depreciation is associated with faster growth. Vieira and Damasceno (2016) analysed the Brazilian economy in the period 1995–2011 and found that exchange rate undervaluation (overvaluation) stimulates (dampens) economic growth and that this dynamic is impaired when exchange rate volatility is greater. Pereira and Missio (2019) studied the relationship between the real exchange rate and structural change in Latin America and found that an overvalued exchange rate hurts long-term economic growth, but a depreciated exchange rate does not necessarily boost growth via indirect effects on structural change towards industrialization.

Overall, the empirical evidence seems to support the conclusion reached by Eichengreen (2008) that keeping the real exchange rate at competitive levels and avoiding excessive volatility are important for stimulating economic growth.

The empirical evidence also confirms the relationship between the real exchange rate and the level of sophistication of the export profile. Oreiro, D'Agostini and Gala (2020), for example, analysed the determinants of the deindustrialization of the Brazilian economy in the period 1998–2017 and found that the fall in the share of domestic manufacturing and consequently in productive sophistication was linked to the significant overvaluation of the real exchange rate. The authors therefore highlight the need to adopt a macroeconomic policy regime with a real exchange rate target to avoid harmful overvaluations, and to adopt industrial policies aimed at increasing the country's economic complexity.

Gabriel and Missio (2017) analysed the relationship between the real exchange rate and the economic complexity level in a model with two regions, the North (developed) and the South (developing), based on the argument that the level of the exchange rate matters for the share of industry in the economy and the attainment of an economic growth rate compatible with balance-of-payments equilibrium. The authors found that an excessively overvalued real exchange rate negatively affects the industrial sector, which may result in regressive productive specialization, especially in developing economies. In addition, exchange rate undervaluation and the larger share of the manufacturing sector in the sample of developing countries have a positive impact on their economic complexity.

Hooy, Baharumshah and Brooks (2016) studied the effect of real exchange rate volatility on the exports of Association of Southeast Asian Nations (ASEAN) countries to China and documented negative effects on high- and medium-technology exports. Thorbecke (2008) also shows that there was a decrease in the flow of electronic components in East Asia when uncertainty increased owing to exchange rate volatility, which points to a decline in the regional benefits of cross-border fragmentation. Similarly, Tang (2014) found that exchange rate volatility had unfavourable effects on intra-Asian exports of intermediate goods and equipment goods, which, according to the author, empirically supports the adverse impact of exchange rate instability on components used as production inputs.

Avom, Kamguia, and Ngameni (2021) also found that output and terms-of-trade volatility negatively affected the economic complexity of a group of 119 countries in the period 1998–2017. The variables related to financial development, foreign direct investment, the Internet and income per capita have a positive effect on economic complexity, while natural resources have a negative effect.

Jun and others (2020) examined bilateral trade links for more than 1,200 products and found that the countries analysed are more likely to increase their exports of a product to a given destination if they already export related products. Therefore, in addition to endowments and advantages, diversification involves learning and spillover between related activities, and overcoming information difficulties to access each export destination. In this regard, the risks and uncertainty stemming from exchange rate volatility can limit opportunities for sophistication of the production structure.

The evidence mentioned thus far suggests that exchange rate volatility can affect factors related to the sophistication process of an economy and have adverse effects on its economic growth, given that volatility tends to heighten risk and uncertainty, which in turn increases the costs associated with the production process, especially in sectors that depend on imported inputs, machinery and technology. Furthermore, the negative relationship between exchange rate volatility and economic complexity may be seen in the efforts to minimize the risks involved in the development of more sophisticated activities, since they are associated with high costs, such as research and development and the effective implementation of investments and projects in activities with higher technological content. These risks may be heightened by the uncertainty resulting from exchange rate volatility and inhibit the expansion of the number of activities in the productive structure (diversification) as well as the progression of activities that require exclusive skills and capabilities (non-ubiquity).

High exchange rate volatility means a reduction in more complex exports, followed by specialization in exports based on comparative advantages, since uncertainty regarding future yields hampers expansion of the production structure towards greater diversity and sophistication. In a context of productive sophistication based on the probability of co-exporting related activities, according to Hidalgo and Hausmann (2009), uncertainty can limit spillover from one activity to another. Even when a country or region has developed sufficient domestic capabilities to perform a given activity, the possibility of spillover to a related activity requiring similar skills may be limited by uncertainty caused by exchange rate volatility.

In addition to effects related to the exchange rate, another obstacle highlighted by scholars of the resource curse when analysing the negative effects of natural resource specialization on a country's economic growth is the quality of its institutions, in view of the associated failures in the conduct of policies and institutional performance. According to Robinson, Torvik and Verdier (2006), many resource-abundant countries underperform in terms of harnessing the potential advantages of their resources. This is owed, among other factors, to poor contract management; to the formulation of policies unable to promote development due to protection of the dominant primary sectors; to corruption; and to the allocation of resources to non-productive activities. Thus, institutional weakness tends to maintain the power and privilege of the primary sectors, which hinders industrial development and diversification and sophistication of the productive and export structure.

In that connection, Mehlum, Moene and Torvik (2006) studied the relationship between economic growth and institutional quality in a sample of 42 natural resource-exporting countries between 1962 and 2000 and found a negative relationship between a country's gross domestic product (GDP) growth rate and its dependence on natural resources, especially in countries with low-quality institutions. Zhu and others (2010) analysed the determinants of countries' export sophistication over the period 1992–2006 and found that the impact of a country's natural resource abundance seems to be moderated by the quality of its institutions: in the absence of effective institutions, natural resource abundance hampers improvements in the structural quality of exports, while the effect can be positive when good institutions exist.

In his study of the extent to which institutional quality shapes international differences in economic complexity, Vu (2021) argues that better institutions tend to generate a higher level of economic complexity, as they facilitate incentives for innovative entrepreneurship, foster human capital accumulation and allocate human resources to productive activities. Using data for 115 countries, the author found that institutional quality (measured by the Economic Freedom of the World Index) had positive effects on economic complexity, and he thus emphasizes the importance of establishing well-functioning institutions in order to undertake structural transformation in favour of more complex productive activities, which would help to alleviate persistent underdevelopment.

Building on the arguments put forward in the literature on economic complexity and the resource curse, the sections that follow present an empirical analysis of the effects of real exchange rate volatility and institutional quality (channels of the resource curse) on export complexity.

III. Methodology and database

The purpose of this study is to ascertain whether two transmission channels of the resource curse —real exchange rate volatility and institutional quality— can have a negative effect on a country's ability to achieve greater economic complexity, in particular countries with predominantly commodity-based or resource-based export profiles.

To that end, the ideal empirical strategy is one that can be used to conduct long-run estimations for a large group of countries and that combines a cointegration model with a panel data structure. The methodology selected for this study takes those two interests into account, since it is based on the autoregressive distributed lag modelling approach to cointegration analysis —proposed by Pesaran and Shin (1999) and Pesaran, Shin and Smith (2001)— combined with panel data estimation, which helps to control for individual heterogeneity and identify unobservable characteristics (Baltagi, 2005).

Pesaran, Shin and Smith (1999) developed the pooled mean group model, which is based on an autoregressive distributed lag structure adapted for panel data. The model's probability estimators are used to obtain long-run coefficients and to obtain short-run and error-correction estimations using homogeneity restrictions through the mean group.

The autoregressive distributed lag model was selected because of the advantages it offers over traditional cointegration tests, such as those developed by Engle and Granger (1987) and Johansen (1991), given that it tends to more efficiently capture long-run relations in small data samples and it can be used with sets of variables with different orders of integration, including stationary, I(0), and nonstationary, I(1), variables (Pesaran and Shin, 1999).

The autoregressive distributed lag model checks for the existence of long-run vectors within a set of variables. Once that relation is confirmed, the long- and short-run coefficients of the models are estimated, as is the speed of adjustment to the long-run equilibrium. For this purpose, the pooled mean group-autoregressive distributed lag model is estimated in the form of error correction vectors, which can be specified as shown:

$$\Delta(y)_{it} = \phi_i \Delta(y)_{it-1} + \beta_i' x_{it} + \sum_{j=1}^{p-1} \lambda^*_{ij} \Delta(y)_{it-1} + \sum_{j=0}^{q} \delta^{*\prime}_{ij} \Delta(x)_{it-1} + \mu_i + \varepsilon_{it} \tag{6}$$

where $(\Delta(y)_{it})$ is the dependent variable, Δ is the first deviation, and (x) are the independent variables; $\phi_i = -\left(1 - \sum_{j=1}^{p} \lambda_{ij}\right)$ represents the error correction mechanism for the i-th group; $\beta_i = \sum_{i=o}^{q} \delta_{ij}$ are the long-run parameters for the i-th group; $\lambda^*_{ij} = -\sum_{m=j+1}^{p} \lambda_{im}$ $j = 1,2,...,p-1$ are the short-run parameters for the i-th group; and (ε_t) are white noise disturbances.

This makes the autoregressive distributed lag panel efficient and superior to other cointegration methods, since it allows for underlying regressors that exhibit orders of integration I(0), I(1) or a mix of the two (Pesaran and Shin, 1999). Other advantages, which justify the use of the model in this study, are that the pooled mean group model allows for the estimation of macro panel data with a time interval of at least 20 years (Asteriou, Pilbeam and Pratiwi, 2021) and that it is less sensitive to the existence of outliers in a relatively small cross section of data (Pesaran, Shin and Smith, 1999); at the same time, it corrects the serial correlation and endogeneity problems that can arise when using the panel data method (Pesaran, Shin and Smith, 1999). The pooled mean group model limits the long-run equilibrium so that it is homogeneous across countries while allowing for country-specific heterogeneity in the short-run relation, which can be focused on such factors as different infrastructure policies, responses to external shocks and financial crises.

In this study, autoregressive distributed lag-pooled mean group models were used to analyse the long-run effects of real exchange rate volatility and institutional quality on economic complexity. Some control variables were also used to improve the specification of the models. A description of the variables used in the estimations follows.

The dependent variable is the economic complexity index (ECI), obtained from the Observatory of Economic Complexity, which generates ECI indicators for a long list of countries using computational methods based on the mathematical tools described in the previous section. Normalized ECI ranges from -2.5 to +2.5. Values that are positive (negative) or closer to the positive (negative) extreme represent more (less) complexity. The database covers the period 1995–2018.

The first explanatory variable of interest is real effective exchange rate volatility (*volatreal*), which is used as a measure of macroeconomic instability and a potential obstacle to the diversification and sophistication of the productive structure. The exchange rate volatility of each country in the sample was measured using autoregressive conditional heteroscedasticity (ARCH) models developed for modelling and predicting conditional variations, in which the variance of the dependent variable is modelled as a function of its past values and the past values of the independent or exogenous variables. These models were introduced by Engle (1982) and generalized by Bollerslev (1986) and Taylor (1986) as generalized autoregressive conditional heteroscedasticity (GARCH) models.

ARCH and GARCH models[1] are widely used for analysing time series whose values fluctuate greatly. They are also used as an uncertainty measure, wherein the researcher can opt to consider a wide range of available specifications for modelling volatility. This study analyses a sample of 54 countries with monthly estimations —from January 1995 to December 2018, subsequently transformed into annual averages— of the real effective exchange rate taken from the BIS database (2021). Table 1 provides a summary of significant exchange rate volatility specifications for each country in the sample. The GARCH (1.1) structure is the most common, with the exponential generalized conditional heteroscedasticity (EGARCH) (0.1) model[2] being used in some cases. For the autoregressive (AR) aspect of the estimations, the AR(2) structure was the most common.

Table 1

Countries in the sample (54 countries):[a] estimations of real effective exchange rate volatility in the autoregressive conditional heteroscedasticity model and the generalized autoregressive conditional heteroscedasticity model, 1995–2018

Country	Models selected	Country	Models selected
Algeria	AR(2), GARCH (2.2)	Latvia	AR(2), GARCH(1.2)
Argentina	AR(1), ARCH(1)	Lithuania	AR(3), ARCH(1)
Australia	AR(3), ARCH(2)	Luxembourg	AR(2), GARCH(1.3)
Austria	AR(3), GARCH(1.4)	Malaysia	AR(2), GARCH(1.1)
Belgium	AR(2), GARCH(1.4)	Malta	AR(1), GARCH(1.2)
Brazil	AR(3), ARCH(1)	Mexico	AR(3), GARCH(2.1)
Bulgaria	AR(4), ARCH(1)	Netherlands (Kingdom of the)	AR(3), GARCH(1.1)
Canada	AR(2), GARCH(1.1)	New Zealand	AR(2), GARCH(2.1)
Chile	AR(2), ARCH(2)	Norway	AR(3), GARCH(3.1)
China	AR(2), GARCH(1.1)	Peru	AR(2), GARCH(0.3)
Colombia	AR(2), GARCH(1.2)	Philippines	AR(3), GARCH(1.3)
Croatia	AR(2), GARCH(1.2)	Poland	AR(2), GARCH(1.1)
Cyprus	AR(1), GARCH(1.3)	Portugal	AR(3), GARCH(1.1)
Czechia	AR(2), ARCH(2)	Republic of Korea	AR(2), GARCH(1.1)
Denmark	AR(3), GARCH(0.2)	Romania	AR(3), ARCH(2)
Estonia	AR(4), MA(2), GARCH(1.1)	Russian Federation	AR(3), GARCH(1.1)
Finland	AR(2), GARCH(0.1)	Saudi Arabia	AR(3), GARCH(0.2)
France	AR(2), GARCH(1.2)	Singapore	AR(3), GARCH(0.2)
Germany	AR(2), EGARCH(0.1)	Slovakia	AR(2), GARCH(1.1)
Greece	AR(3), GARCH(1.2)	Slovenia	AR(3), GARCH(2.2)
Hungary	AR(2), GARCH(1.1)	South Africa	AR(2), ARCH(2)
Iceland	AR(3), GARCH(1.3)	Spain	AR(3), EGARCH(0.1)
India	AR(2), GARCH(1.2)	Sweden	AR(3), GARCH(1.3)
Indonesia	AR(2), GARCH(2.1)	Switzerland	AR(2), GARCH(1.3)
Ireland	AR(2), GARCH(1.1)	Thailand	AR(2), GARCH(2.1)
Israel	AR(3), GARCH(1.1)	Türkiye	AR(3), GARCH(1.1)
Italy	AR(3), GARCH(1.2)	United Kingdom	AR(1), GARCH(2.1)
Japan	AR(2), GARCH(2.1)	United States	AR(3), GARCH(1.0)

Source: Prepared by the authors on the basis of estimates made using the EViews software.
[a] Owing to limited data availability for certain variables in some countries, the models were estimated using data from 54 countries.

[1] See Engle (1982) for a more detailed explanation of the equations.
[2] A structure that considers an exponential specification.

The second explanatory variable of interest is institutional quality, which is aimed at capturing the potential positive effect of the presence of better, more effective institutions on the process of productive sophistication. The measure used to calibrate institutional quality is governance, which, according to the World Bank (2021), consists of the traditions and institutions by which authority in a country is exercised. This includes the process by which governments are selected, monitored and replaced; the capacity of the government to effectively formulate and implement sound policies; and the respect of citizens and the State for the institutions that govern economic and social interactions among them. On the basis of that concept, the World Bank developed the worldwide governance indicators, prepared using a large research data set summarizing the views on governance quality of a significant number of businesses, individuals and experts interviewed in various countries. One of the strengths of the indicators is its multitude of data sources, obtained from various research institutes, study groups, non-governmental organizations, international organizations and private enterprises.

The end product of the world governance indicators consists of the six dimensions of governance, three of which were chosen for the purposes of this study: government effectiveness, regulatory quality and control of corruption. The indicators are assigned a value from 0 to 100; values closer to 100 indicate that agents have a better perception of institutional quality in the country in question. The three institutional dimensions are defined as follows:

(i) Government effectiveness (Efigob) captures perceptions of the quality of public services, the degree of government independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.

(ii) Regulatory quality (Qalireg) captures perceptions of the ability of the government to formulate and implement sound policies and regulations that promote private sector development.

(iii) Control of corruption (Corrup) captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the State by elites and private interests.

The control variables of the estimations reflect characteristics of the countries included in the sample, as shown in table 2. Industrial employment as a share of total employment (*Emp*) is used to estimate the skill level of the workforce. It is assumed that industrial activities are more complex and require a more skilled workforce than resource-based activities, and thus are a source of capacities for the sophistication of the productive structure. GDP per capita (*GDP*) is used to control for the size of the economy, since wealthier (developed) economies tend to develop more sophisticated productive structures. Lastly, a variable was created for the interaction between real effective exchange rate volatility and GDP per capita (*Volat*GDP*), with a view to estimating whether the potential negative effects of exchange rate volatility on economic complexity remain the same when combined with the size of the economy. The purpose of this variable is to capture the possibility that the size of the economy (*GDP*) acts as a buffer to the effects of exchange rate volatility, since the variable checks whether more advanced economies with more complex productive and export structures are less sensitive to exchange rate volatility.

Table 2
Summary of the variables

Variable	Definition and unit	Source	Expected sign
ECI	Economic complexity index (normalized range from -2.5 to +2.5)	Observatory of Economic Complexity	Dependent variable
Volatreal	Estimated using the ARCH and GARCH models	Bank for International Settlements Prepared by the authors	Negative
Efigob	Perception of government effectiveness (index, 0–100)	World Bank	Positive
Qalireg	Perception of government regulatory quality (index, 0–100)	World Bank	Positive
Corrup	Perception of "capture" of the State (index, 0–100)	World Bank	Positive
Emp	Industrial employment as a share of total employment (%)	United Nations Educational, Scientific and Cultural Organization	Positive
GDP	GDP per capita (in dollars at purchasing power parity)	Organisation for Economic Co-operation and Development (OECD), OECD.Stat database	Positive
*Volat*GDP*	Interaction between exchange rate volatility and the country's GDP per capita	Prepared by the authors	Negative

Source: Prepared by the authors.

The autoregressive distributed lag-pooled mean model approach developed by Pesaran, Shin and Smith (2001) is used to specify some versions of the model with the variables that will be observed for the short- and long-run effects. The general equation for the model is:

$$\begin{aligned}\Delta(ICE)_{it} = \alpha + \alpha_1 T + \beta_1 (Volatreal)_{it-1} + \beta_2 (Efigob)_{it-1} + \beta_3 (Qalireg)_{it-1} + \beta_4 (Corrup)_{it-1} + \\ \beta_5 (Emp)_{it-1} + \beta_6 (GDP)_{it-1} + \beta_7 (Volat*GDP)_{it-1} + \sum\nolimits_{j=}^{p} \beta_8 \Delta(ICE)_{it-j} + \sum\nolimits_{j=}^{q} \beta_9 \Delta(Volatreal)_{it-j} + \\ + \sum\nolimits_{j=}^{r} \beta_{10} \Delta(Efigob)_{it-j} + \sum\nolimits_{j=}^{r} \beta_{11} \Delta(Qalireg)_{it-j} + \sum\nolimits_{j=}^{r} \beta_{12} \Delta(Corrup)_{it-j} + \sum\nolimits_{j=}^{r} \beta_{13} \Delta(Emp)_{it-j} + \\ \sum\nolimits_{j=}^{r} \beta_{14} \Delta(GDP)_{it-j} + \sum\nolimits_{j=}^{r} \beta_{15} \Delta(Volat*GDP)_{it-j} + \varepsilon_t\end{aligned} \tag{7}$$

Two models with two distinct data sets were estimated. The first model includes the 54 countries included in the sample (see annex 1) in order to determine whether, regardless of export profile, the channels of real exchange rate volatility and institutional capacity act as an obstacle to increasing economic complexity. For the second model, the sample was reduced to 31 countries, using the classification of the technical structure of exports developed by Lall (2000), and only considers countries whose export baskets include primary products or resource-based manufactures among their main exports (by value and amount). The aim is to estimate whether the effect of the above-mentioned channels is stronger in countries with resource-intensive (specialized) export profiles.

IV. Results

Before estimating the coefficients of the models specified in this article, we verified the order of integration of the variables used via panel unit root tests: the Levin, Lin, Chu (2002) (LLC) test; the Im, Pesaran, Shin (2003) (IPS) test; and the second-generation cross-sectionally augmented IPS (CIPS) test of Pesaran (2007). The assumption of the LLC test is that there is no heterogeneity in the autoregression parameter; the IPS test allows for heterogeneity; and the CIPS unit (safer) relaxes the assumption of cross-sectional independence of the contemporary correlation. For all the tests, the presumed null hypothesis is non-stationarity. The lag longitude was selected using the Bayesian-Schwarz information criterion. The tests are relevant to avoid the use of series with an order of integration other than I(0) and I(1). Table 3 shows the results of the tests conducted and confirms that the series are appropriate for the application of the proposed method.

Table 3
Unit root tests

	Levin-Lin-Chu	Im-Pesaran-Shin	Fisher based on the augmented Dickey-Fuller test	Fisher based on the Phillips-Perron test	Decision
ECI	-2.60095	-3.90199	182.450	367.266	Stationary
	[0.0046]	[0.0000]	[0.0000]	[0.0000]	
Volatreal	1.3E+13	-72.9635	619.748	2 384.57	Stationary
	[1.000]	[0.0000]	[0.0000]	[0.000]	
Efigob	-1.71789	-0.60183	111.093	143.584	Non-stationary
	[0.0429]	[0.2736]	[0.3998]	[0.0125]	
Qalireg	-2.07570	1.50555	-121.718	112.790	Non-stationary
	[0.0190]	[0.0661]	[0.1732]	[0.3570]	
Corrup	3.67000	-4.29350	173.373	259.611	Stationary
	[0.0001]	[0.0000]	[0.0001]	[0.0000]	
Emp	-4.35443	0.97351	94.1031	115.765	Non-stationary
	[0.0000]	[0.8349]	[0.8273]	[0.2873]	
GDP	-1.58756	-0.36763	115.245	62.7850	Non-stationary
	[0.052]	[0.3566]	[0.2989]	[0.9998]	
*Volat*GDP*	4.54606	-2.77007	176.765	693.457	Stationary
	[1.000]	[0.0028]	[0.000]	[0.000]	

Source: Prepared by the authors from Eviews estimations.

We then estimated the panel data cointegration tests using the Pedroni (1996) cointegration test. The Engle and Granger (1987) cointegration test is based on an examination of the residuals of a spurious regression performed using I(1) variables. If the variables are cointegrated, the residuals will be I(0); otherwise, they will be I(1). Pedroni (1999) extends the Engle and Granger structure to panel data tests and proposes various cointegration tests that allow for cross-sectional heterogenous intercepts and trend coefficients. We considered the following regression:

$$y_{it} = \alpha_{it} + \beta_1 x_{1it} + \beta_2 x_{2it} + \ldots + \beta_m x_{mit} + \mu_i + \varepsilon_{it} \tag{8}$$

where y, x are variables I(1) by supposition; t is the number of time series observations (t = 1, 2, …, T); i is the number of individual members of the panel (i = 1, 2, ..., N); m is the number of variables (m = 1, 2, ..., M); α_i refers to individual effects, which can be zero, and the parameters β_{1i}, β_{2i}, …, β_{Mi}, which can vary between individuals in the panel, thus allowing for cross-sectional heterogenous intercepts and trend coefficients.

Once the equation (6) was estimated, we tested the residuals obtained to determine non-stationarity I(1), estimating the following auxiliary regression for each cross section:

$$\varepsilon_{it} = \rho_{it}\varepsilon_{it-1} + \sum_{k=1}^{k_i} \rho_{ik}\Delta(\varepsilon)_{it-k} + \mu_{it} \tag{9}$$

Pedroni (1999) sets out various methods for developing statistics that can be used to evaluate the no cointegration null hypothesis ρ_i of the residuals equation. Table 4 shows the results of the within-group and between-group statistics applied to the dimension test. In at least one of the statistics, there is cointegration in the models estimated. The results therefore suggest the existence of a long-term equilibrium relationship between the economic complexity index (ECI) variable and the other variables of the model.

Table 4
Pedroni cointegration test

	Within-group dimension			
	Full sample		Limited sample	
	Statistic	Probability	Statistic	Probability
Panel difference statistic	-3.86011	0.9999	-1.57100	0.9419
Spearman's rho panel statistic	1.28747	0.9010	0.596040	0.7244
Phillips-Perron panel statistic	-22.8909	0.0000	-16.7327	0.0000
Augmented Dickey-Fuller panel statistic	-6.39406	0.0000	-4.42804	0.0000
	Between-group dimension			
	Full sample		Limited sample	
	Statistic	Probability	Statistic	Probability
Spearman's rho group statistic	5.256928	1.0000	4.590222	1.0000
Phillips-Perron group statistic	-25.5421	0.0000	-12.0269	0.0000
Augmented Dickey-Fuller group statistic	-3.75944	0.0001	-2.287785	0.0111

Source: Prepared by the authors on the basis of estimations made using the EViews program.
Note: Null hypothesis = without cointegration.

It should be noted that each model estimated had six different specifications, since the inclusion of variables indicating institutional quality (*Corrup, Efigob* and *Qualireg*) require an entry in separate equations. On the other hand, the *Volatreal* and *Volat*GDP* variables show a strong correlation. Specification I estimates the individual impact of real effective exchange rate volatility on the economic complexity index (ECI), while specifications II, III and IV include variables representing institutional quality. Specification V estimates the combined impact of real exchange rate volatility and the *Corrup* variable, chosen as a relevant indicator of institutional quality.[3] Specification VI measures the impact of real effective exchange rate volatility weighted by the size of the economy. All the specifications are controlled for the share of industrial employment in total employment (*Emp*) and for per capita GDP (*GDP*).

Tables 5 and 6 present the results of estimations of long-term coefficients and short-term error correction mechanisms for the full sample of countries and the limited sample, respectively.

Table 5
Full sample of countries (54 countries): long-term coefficients and error correction mechanisms (economic complexity index: dependent variable)

	I	II	III	IV	V	VI
Volatreal	-0.62044* (0.104816)				-1.658784* (0.356341)	
*Volat*GDP*						7.45E-08* (2.56E-08)
Efigob		0.572263* (0.069690)				
Qalireg			0.302528* (0.54688)			
Corrup				0.929427* (0.189260)	4.514914* (0.277563)	2.027227* (0.371823)

[3] The corruption indicator (Corrup) was selected because it delivered higher coefficients in specifications II, III and IV than the other two institutional quality indicators.

	I	II	III	IV	V	VI
Emp	0.044591* (0.011649)	0.032211* (0.011143)	0.009835* (0.003583)	0.079156* (0.018869)	0.202313* (0.031321)	0.377927* (0.050036)
GDP	0.000142* (1.88E-05)	0.173294* (0.056501)	0.475174* (0.015681)	0.513363* (0.069407)	0.057164 (0.182238)	
Lags (autoregressive distributed lag model)	[3.3.3.3]	[1.1.1.1]	[1.1.1.1]	[1.2.2.2]	[2.3.3.3.3]	[3.3.3.3]
Maximum lags	3	3	2	2	3	3
Error correction mechanism	-0.950710*	-0.558718*	-0.588747*	-0.502039*	-0.583062*	-0.519300*

Source: Prepared by the authors on the basis of estimations made using the EViews program.
Note: (*) (**) (***) indicate a 1%, 5% and 10% statistical significance, respectively.
Standard errors in parentheses.

Table 6

Sample of natural resource-based countries (31 countries): long-term coefficients and error correction mechanisms (economic complexity index: dependent variable)

	I	II	III	IV	V	VI
Volatreal	-0.672304* (0.083911)				-1.064955* (0.129651)	
*Volat*GDP*						-2.97E-08 (7.30E-08)
Efigob		1.274437* (0.030780)				
Qalireg			1.957057* (0.381055)			
Corrup				2.255231* (0.130677)	1.849103* (0.162510)	1.322799* (0.040086)
Emp	0.037319* (0.008119)	0.005587 (0.004871)	0.817803* (0.104212)	0.023298* (0.009404)	0.02627*** (0.014601)	0.077149* (0.001134)
GDP	0.147418* (0.036810)	0.469344* (0.016139)	3.322076* (0.597010)	0.562788* (0.058004)	0.034373 (0.067016)	
Lags (autoregressive distributed lag model)	[1.4.4.4]	[3.3.3.3]	[2.3.3.3]	[1.4.4.4]	[1.3.3.3.3]	[3.3.3.3]
Maximum lags	4	3	3	4	4	3
Error correction mechanism	-0.615942*	-0.568397*	-0.423875*	-0.538091*	-0.446305*	-0.797330*

Source: Prepared by the authors on the basis of estimates made using the EViews program.
Note: (*) (**) (***) indicate a 1%, 5% and 10% statistical significance, respectively.
Standard errors in parentheses.

The first channel analysed is the behaviour of real effective exchange rate volatility, which shows that the directions and magnitudes of the *Volatreal* variable are similar in both specifications: when the model is estimated without distinction as to export profile (see table 5), and when the sample is restricted to countries with commodity-intensive natural resource-based economies (see table 6). The variable presents the negative sign expected in the specifications in which it is included (I and V), which suggests that high exchange rate volatility hinders an increase in the degree of sophistication of the economy, and also denotes larger magnitudes when combined with the *Corrup* institutional quality indicator in version V.

Consequently, in keeping with the hypothesis set out in this work and the tests presented in the literature —such as in Oreiro, D'Agostini and Gala (2020), Hooy, Baharumshah and R. Brooks (2016), and Thorbecke (2008)— it is reasonable to consider that exchange rate instability creates a context of uncertainty with regard to the proper implementation of structural change mechanisms, thus discouraging the development of industrial sectors and more sophisticated products with higher technological and knowledge content.

This reinforces the process of productive specialization in commodities and natural resource-intensive goods, as Gabriel and Míssio (2017) argue, since the product space is limited to the production of less sophisticated goods. In line with the premise defended by Hidalgo and Hausmann (2009), the greater the similarity and proximity between products, in terms of their comparative advantages, in a country's productive fabric, the greater the possibilities of occurrence of a process of sophistication of the production structure. This is because the basic requisite capabilities are already available locally, which facilitates the expansion and development of other similar activities requiring similar capabilities (product space). Consequently, a context of real exchange rate volatility, which discourages the development of products with higher technological content, may prevent the subsequent diversification of products and sectors with a similar level of sophistication in the productive fabric, such that the production structure would remain focused on low value-added production.

The second channel examined —institutional quality— has a positive correlation with economic complexity: in both the full sample of countries (see table 5) and the limited sample (see table 6), there is a strong relationship between higher-quality institutions and more complex production structures. Hence, countries with institutions that are more efficient in the implementation of their economic policies, in the regulation of the economy to allow for greater stability and, above all, the adoption of effective mechanisms for combating and controlling corruption tend to develop more sophisticated products and sectors. This result is consistent with the test results obtained in the works of Zhu and others (2010) and Vu (2021), which emphasize that higher-quality institutions promote knowledge accumulation, entrepreneurship and innovative capabilities that help to raise the technological content of the product space and drive productive sophistication.

The other control variables employed delivered the positive signals expected. The share of industrial production in total employment (*Emp*) reveals a positive and statistically significant relationship with the economic complexity index (*ECI*) indicator; this shows the relevance of the level of qualification of the labour force for the development of more complex activities. Per capita GDP (*GDP*) also has a positive and statistically significant relationship with ECI, which suggests that the size of the economy (more developed economies) is relevant in the export profile sophistication process. The results of the variable of the interaction between real effective exchange rate volatility and per capita GDP volatility (*Volat*GDP*), to capture the effects of volatility weighted by size of the economy, were not of much interpretative value.

With regard to the short term, the error correction mechanism (ECM) coefficients of the different specifications were negative and statistically significant. ECM refers to the speed at which the estimated model returns to long-term equilibrium. Specification I of the model of the full sample of countries (see table 5) shows a very rapid speed of adjustment to long-term equilibrium (95.07%), which means that a little more than one year is required for the variables to return to equilibrium. In the remaining specifications, which involve structural variables (institutions), the adjustment speed was slower, around 55%, which indicates that it takes an average of almost two years for recovery from short-term shocks.

In the model based on the restricted sample of countries with natural resource-based economies, the speed of adjustment to long-term equilibrium in specification I was relatively slower than that of the full sample (61.59%), which indicates that almost two years are required for the variables to return to long-term equilibrium. This suggests that countries with that export profile have more difficulties dealing with the effects of shocks in real effective exchange rate volatility. The other specifications presented similar speeds of adjustment, also around 55%.

V. Concluding remarks

The aim of this article was to ascertain whether the two channels of transmission of the natural resource curse —real exchange rate volatility and institutional quality—which have harmful effects relating to the link between specialization in commodities and low long-term economic growth potential, may have a negative impact on a country's capability to achieve greater economic complexity, especially in countries with an export profile dominated by commodities and natural resource-based manufactures. The empirical strategy used to achieve that objective was based on long-term estimations with a sample of 54 countries combined with a model of cointegration with a panel structure.

The study estimated two models. The first model, which included the full sample of 54 countries, was designed to determine whether a heterogenous group of export profiles, real exchange rate volatility and institutional quality indicators prevent a country's economic complexity from rising. The second model restricted the sample to 31 countries, using Lall's (2000) classification of exports by technological intensity , and therefore included only countries specializing in the export of commodities or natural resource-based manufactures.

The results obtained confirm the hypothesis of this article, that real exchange rate volatility can hinder the implementation of structural measures designed to diversify and sophisticate the productive fabric of an economy. As suggested by the hypothesis, supported by empirical tests extracted from the literature, there is a factor limiting productive diversification in countries that suffer from exchange rate instability, especially those whose productive structure is based on natural resources and which are more sensitive to the long-term negative effects of the channels of transmission of the natural resource curse. Thus, the trend towards regressive specialization in natural resources, based on comparative advantages, may accelerate in a context in which instability, associated with risks and uncertainties, obstructs the transfer, development and co-export of related activities, including when domestic skills and capabilities are potentially inherent. Furthermore, this situation worsens in a scenario where diversified activities with higher technological (sophisticated) content and possibly exclusive activities (non-ubiquitous) may be prevented from succeeding because of a given country's inability to address the unfavourable effects of exchange rate instability. Further research on this hypothesis, focusing on the effects on more sophisticated activities, is needed to complement the results presented in this study.

The results also confirm that institutional quality has a positive relationship with economic complexity, showing that higher-quality institutions offer greater opportunities for the development of local skills, which could translate in the future into products with higher added value and a more sophisticated and diversified export profile. Institutions that are more efficient, more credible and less beholden to private interests may be more active at the time of adoption of measures and guidelines not only to address the effect of economic instability, but also to create an enabling environment for diversification and sophistication. It is presumed, therefore, that some good institutions have sufficient and effective mechanisms for domestic activities and capabilities to be stimulated and turned into a more complex production structure, to be able to benefit from their favourable effects on economic growth in the long term.

It is clear, therefore, that there is strong complementarity between the economic complexity approach and the theory of the natural resource curse. While the natural resource curse and its empirical tests demonstrate the significant long-term negative impact of an export profile dominated by natural resources and especially affected by conditioning channels, the economic complexity methodology reaffirms that concern by showing the need for the productive fabric of the country or region to be diversified and sophisticated. Furthermore, like the natural resource curse, the economic complexity analysis shows the negative effects of maintaining a low-complexity productive structure on long-term economic growth since, as suggested by the literature, countries capable of moving toward nodes and conglomerates representing more sophisticated activities in the product space tend to converge toward a long-term growth trajectory. In other words, the nature of the activity in which the country specializes or diversifies is important for its long-term trajectory.

The opportunity thus emerges for a future research agenda based on two synchronous approaches: the measurement of similarities within the product space and the feasibility of developing potential local capabilities, while identifying and establishing the requisite mechanisms for avoiding obstacles so as to escape the low-complexity trap.

Bibliography

Asteriou, D., K. Pilbeam and C. E. Pratiwi (2021), "Public debt and economic growth: panel data evidence for Asian countries", *Journal of Economics and Finance*, vol. 45, No. 2, April.

Avom, D., B. Kamguia and J. P. Ngameni (2021), "Does volatility hinder economic complexity?", *Economics Bulletin*, vol. 41, No. 3.

Baltagi, B. H. (2005), *Econometric Analysis of Panel Data*, New York, John Wiley & Sons.

BIS (Bank for International Settlements) (2021), "Effective exchange rates" [online] https://www.bis.org/statistics/eer.htm?m=6%7C381%7C676 [accessed on 15 May 2021].

Bollerslev, T. (1986), "Generalized autoregressive conditional heteroskedasticity, *Journal of Econometrics*, vol. 31, No. 3, April.

Bresser-Pereira, L. C. (2009), "A doença holandesa", *Globalização e Competição: por que alguns países emergentes têm sucesso e outros não*, Rio de Janeiro, Elsevier.

Corden, W. M. and J. P. Neary (1982), "Booming sector and de-industrialisation in a small open economy", *The Economic Journal*, vol. 92, December.

Eichengreen, B. (2008), "The real exchange rate and economic growth", *Working Paper*, No. 4, Washington, D.C., World Bank.

Engle, R. F. (1982), "Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation", *Econometrica*, 50, No. 4, July.

Engle, R. F. and C. W. J. Granger (1987), "Co-integration and error correction: representation, estimation, and testing", *Econometrica*, vol. 55, No. 2, March.

Frankel, J. A. (2010), "The natural resource curse: a survey", *Working Paper*, No. 15836, National Bureau of Economic Research (NBER).

Gabriel, L. F. and F. J. Missio (2017), "Real exchange rate and economic complexity in a North-South structuralist BoPG model", *Anais do X Encontro Internacional da Associação Keynesiana Brasileira*, Brasilia, Brazilian Keynesian Association.

Hidalgo, C. A. and others (2007), "The product space conditions the development of nations", *Science*, vol. 317, No. 5837, July.

Hidalgo, C. A. and R. Hausmann (2009), "The building blocks of economic complexity", *PNAS*, vol. 106, No. 26, June.

Hooy, C., A. Z. Baharumshah and R. D. Brooks (2016), "The effect of exchange rate volatility on the nexus of technology sophistication and trade fragmentation of ASEAN5 exports to China", *Journal of Asia-Pacific Business*, vol. 17, No. 3.

Im, K. S., M. H. Pesaran and Y. Shin (2003), "Testing for unit roots in heterogeneous panels", *Journal of Econometrics*, vol. 115, No. 1, July.

Johansen, S. (1991), "Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models", *Econometrica*, vol. 59, No. 6, November.

Jun, B. and others (2020), "Bilateral relatedness: knowledge diffusion and the evolution of bilateral trade", *Journal of Evolutionary Economics*, vol. 30, September.

Kaldor, N. A. (1957), "A model of economic growth", *The Economic Journal*, vol. 67, No. 268, December.

Krugman, P. R. (1994), "A model of innovation, technology transfer, and the world distribution of income", *Rethinking International Trade*, Cambridge, The MIT Press.

Lall, S. (2000), "The technological structure and performance of developing country manufactured exports, 1985-1998", *QEH Working Paper Series*, No. 44, University of Oxford.

Levin, A., C. Lin and C. J. Chu (2002), "Unit root tests in panel data: asymptotic and finite-sample properties", *Journal of Econometrics*, vol. 108, No. 1, May.

Mehlum, H., K. Moene and R. Torvik (2006), "Institutions and the resource curse", *The Economic Journal*, vol. 116, No. 508, January.

OEC (Observatory of Economic Complexity) (2021), *"Methods"* [online] https://oec.world/en/resources/methods [accessed on 14 May 2021].

Oreiro, J. L. and C. A. Feijó (2010), "Desindustrialização: conceituação, causas, efeitos e o caso brasileiro", *Revista de Economia Política*, vol. 30, No. 2, June.

Oreiro, J. L., L. L. M. D'Agostini and P. Gala (2020), "Deindustrialization, economic complexity and exchange rate overvaluation: the case of Brazil (1998-2017)", *PSL Quarterly Review*, 73, No. 295, December.

Pedroni, P. (1999), “Critical values for cointegration tests in heterogeneous panels with multiple regressors”, *Oxford Bulletin of Economics and Statistics*, vol. 61, No. S1, November.

___(1996), “Fully modified OLS for heterogeneous cointegrated panels and the case of purchasing power parity”, *Working Paper*, No. 96-020, Indiana University.

Pereira, H. C. I. and F. J. Missio (2019), “Exchange rate and structural change: evidences for Latin America”, paper presented at the forty-seventh National Meeting on Economics, São Paulo, 10–13 December.

Pesaran, M. H. (2007), “A simple panel unit root test in the presence of cross-section dependence”, *Journal of Applied Econometrics*, vol. 22, No. 2, March.

Pesaran, M. H. and Y. Shin (1999), “An autoregressive distributed-lag modelling approach to cointegration analysis”, *Econometrics and Economic Theory in the 20th Century: The Ragnar Frisch Centennial Symposium*, S. Strom (ed.), Cambridge University Press.

Pesaran, M. H., Y. Shin and R. J. Smith (2001), “Bounds testing approaches to the analysis of level relationships”, *Journal of Applied Econometrics*, vol. 16, No. 3, May–June.

Pesaran, M. H., Y. Shin and R. P. Smith (1999), “Pooled mean group estimation of dynamic heterogeneous panels”, *Journal of the American Statistical Association*, vol. 94, No. 446, June.

Razin, O. and S. M. Collins (1997), “Real exchange rate misalignments and growth”, *Working Paper*, No. 6174, National Bureau of Economic Research (NBER).

Robinson, J. A., R. Torvik and T. Verdier (2006), “Political foundations of the resource curse”, *Journal of Development Economics*, vol. 79, No. 2, April.

Rodrik, D. (2009), “Growth after the crisis”, *Working Paper*, No. 65, Washington, D.C., World Bank.

Sachs, J. D. and A. M. Warner (1997), “Natural resource abundance and economic growth”, Harvard Institute for International Development [online] https://www.earth.columbia.edu/sitefiles/file/about/director/documents/NaturalResourceAbundanceandEconomicDevelopmentwithWarner-1997.pdf.

_____ (1995), “Natural resource abundance and economic growth”, *Working Paper*, No. 5398, National Bureau of Economic Research (NBER).

Tang, H. C. (2014), “Exchange rate volatility and intra-Asia trade: evidence by type of goods”, *The World Economy*, vol. 37, No. 2, February.

Taylor, S. J. (1986), *Modelling Financial Time Series*, New York, John Wiley & Sons.

Thirlwall, A. P. (1979), “The balance of payments constraint as an explanation of international growth rate differences”, *Banca Nazionale del Lavoro Quarterly Review*, vol. 32, No. 128.

Thorbecke, W. (2008), “The effect of exchange rate volatility on fragmentation in East Asia: evidence from the electronics industry”, *Journal of the Japanese and International Economies*, vol. 22, No. 4, December.

Van der Ploeg, F. (2011), “Natural resources: curse or blessing?”, *Journal of Economic Literature*, vol. 42, No. 2, June.

Vieira, F. V. and A. O. Damasceno (2016), “Desalinhamento cambial, volatilidade cambial e crescimento econômico: uma análise para a economia brasileira (1995-2011)”, *Revista de Economia Política*, vol. 36, No. 4, October–December.

Vu, T. V. (2021), “Does institutional quality foster economic complexity?”, *MPRA Paper*, No. 108354, Munich Personal RePEc Archive (MPRA).

World Bank (2021), “Worldwide governance indicators”, DataBank [online] https://databank.worldbank.org/source/worldwide-governance-indicators [accessed on 20 June 2021].

Zhu, S. and others (2010), “What drives the export sophistication of countries”, *Journal of World Economy*, vol. 4.

Annex 1

Table A1.1
Characteristics of the export profiles of the countries included in the full sample, 2019

Country	Primary products	Resource-based manufactures	Low-technology manufactures	Medium-technology manufactures	High-technology manufactures
Algeria	X	X			
Argentina		X			
Australia	X	X			
Austria				X	X
Belgium				X	X
Brazil	X	X			
Bulgaria		X			
Canada		X		X	X
Chile	X				
China				X	X
Colombia	X	X			
Croatia		X			X
Cyprus		X			X
Czechia				X	X
Denmark				X	X
Estonia				X	X
Finland		X		X	X
France				X	X
Germany				X	X
Greece		X		X	
Hungary				X	X
India		X	X	X	
Indonesia	X	X	X		
Ireland				X	X
Israel		X			X
Italy		X			X
Japan				X	X
Latvia		X			X
Lithuania		X	X		
Malaysia		X			X
Mexico	X				X
Netherlands (Kingdom of the)		X			X
New Zealand		X			
Norway		X			
Peru	X	X			
Philippines					X
Poland				X	
Portugal			X	X	
Republic of Korea				X	X
Romania				X	
Russian Federation	X	X			
Saudi Arabia	X	X			
Singapore				X	X
Slovakia				X	X
Slovenia				X	X
South Africa	X	X			
Spain		X			X
Sweden				X	X
Switzerland		X			X
Thailand			X	X	X
Türkiye			X	X	X
United Arab Emirates	X	X	X		X
United Kingdom	X				X
United States	X	X		X	X

Source: Prepared by the authors using data from the Observatory of Economic Complexity (OEC) and the classification developed by S. Lall, “The technological structure and performance of developing country manufactured exports, 1985–1998”, *QEH Working Paper Series*, N° 44, University of Oxford, 2000.