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Economic complexity, exports and natural resources in the Gulf Cooperation Council

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Abstract

The concept of economic complexity, introduced by Hidalgo and Hausmann (2009), suggests that countries' knowledge and capabilities can be inferred through their ability to export a wide range of products relative to the rest of the world. The associated Economic Complexity Index (ECI) has since grown in popularity as a way of predicting countries' economic growth, income inequality, and human development, among other outcomes. However, the applicability of this concept across different contexts has remained unquestioned. We argue that the unique characteristics of natural resource dependent countries are largely disregarded. Using the ECI for 179 countries from 1995 to 2019, we focus on the case of the Gulf Cooperation Council countries (GCCs), generally considered as high-income economies heavily reliant on oil and natural gas exports. While we find that the link between the ECI and subsequent economic growth observed across countries holds for the GCC and other oil-dependent countries, our analysis exposes important ways in which the ECI is affected by the high dependence on oil and its price volatility. Contrary to existing literature, we found no association between economic complexity and economic growth within countries over time. Our analysis calls for more caution when relying on economic complexity measures for policy-making and highlights the need for additional and more granular analysis of different contexts, particularly those heavily reliant on natural resources.

Keywords: Economic Complexity Index, Economic Growth, Natural Resources, Oil-dependency, GCC

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1 Introduction

The concept of economic complexity, as introduced by Hidalgo and Hausmann (2009), argues that countries' knowledge and capabilities can be inferred from their ability to export products that are rare relative to the rest of the world. The associated Economic Complexity Index (ECI) has since grown in popularity as a way of predicting countries' economic growth, income inequality, human development, and other macroeconomic outcomes (Hidalgo, 2021). The link between economic complexity and income growth has been presented as a universal empirical regularity and as a key reason to support such indicators (e.g., Hausmann et al., 2014). However, the applicability of this concept across different contexts has remained largely unquestioned, with research applying it with limited consideration of wider socioeconomic and development context. In this paper we argue that, once we consider countries that rely disproportionately on natural resources, the ECI method and conceptualisation can become problematic.

In a review of the literature from the past decade, Hidalgo (2021) argues that the strong predictive power of the ECI in explaining long-term economic growth suggests that a country's complexity level pins an equilibrium income level (i.e., countries will converge towards a certain income level predicted by their complexity, thus the link between the initial ECI and subsequent growth). He further maintains that the direction of this relationship is from economic complexity to income growth, rather than the opposite, and that it would be somewhat improbable that countries with relatively low complexity given their income – such as Qatar, Oman, Bahrain and Kuwait, among others (Hidalgo, 2021: 15-16) – will increase their complexity in the future. The implication of this argument is that these economies would grow less than others with similar GDP per capita, reverting to a lower 'equilibrium' income level in line with their ECI.

In parallel, Canh et al. (2020) estimate that economic complexity has a significant negative impact on total natural resource rents, and argue that focusing on improving economic complexity could help lessen the dependence on natural resource wealth. They find a strong negative relationship between the ECI and natural resource rents for upper-middle- and high-income countries – the latter group including Kuwait, Qatar, Saudi Arabia and the United Arab Emirates (UAE) together with other economies that do not rely on natural resource exports. Canh et al.'s (2020) results, however, may be biased by pooling together very different countries and then estimating an average effect, because of reverse causality between natural resource rents and economic complexity, and by the fact that the analysis did not include oil revenues.

More generally, economic complexity studies tend to disregard the specific context and unique characteristics of natural-resource dependent countries. Important questions remain over whether the complexity concept and method can be meaningfully interpreted in all contexts, or rather should remain as a 'big picture' empirical regularity that should not be relied upon for finer-grained and specific analyses aimed to inform policy-making. Thus, to address these questions, this paper explores the applicability and usefulness of economic complexity in oil-dependent countries, with a focus on the Gulf Cooperation Council (GCCs) region.

Using data from the Observatory of Economic Complexity (OEC) for the period from 1995 to 2019, we calculate the ECI for 179 countries and look at how it evolves over time across the GCCs, as well as where the GCCs stand in the correlations between the ECI and different key variables, such as income and industrial structure. We carry out regression analysis to assess whether and how the relationship between ECI and income growth differs for the GCCs vis-a-vis the rest of the sample, and explore whether the ECI can be meaningfully applied to this context. To better understand the impact of oil and natural gas products on the ECI measures for the GCCs, we calculate the ECI excluding these products and investigate how this impacts economic complexity and its implications in contexts of high dependence on oil and natural gas.

Focusing on growth over 20-, 10- and 5-year periods between 2000 and 2019, we find that the positive cross-country association between the ECI and subsequent economic growth observed in the literature holds for the GCC and other oil-dependent economies. Nevertheless, the ECI is not able to explain changes in income over time within countries, and is affected in different ways by oil and natural gas exports, suggesting caution and further consideration of context specificity when applying economic complexity measures.

The remainder of this paper is organised as follows. Section 2 provides a literature review, focused on the natural resource curse and economic complexity. Section 3 describes our research aims and motivation, and provides a detailed discussion about the research context, the GCCs, followed by a description of the data and methodology in Section 4. Section 5 outlines the results, focusing firstly on exploring the economic complexity measures, for countries and products separately, and secondly on the empirical estimation results. Section 6 provides further analysis, where we exclude oil and natural gas products from the ECI calculation. Section 7 discusses our finding and conclusions.

2 Economic development, complexity, and the resource curse

2.1 The natural resource curse

Economists such as Rostow (1961) initially argued that natural resources could be a blessing, allowing in particular developing countries to make a transition to industrial take-off, as had happened in the UK, US and Australia (Rosser, 2009; Badeeb et al., 2017). Natural resources, on the one hand, only need to be extracted, rather than produced, and therefore can occur somewhat independently of other economic changes and with limited employment creation; on the other hand, they are non-renewable and thus they should be seen more like an asset than a source of income (Humphreys et al., 2007; Badeeb et al., 2017). These assets can then finance higher levels of public and private consumption, including public goods such as infrastructure (Sachs, 2007), thus leading to the idea of a potential 'blessing' of natural resources.

While positive views were held until the 1980s, researchers started increasingly noting the lack of economic growth and worse development outcomes in Africa and Middle East countries that were rich in natural resources, and the idea of the 'Dutch disease' emerged (Corden & Neary, 1982; Corden, 1984; Neary & van Wijnbergen, 1986) – a phenomenon named after the discovery of natural gas in Groningen, which led to de-industrialisation and poorer macroeconomic performance in the Netherlands. In parallel, Gelb (1988) found that oil economies experienced more serious deterioration in the efficiency of their domestic capital formation during the boom period in the 1970s. The first use of the term “resource curse” is attributed to Auty (1993) who, along with Gelb (1988), stressed the volatile nature of revenues from minerals.

The first empirical paper was by Sachs and Warner (1995) and showed that economic dependence on oil and mineral resources was correlated with slow economic growth in a cross section of countries. Further cross-sectional studies by Sachs and Warner (1999, 2001) confirmed the adverse effects of natural resource dependence on economic growth. Following this, researchers turned their attention to the potential channels through which the resource curse operates. In terms of economic mechanisms, the literature points to Dutch disease, volatility of commodity prices, failures of economic policy, including the neglect of education, as the key drivers; with regards to political mechanisms, rent seeking, weak institutions and corruption tend to be indicated as the culprits.

Natural resource revenues have a significant impact on the economic structure of a country, particularly when they make up a large share of exports (Venables, 2016). The Dutch disease occurs when the discovery or boom of natural resources leads to an increase in income and demand, which in turn generates inflation and a real exchange rate appreciation, making the relative prices of non-resource commodities higher and leading to lower competitiveness in world markets, ultimately also receiving lower investment (Sachs & Warner, 1995; Gylfason, 2001; Frankel, 2010; Badeeb et al., 2017). This can lead to a crowding out of the manufacturing sector, which often needs government intervention in the form of industrial policy, in particular to incentivise important ‘learning by doing’ mechanisms (Frankel, 2012). Overall, in the presence of natural resources it is likely that the focus will be on current spending rather than long-term investment (Venables, 2016).

The prices of commodities such as oil and other resources are highly volatile, creating high uncertainty in measuring expected revenues, ultimately hampering planning for economic development (Badeeb et al., 2017). This volatility is in large part due to short-run elasticities of natural resources – for any given increase in price, demand does not fall much in the short-run and supply does not rise significantly in short term either (Frankel, 2010, 2012). Volatile revenues harm innovation especially in contexts of weak financial development, leading to exchange rate volatility; on the political side, this can lead to shortsighted policy making, by inducing a false sense of security (Van der Ploeg & Poelhekke, 2009). Thus, although a positive direct effect of resources on growth is often found, the indirect effect through volatility is negative and often dominant (Van der Ploeg and Poelhekke, 2009).

Natural resources also create economic challenges related to economic mismanagement and the incentive structure created by the presence of natural resources– e.g., resource abundance reduces pressure on the government to collect taxes and exert fiscal discipline, and it can also lower incentives for human capital accumulation due to high levels of non-wage income or resource-based wages (Badeeb et al., 2017). Gylfason (2001) and Gylfason and Zoega (2006) focused their attention on broader channels through which natural resource dependence could be affecting sustained economic growth including savings, investment and human capital formation.

On the political side, rent seeking caused by a windfall of resource revenue can lead to increased power of elites, triggering very high inequalities (e.g., Gylfason, 2001), and to money being spent to the benefit of elites' immediate circles, rather than invested in infrastructure or development (Badeeb et al., 2017). Moreover, these revenues may also become a main cause for conflict between different stakeholders, including politicians, citizens and local communities (Davis & Tilton, 2005; Sala-i-Martin & Subramanian, 2013; Bodea et al., 2016). Valuable extractive resources such as oil, which do not require substantial labour and capital inputs (compared to, for instance, production), make factions more likely to fight over them (Frankel, 2012).

Further to this, corruption and institutional quality have been extensively researched in natural resource curse contexts and the evidence is mixed, and likely highly context-dependent. The quality of institutions is among the most hypothesised channels through which natural resources may influence long-run economic growth. On the one hand, quality of institutions is seen as a potential mediating factor in turning natural resources either into a curse or a blessing – in the presence of good quality institutions, countries may be able to invest their resource rents in ways that help development; on the other hand, natural resources and their large rents can cause a deterioration in institutional quality (e.g., through the creation of conflict, rent seeking or eliminating the need for taxation and government restraint, among others).

More recently, questions have emerged over the validity of the natural resource curse. The main reasons fall across three broad areas: first, concerns about the empirical strategies used in early papers; second, questioning of the time sensitivity of findings; and third, researchers have started to distinguish between abundance and dependence measures and argued the conclusions for each of these aspects and implications diverge.[1]

In terms of empirical evidence relating to the GCC countries or broader geographical areas, Apergis and Payne (2014) look at the oil curse and growth in Middle East and North Africa (MENA) countries between 1990 and 2013. Their long-run results for the resource-rich labour-abundant countries support the hypothesis of an oil curse throughout the entire period, whereas for the resource rich labour-importing group, which includes the GCCs, the oil reserves coefficient is positive beyond 2003 to the end of the period: they argue that institutional conditions over time played a significant role in mitigating the adverse effects of an oil curse. Exploring the case of 30 oil rich countries for the 1992-2005 period, Bjorvatn et al. (2012) find that the association between oil rents and income per capita varies with the balance of political power – oil rents are less likely to have a positive effect on GDP in countries with a high fractionalisation. Overall, although there is no general consensus, it seems that the natural resource curse is not inevitable as some countries have managed to avoid such outcomes. Instead, as Badeeb et al. (2017) argue, it is not resource abundance per se that causes the resource curse, but rather how the revenues are managed and the extent of the reliance on

[1] See available comprehensive surveys of the literature (e.g., Frankel, 2010; Van der Ploeg, 2011; Badeeb et al., 2017; Venables, 2016) for more detailed evidence.

such revenues.

Countries such as the GCCs have often turned to diversification in an attempt to limit resource revenues becoming the sole economic activity and source of income; resource revenues can be used for investments such as human capital, public infrastructure, as well as targeting different sectors specifically (Venables, 2016). This can involve promoting sectors with backward linkages with the resource sector, for instance promoting the use of local inputs – an example of this are internationally competitive national resource companies like Saudi Aramco – or forward linkages which involves processing further the natural resource prior to export or for local use, as well as supporting investment in sectors that are not directly linked with natural resources (Venables, 2016). Despite these efforts, failures to successfully diversify are common.

2.2 Economic complexity and natural resources

Hidalgo and Hausmann (2009) introduced the ECI concept and measure as a way of quantifying countries' productive structures and showed that it was a good predictor of future growth. Since then, a vast number of empirical papers have emerged. On the one hand, several papers look at the links between economic complexity and different outcomes, including: economic growth (Poncet & Starosta de Waldemar, 2013; Hausmann et al., 2014; Stojkoski et al., 2016; Tacchella et al., 2018), income inequality (Hartmann et al., 2017; Lee & Vu, 2020), greenhouse gas emissions (Can & Gozgor, 2017; Neagu & Teodoru, 2019), and natural resource rents (Canh et al., 2020). On the other hand, research has started to explore the apparent drivers of economic complexity, looking at variables such as: institutions (Vu, 2019), modes of taxation (Lapatinas et al., 2019), intellectual property rights (Sweet & Maggio, 2015), demographics (Bahar et al., 2020; Vu, 2020), digital connectivity (Lapatinas, 2019), and structural reforms (Demir, 2019).

The link between economic complexity and natural resources is a complex one. The ECI calculation includes all goods, including natural resources, which might make up a very large share of exports in some countries, as is the case of the GCCs. As a result, natural resources are likely to impact firstly the ECI calculations themselves and, secondly, the link between the ECI and economic growth or development.

The intuitive description of the methodology used in the ECI in the Atlas of Economic Complexity by Hausmann et al. (2014) refers to the example of diamonds. The ECI departs from the ubiquity – how common a product is among countries' exports – and the diversity – how many products a country exports competitively – and combines these two simple variables in an iterative process. The intuition is that a product that is exported competitively by very few countries would require a high level of capabilities (a term which the authors use to reflect pretty much anything a country might have that enables them to produce those exports, e.g., knowledge, skills, institutional settings, among others). Similarly, a country that is very diverse and able to export competitively a high number of products, is expected to have many and varied capabilities. Natural resources are an exception to this logic – as Hausmann et al. (2014) describe, diamonds are produced in very few places and thus their ubiquity is low for reasons unrelated to knowledge-intensity. The iteration of ubiquity with diversity, they argue, will help correct for this – if diamonds were complex, the countries exporting them would be able to export many other products due to the high capabilities they had from exporting diamonds, but we know that this is not the case and that the countries that export diamonds or other natural resources tend to have very limited diversity and mainly export the natural resources available to them.

Natural resource revenues play an important role in generating higher GDP levels and growth, and thus natural resource rents were included as a key control variable in regressions in Hausmann et al. (2017), who regress annualised growth in GDP per capita by decade on initial income per capita and initial ECI, controlling for the increase in net natural resource exports as a share of initial GDP. This was applied in subsequent empirical papers and the link between the ECI and GDP growth remains statistically significant when natural resource exports are included in regressions (e.g., Stojkoski et al., 2016; Hausmann et al., 2017). Among the few papers that explicitly link economic complexity and natural resources, Canh et al. (2020) investigate whether economic complexity is a solution for the resource curse. Regressing natural resource rents on the ECI and several control variables, they found that economic complexity had a statistically significant negative impact on total natural resource rents, and argued that focusing on improving complexity could help lessen dependence on natural resource wealth. The authors also split the analysis between different World Bank income classification groups and find a strong negative relationship for upper-middle- and high-income countries – the latter group combining Kuwait, Qatar, Saudi Arabia and the UAE together with other economies that have long moved away from relying on natural resource exports.

More recently, Yalta and Yalta (2021) consider the determinants of economic complexity in MENA, using a panel of 12 countries between 1970-2015. They regress the ECI on key variables – GDP per capita, capital stock, education, FDI, institutions and natural resources – and find that education plays an important positive role in explaining ECI, while a strong negative effect of natural resource rents on economic complexity is interpreted in support for the resource curse hypothesis. Moreover, they explore the interaction between natural resources and education and find that the marginal effect of natural resource rents depends on human capital accumulation. Avom et al. (2022) also investigate the effect of natural resources on economic complexity, focusing on the interaction between political regime type and complexity, and find that democratic government can help mitigate the negative effects of natural resource abundance (Avom et al., 2022), stressing once again to the importance of the governance of natural resources.

Tabash et al. (2022) link economic growth with natural resources and economic complexity, focusing on 24 African countries, and find a negative association between natural resource rents and economic growth and a positive one between economic complexity and growth. While discussing policy implications, the authors argue that "economic analysts from the African region should consider the option of economic complexity as a remedy for low economic growth" (Tabash et al., 2022, p.7).

While these are important initial contributions towards our understanding of the link between economic complexity, natural resources and economic growth, they leave important issues unaddressed. First, results may be affected by pooling together countries with very differentiated economic and productive structures. Second, these papers all consider varying models – with natural resource rents, the ECI and GDP as dependent variables, and some combination of the ECI and natural resources as the independent variables – without much discussion about reverse causality between natural resource rents and economic complexity. Third, oil revenues are not always considered as such, and the impact that abundance or dependence natural resources could have on ECI calculations is not sufficiently explored.

3 Research aims and context

3.1 Research aims

The link between economic complexity and economic growth estimated in the literature is seen as a general law, and proponents argue that it is the key reason behind the importance of economic complexity indicators (e.g., Hausmann et al., 2014). Yet, the GCCs have unique economic and political contexts. The aim of our research is to analyse the applicability of the ECI concept and measure to this group of countries. In particular, we investigate whether the link between economic complexity and income growth differs for the GCCs, and for oil-dependent countries more broadly. This will also help us understand to what extent policy implications can be derived from the ECI concept and measure in the GCCs and oil-dependent economies more generally.

Theoretically, there are three broad hypotheses on the link between economic complexity and natural resource dependence. First, economic complexity could be viewed as an explanation or 'driver' of the natural resource curse – i.e., countries that can increase their economic complexity levels manage to break away from dependence on natural resource rents (Canh et al., 2020). Second, the ECI might simply capture over-dependence on natural resources in some countries – for instance, by reflecting their lack of knowledge and capabilities needed to export more diverse and complex products (as implied in Hidalgo and Hausmann, 2009, and Hausmann et al., 2017, and in line with the findings by Yalta and Yalta, 2021). Third, the ECI might not be adequate as a concept in countries that are heavily reliant on natural resources, as it might simply reflect too strongly the fluctuations in commodity prices, which are highly volatile. Furthermore, there is a question of how the ECI is affected by changes in demand and prices of natural resource exports (i.e., volume of exports versus their monetary value), given the ECI reliance on export data.

The first hypothesis is theoretically problematic, not least because of the potential reverse causality between the ECI and natural resources. The second hypothesis is plausible: indeed, the ECI tends to be overly punishing towards high income economies with high shares of natural resource exports – an often-cited example is Australia, which has an advanced knowledge economy focused on services, but whose exports involve a lot of natural resources. However, we argue that this hypothesis is incomplete, as it overlooks the potential issues that natural resource volatility can have for ECI calculations over time. The third hypothesis, that the ECI is inadequate in contexts of high natural resource reliance, is therefore a plausible one, and it has not been explored in existing literature.

Importantly, the ECI in itself cannot predict a natural resource curse. While having a low ECI might indicate that current or initial productive structure is not very sophisticated and moving into more complex products may be hard, a natural resource-based country might still be able to investment in education and innovation and manage to increase both economic complexity and income, transforming dependence into a resource 'blessing' since, as discussed in Section 2.1, the resource curse does not appear to be inevitable.

3.2 Research context: GCC countries

Although the broad discussions in the paper are applicable to other oil-dependent countries, there are several reasons why we focus on GCC countries. First, all six countries have very high shares of oil and natural gas exports, ranging from 45% of merchandise exports in Bahrain and 88% in Qatar in 2019. Second, they are all classified as high-income countries by the World Bank and have roughly comparable GDP per capita levels (World Bank, 2022). Third, the GCCs share a similar geographical context and have broad similarities in terms of history and culture (Valenta & Jakobsen, 2016).

Oil and natural gas play a crucial role in the economy of the GCCs (see Appendix A1). Figure 1 shows oil and natural gas exports as a share of total merchandise exports from 1995 to 2019: these range from lower levels in Bahrain (although above 30 percent most years), to over 80 percent in Kuwait and Qatar over time.[2] The largest change occurred in the UAE, with a significant overall decrease over the period, while Bahrain saw the sharpest oscillation, with a sharp increase in 2014 due to a significant increase in oil production, followed by decreases, as in the rest of the group, due to low oil prices in those years. There was relative stability in Kuwait and Qatar, and some decline in the last decade in Oman and Saudi Arabia.

Figure 2 shows oil rents as a percentage of GDP from 1995 to 2019: significant oscillations are observed, with sharp increases and drops every five to ten years that occur with similar patterns across all countries, mimicking the business cycle. The exception is somewhat Bahrain, where oil plays a more limited role in the economy; moreover, the sharp increase in oil exports share observed in 2014 was driven by increased production and, as a result, when we look at oil rents (which account for production costs), the oscillations are not as sharp.[3]

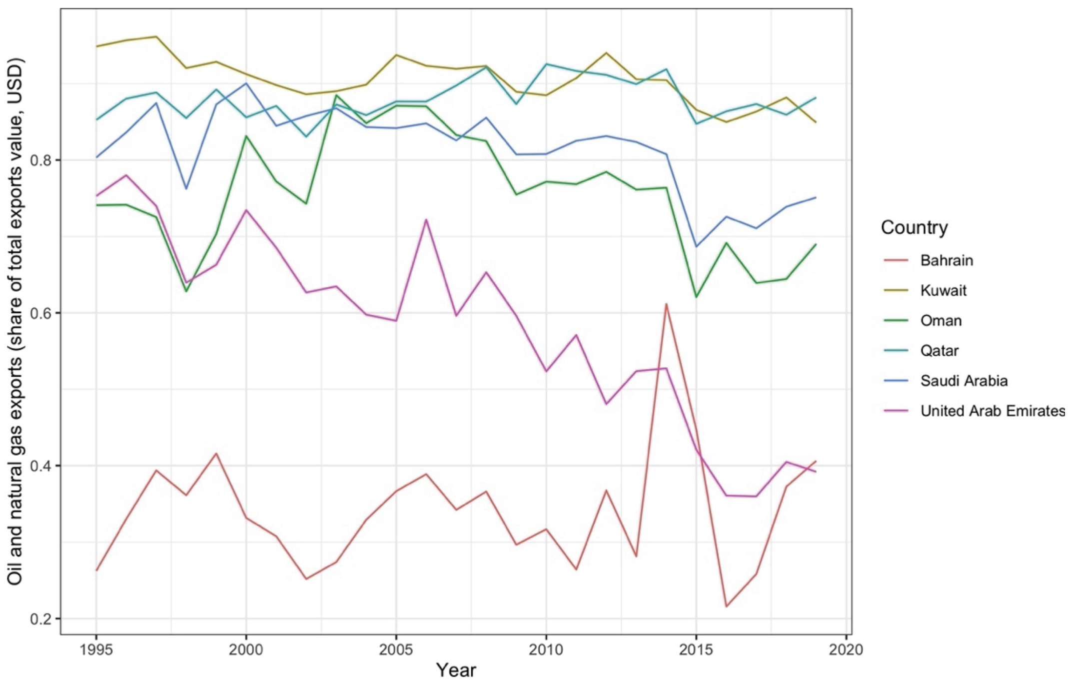
A crucial implication of such a heavy reliance of GCCs on oil and natural gas is that, as described by Beblawi (2011), oil extraction is not simply another economic activity that exists in addition to an advanced productive structure (as in the case of Canada, Australia or Scandinavian countries, for example), but it dominates the economy and is the almost exclusive

[2] Data for this figure originates from the Observatory of Economic Complexity and include oil and gas products as detailed under HS-92 four-digit level classification: Petroleum oils, crude (2709); Petroleum oils, refined (2710); Petroleum gases (2711); Petroleum jelly (2712); Petroleum coke (2713).
[3] Both oil rents and natural resource rents indicators are estimated by the World Bank. Oil rents are the difference between the value of crude oil production and total costs of production. Total natural resource rents is the sum of oil rents, natural gas rents, coal rents, mineral rents, and forest rents.

source of wealth. Importantly, the GCC area has achieved high GDP growth and ultimately high income levels through natural resource availability, though without recording much improvement in other socio-economic conditions vis-a-vis other high-income economies. GCCs, although to different extents, show limited advancement in aspects considered crucial for knowledge-based and complex economies, such as education and skills, R&D investment, general openness and overall business environment (Hvidt, 2013; Kumar & van Welsum, 2013; Arman et al., 2021a). The main explanations are connected to the existence of an 'allocation state' model, driven purely by the state, focused on wealth distribution, extensive reliance on migrant labour, and significant underdevelopment of productive assets, resulting in a failure to deliver further development (Hvidt, 2011, 2013).

As Figure 3 shows, GDP per capita has remained stable over the 1995 to 2019 period in Bahrain, Qatar and Saudi Arabia, whereas Kuwait, Oman and the UAE saw oscillations and an overall decrease: these trends result from an overall GDP increase across all GCCs, but the population grew at a higher rate.[4]

Figure 1: Oil and natural gas exports (% of total exports), GCCs, 1995-2019



[4] Figure 3 relies on data from the World Bank (see Section 4.1 below).

Figure 2: Oil rents (% of GDP), GCCs, 1995-2019

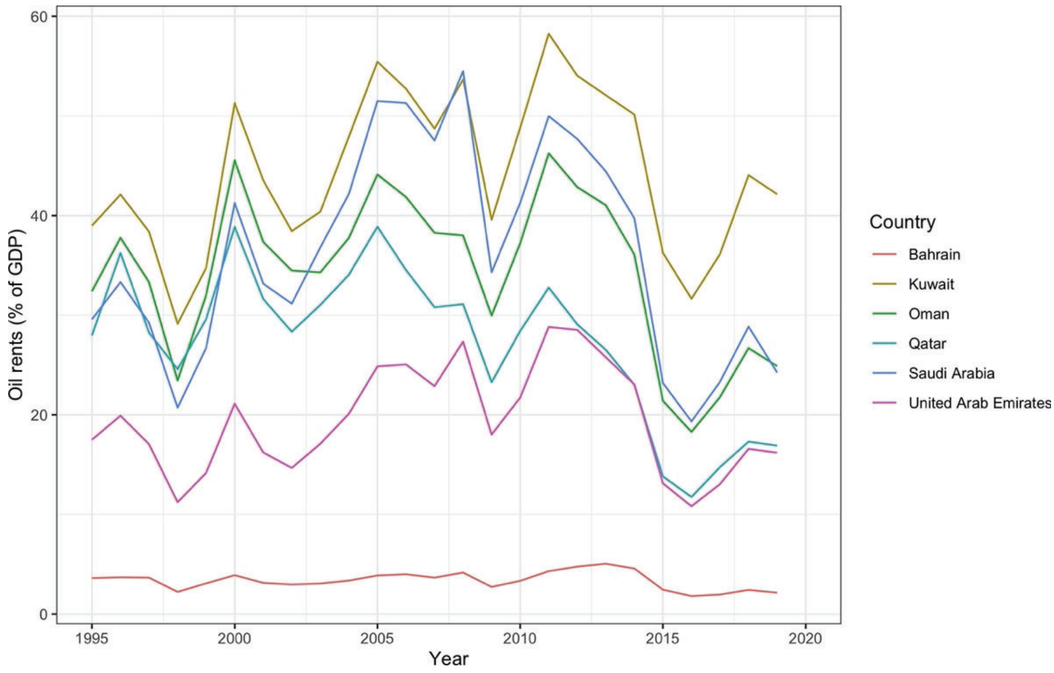
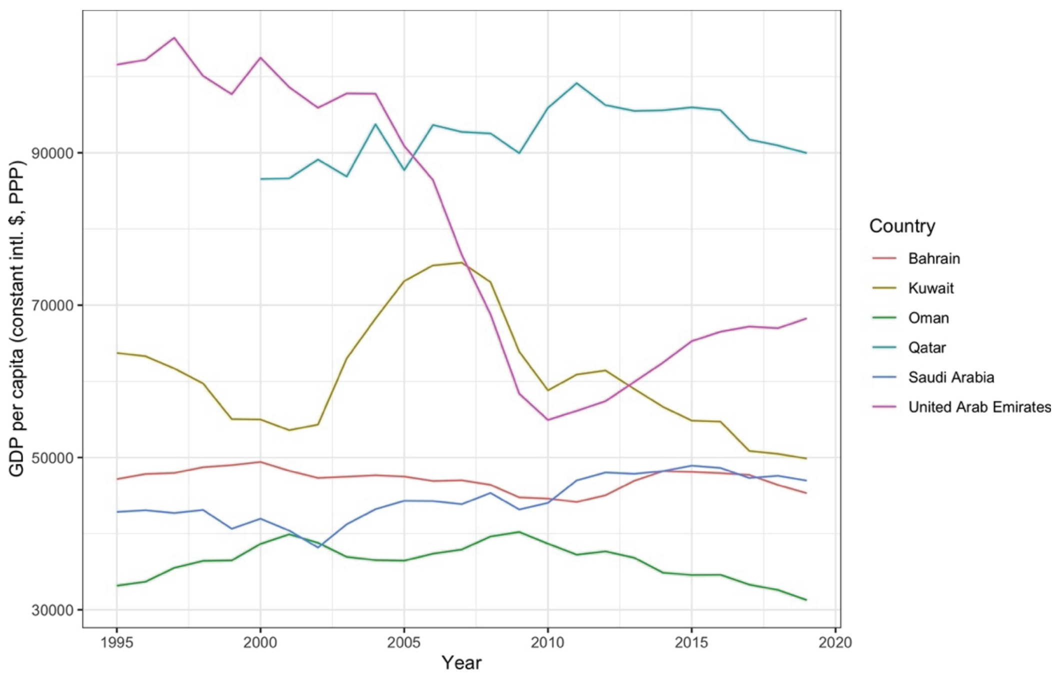


Figure 3: GDP per capita, GCCs, 1995- 2019



In addition to the reliance on oil extraction and on foreign workers, the GCCs depend extensively on the public sector to generate employment, particularly for native workers. In recent decades, all countries have tried to address this issue in their development and diversification plans, identifying the need to move away from this reality to ensure longer term sustainability, with the GCCs with more limited oil resources expressing more urgency than the others (Hvidt, 2013). Efforts to increase private sector R&D in Kuwait, Oman and Qatar have tried to address precisely the two key challenges of lack of diversification and over-reliance on the public sector (Ennis, 2015; Arman et al., 2021b). However, despite these efforts over the past few years, private sector R&D remains low in Kuwait and other GCCs, and often at levels that would be expected in much poorer economies (Arman et al., 2021b). Furthermore, all GCCs show a strong duality in the labour force, with migrant workers performing most of the technical, service and manual jobs predominantly in the private sector, and native workers mostly occupied in the public sector (Samans & Zahidi, 2017).

Turning to employment, the share in manufacturing industry increased in Qatar, Oman and to lesser extent in Bahrain in the observed period, while it remained relatively stable across the others, accounting for roughly a quarter of jobs in the GCCs, where services are by far the most important source of jobs. The decrease in service employment in Qatar, Oman and Bahrain mirrors closely the increase seen in employment in industry, while the UAE experienced a small rise, due to the diversification efforts towards services, including banking and tourism, over the past decades.[5]

Given the oil dependence, diversification has been at the forefront of economic policy in the GCCs for several decades. As described in detail by Hvidt (2013), the reasoning behind this has been twofold, with slight changes experienced over time. On the one hand, diversification away from oil is highly desirable given the limited lifespan of oil and natural gas, being this latter the main reasoning behind diversification in the 1970s (Koren & Tenreyro, 2010); in addition to the finite physical reserves, the imminent need to move towards cleaner sources of energy has merged more recently. On the other hand, diversification can be beneficial even in the presence of extensive oil reserves, as it can help alleviate the sharp oscillations generated by oil market volatility. The sharp decline in oil prices experienced in the 1980s and the volatility that persisted also throughout the 1990s shifted the focus towards this second rationale for diversification (Hvidt, 2013).

Nonetheless, the drive towards diversification has not been particularly successful, with several shortcomings and challenges outlined in existing literature. For example, considering Kuwait's transition to a knowledge economy, the lack of a systemic approach and the neglect of the institutional basis of the National Innovation System has been identified as one of the key reasons for the frequent failure of development strategies (Brinkley et al., 2012; Arman et al., 2021b).

A key aspect to consider is the measurement of diversification. While diversification can usually be measured in very simple ways across countries, it is not an easy exercise in the case of the GCCs, due to both the lack of high-quality data for some variables and the impact of changing oil prices on available variables (Hvidt, 2013). The variables that are typically applied in the case of the GCCs include: i) the percentage contribution of oil and non-oil sectors to GDP; ii) the proportion of oil revenues as a share of total government revenues; iii) the share of non-oil exports in total export earnings; iv) the relative contribution of public and private

[5] Agriculture makes up a very small share of employment across the GCC area and decreased over the time period.

sector to GDP; v) GDP volatility in relation to oil price fluctuations (Hvidt, 2013).

In this regard, economic complexity measures based on exports suffer the same issues and challenges, though this is rather disregarded in the literature, with existing contributions simply addressing this challenge by controlling for natural resources when assessing the impact of economic complexity on income growth.

Several papers investigate the validity of the export-led growth hypothesis in the GCC context (Kalaitzi & Chamberlain, 2021). Broadly speaking, these studies analyse the relationship between merchandise exports and economic growth, focusing on several GCC countries (e.g., Kalaitzi and Chamberlain, 2021), or specific ones (e.g., Kalaitzi and Cleeve, 2018; Kalaitzi and Chamberlain, 2019; Chamberlain and Kalaitzi, 2020; Kalaitzi and Chamberlain, 2020, for the UAE). The results tend to show rather disparate patterns, with Kalaitzi and Chamberlain (2021) finding differing results across GCCs, as well as different short- and long-run patterns in causality between exports and economic growth between 1975 and 2016. Overall, the volatility experienced by the GCC group is a crucial aspect: in part due to their strong dependence on oil, these economies are intrinsically more volatile than others at the same level of development (Koren and Tenreyro, 2010).

4 Data and methodology

4.1 Data

This paper uses world export data to calculate economic complexity. The data was downloaded from the OEC, based on the BACI international trade database at the product level, and we used the HS-1992 four-digit level classification.[6] The yearly ECI and PCI measures are calculated from a network with 1241 products and 179 countries, for the period from 1995 to 2019. The indicators were built using the Method of Reflections introduced by Hidalgo and Hausmann (2009), following their equations and method, and based on the RCA threshold of 1: for a detailed overview of how the ECI is measured, we refer to Technical Box 2.1 on page 24 of the Atlas of Economic Complexity (Hausmann et al., 2014).

In addition to this, in our further analysis section, we calculated the ECI based on a network that excludes the following products: Petroleum oils, crude (2709); Petroleum oils, refined (2710); Petroleum gases (2711); Petroleum jelly (2712); Petroleum coke (2713), which we use to explore the impact that these products have in complexity measures for the GCCs and other oil-dependent countries.

While we could have used the OEC or the Atlas of Economic Complexity calculations, we calculated the ECI ourselves, which provides two major advantages that allow us: 1. to work with a more stable sample of countries over time and leave out very small countries or territories; 2. not only to calculate the ECI including all products, but also to exclude oil products and explore what happens to the GCC and other oil-dependent countries.

The control variables were downloaded from the World Bank Open Data. Tables A1 and A2 in the Appendix provide GCC statistics, definitions and sources of our variables, Tables A3 to A5 provide summary statistics, while Table A6 lists the 179 countries included in our analysis.

4.2 Methodology

The objective of this paper is to explore the applicability of the ECI to the GCC countries. On the one hand, we want to investigate the ECI's internal validity for the GCC group, focusing on how economic complexity levels changed over time and what may be driving oscillations. To this end, we start by exploring how the ECI evolves from 1995 to 2000 and how it correlates with other key variables, with a focus on where the GCC countries stand vis-a-vis the other countries in the sample.

On the other hand, we want to explore external validity and look at the relationship between the ECI and economic growth, and whether it differs for this group of countries. Here, we turn to regression analysis. We replicate the common specification in the economic complexity literature, originally done by Hidalgo and Hausmann (2009) and Hausmann et al. (2014) and later by Stojkoski et al. (2016) among others, of regressing economic growth over

[6] We use the four-digit level classification as it provides enough granularity and country reporting at this level is more reliable than at the six-digit level.

long time periods on the initial income level, initial ECI and control variables capturing natural resource dependence and trade openness, and explore whether the results differ for GCC countries and oil-dependent countries more broadly. Our main specification is as follows:

$$growth_{i,t+n} = \alpha + \beta_1 ECI_{i,t} + \beta_j X_{j_{i,t}} + \eta_t + \varepsilon_{i,t}$$

where $growth_{i,t+n}$ is the GDP growth between t and $t+n$ for country i. Growth is calculated as the GDP per capita growth of country i between t and $t+n$ as $growth_{i,t+n} = \log(GDPpc_{i,t+n}/GDPpc_{i,t})$. $ECI_{i,t}$ is the initial ECI, our independent variable of interest. $X_{j_{i,t}}$ is a vector representing the control variables – in line with the existing contributions including: i) initial GDP per capita (natural logarithm) to control for convergence across countries; ii) increase in natural resource exports over the time period (as a share of initial GDP); iii) increase in total exports (as a share of initial GDP) to capture the growth in exports and show that, despite being based on exports, the predictive power of the ECI is not lost due to controlling for increases in exports over time; iv) initial ratio of exports to GDP to control for different levels of openness across countries; and v) initial population (natural logarithm). η_t and $\varepsilon_{i,t}$ represent time fixed effects and error term, respectively. The transformations of the variables used are in line with the aforementioned papers, for comparability.

Furthermore, we add a dummy variable representing whether a country is part of the GCC or not, as well as an interaction term between the GCC dummy variable and the initial ECI. This helps us understand whether the widely-cited link between ECI and future economic growth differs for the GCC countries vis-a-vis the rest of the sample.

Further to this, we perform the same regression analysis on the sample of oil-dependent countries only – identified by looking at the share of exports in oil and natural gas products in total exports over time, and selecting the countries where these products make up over 30 percent of exports on average (Table A6 in the Appendix identifies the oil-dependent countries). Overall, the aim is to understand whether and how the relationship between the ECI and income growth differs for GCC or oil-dependent countries.

We focus on the cross-country association between initial economic complexity and subsequent income growth for 20-, 10- and 5-year periods between 2000 and 2019.[7] To check for within-country association, we also estimate our model using fixed effects. This is in line with existing literature, including the original contribution by Hidalgo and Hausmann (2009) and more recent ones at the regional level e.g., by Mewes and Broekel (2020).[8] While we cannot include the GCC dummy variable and interaction term in the fixed effects estimations, we also do the analysis with the full sample and with oil-dependent countries separately. Across all models, we use and report robust standard errors, clustered at the country level, to avoid violations of the OLS assumptions.[9]

[7] We start our analysis in 2000 due to the missing GDP data for Qatar up until then. The use of averages to attenuate the impact of business cycles is common, and the time lengths used here are in line with existing literature.

[8] We also ran the Hausman test, to check whether the random effects or fixed effects estimation is the most appropriate for our data; based on the test, we rejected the null hypothesis that the difference in coefficients is not systematic, and thus the fixed effects specification is preferred.

[9] To test for autocorrelation, we ran the Wooldridge test for autocorrelation in panel data – the null hypothesis

5 Results

5.1 Exploring the data

This subsection takes a first look at the economic complexity indicators, focusing on the country-based measures and on the GCCs. For reference, the ECI ranges from around -3 to 3, with average zero. Figure 4 plots the correlations between the ECI and GDP per capita for 1995 and 2019. We see that the GCCs have lower economic complexity than expected for their income level, particularly in 1995, as Hidalgo alluded to.

Figure 5 shows the scatter plots between the ECI and oil rents (as a percentage of GDP) in 1995 and 2019 (the latest available year). In addition to the GCC group, countries with oil rents above 10% of GDP are labelled to allow for comparison. Both figures show that the GCCs are marginally more complex than other, mostly lower income, countries with similar levels of oil dependence, showing the expected negative correlation between natural resource rents and levels of complexity. Kuwait stands out, as it displays the highest level of oil rents within the GCC and, at the same time, a higher ECI than every other country with natural resource rents over 35 percent of GDP.

Turning to the evolution of economic complexity, Figure 6 shows relatively high variation in ECI values over time in GCC countries. For example, between 2010 and 2012, Kuwait saw a drop in economic complexity from a high of 0.77 to a low of −0.47, followed by a recovery and more recent rise. Other GCCs experienced similarly volatile patterns, though not as sharp. From Figure 7, showing the dynamics of economic complexity country rankings, the oscillation emerges also in terms of rankings, and does not simply reflect changes in values that are also experienced by other countries. As reflected in the lines in grey, the rest of the sample also experiences oscillations in values and ranking, with the latter remaining much more stable for countries that are at the top in terms of complexity levels.

We investigate further what may be driving the ECI fluctuations over time by looking at diversity, one of the two key variables behind the ECI measure – the total number of products that a country exports competitively relative to the rest of the world in a particular year (i.e., Balassa's (1965) Revealed Comparative Advantage index, using a threshold of 1). Figure 8 shows changes in diversity across the GCCs: there are sharp oscillations in diversity across the period, which are somewhat reflected in the ECI values and rankings, though not always perfectly aligned (e.g., Kuwait's ECI value dropped significantly from 2010 to 2011, whereas diversity only decreased in 2012). Despite Saudi Arabia showing generally the highest complexity levels among the GCCs, they are not the most diverse, with the UAE showing the highest levels of diversity throughout the period. Moreover, Kuwait and Qatar, the GCCs with the highest dependence on oil, show very low levels of diversity over the entire period – we investigate whether this might be influenced by their high dependence on oil and natural gas below.

of 'no first-order autocorrelation' was rejected at the 5% significance level, indicating the presence of serial correlation. Furthermore, due to our limited number of time periods (and larger number of countries), we clustered the standard errors. This also allows for the violation of the homoskedasticity assumption.

Figure 4: ECI and GDP per capita, 179 countries, 1995 and 2019

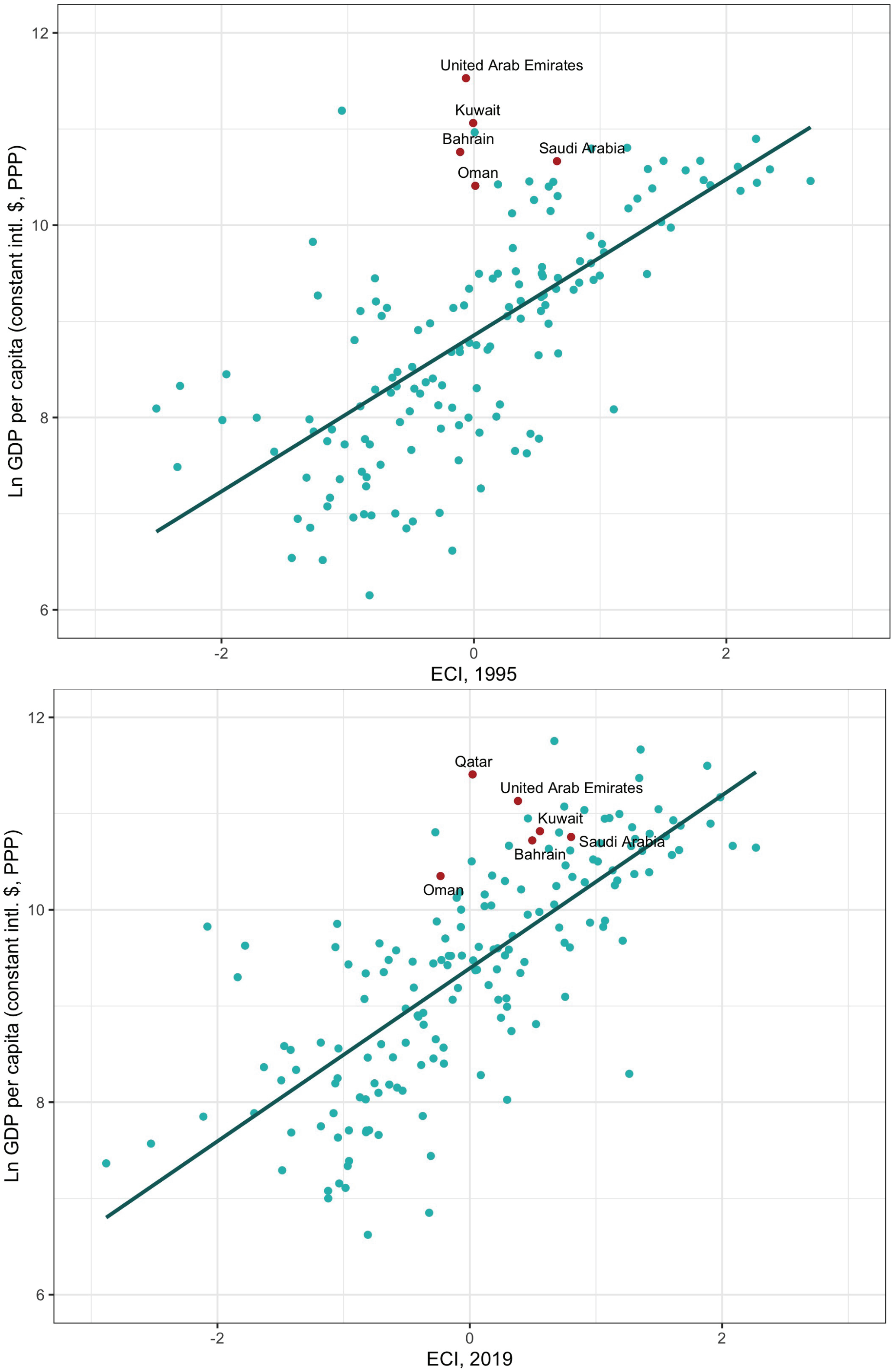


Figure 5: ECI and oil rents, 179 countries, 1995 and 2019

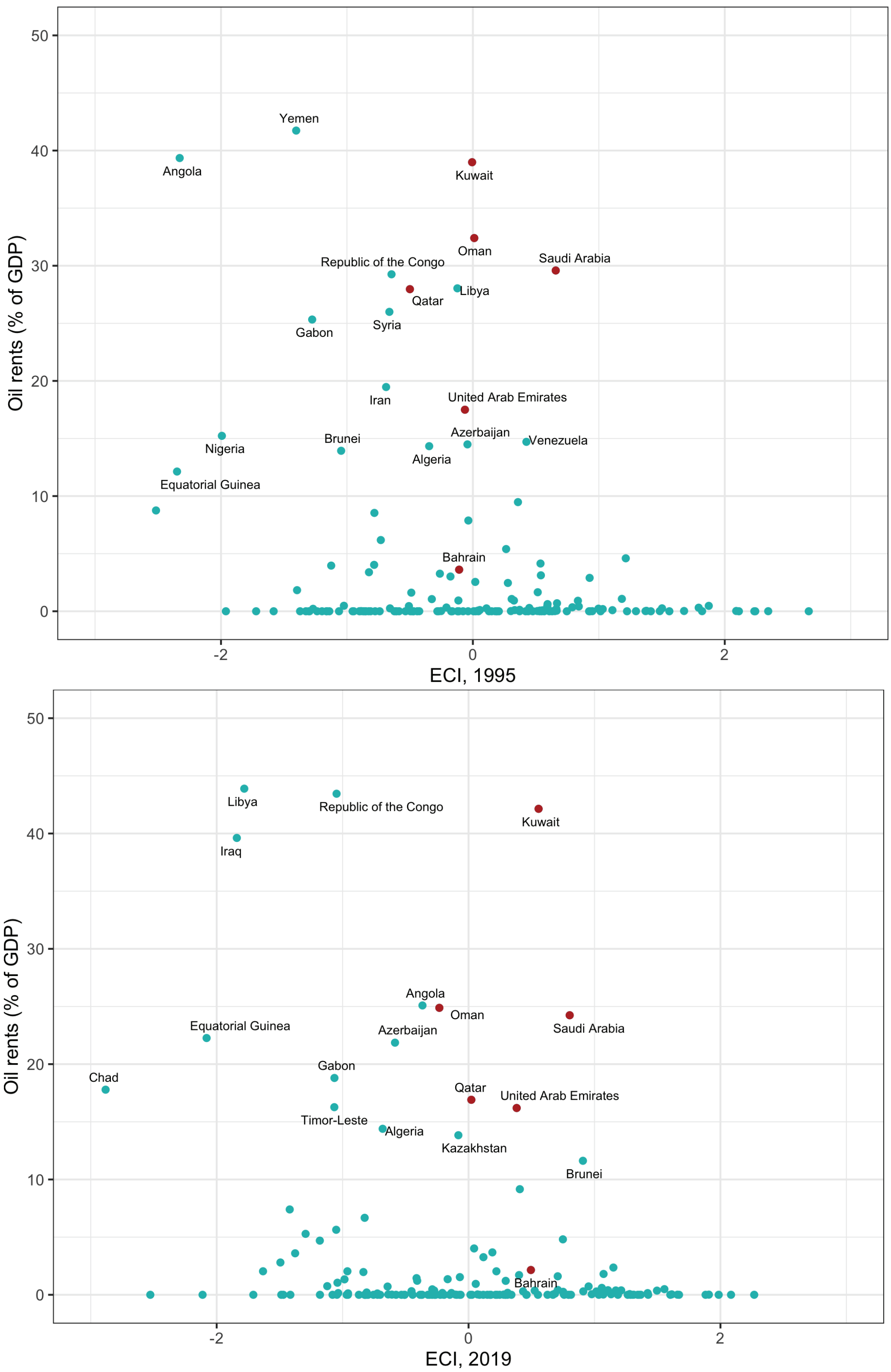


Figure 6: ECI value, 1995 to 2019, 179 countries (GCCs highlighted)

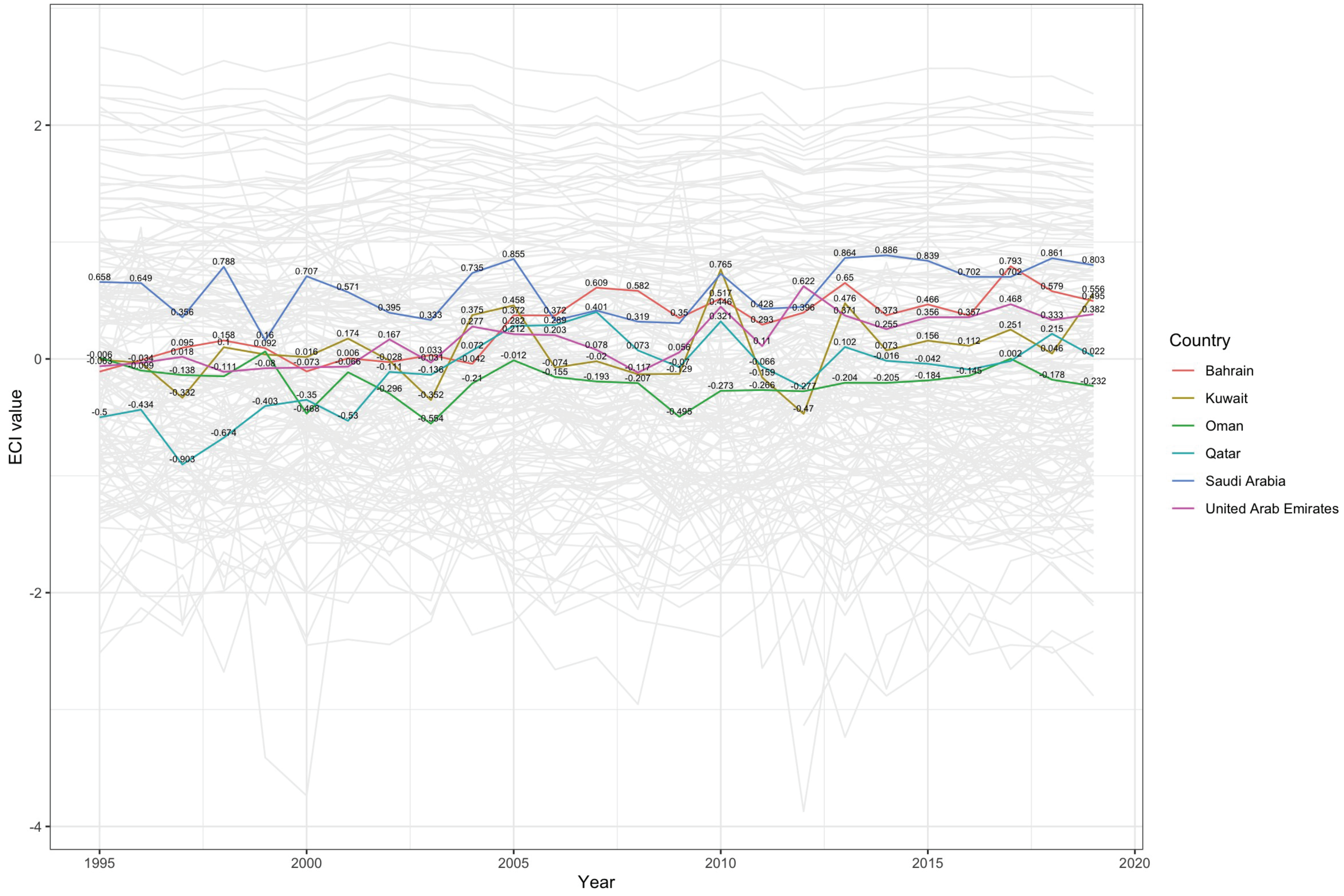


Figure 7: ECI rankings, 1995 to 2019, 179 countries (GCCs highlighted)

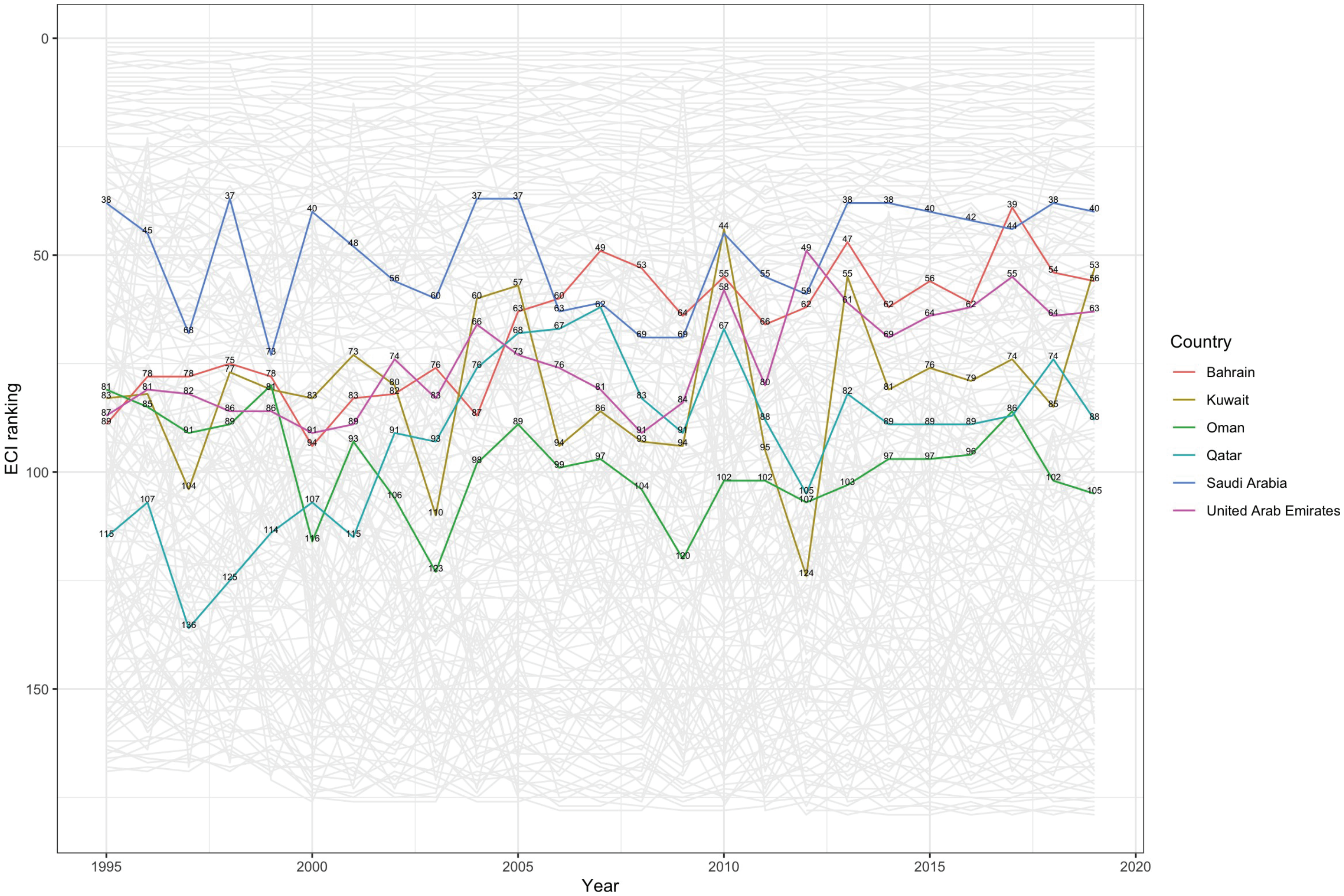
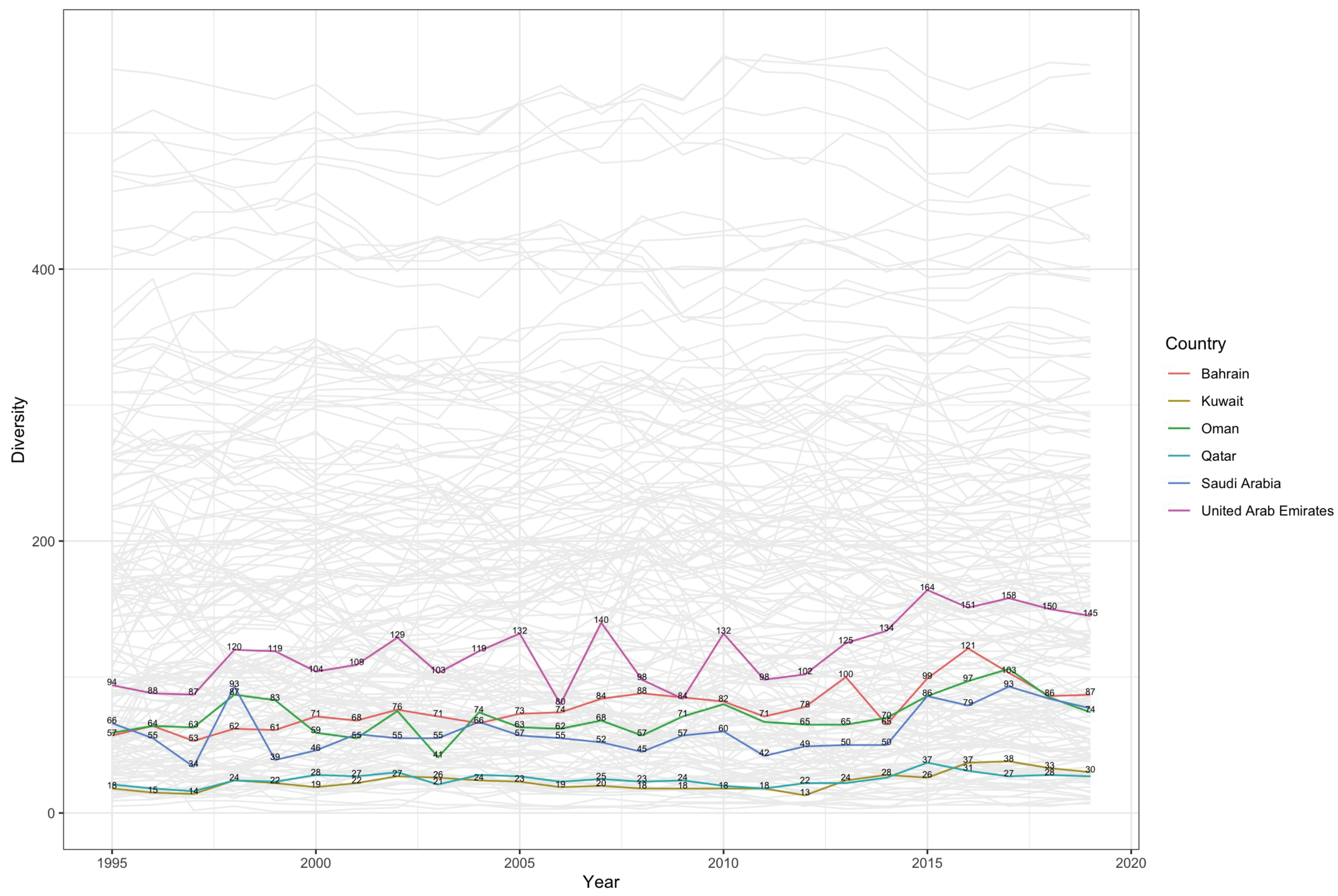


Figure 8: Diversity (number of products with $RCA > 1$), GCCs, 1995 to 2019



5.2 Empirical estimation

5.2.1 ECI and economic growth

Our starting point is to replicate the most common analysis in the economic complexity literature, of regressing economic growth on the initial ECI and income level. We do this for 20-, 10- and 5-year growth periods from 2000 to 2019. In each case, we start from the full model and, following this, explore how much of the variation in growth across countries is explained by the ECI. There were concerns over multicollinearity in selecting the control variables, particularly as several of them relate to exports: we performed a Variance Inflation Factor (VIF) test – the highest VIF was 2.44, below most of the thresholds used in the literature, with VIF for most of the variables being below 2.

Starting from the 20-year growth period, from 2000 to 2019, Table 1 presents the cross-section results, showing a positive association between the initial ECI and income growth, statistically significant across all specifications. When the ECI is removed from the model in column (5) in Table 1, there is a drop in the adjusted R-squared from 0.344 to 0.248, indicating that 9.6% of the variance in economic growth that is not accounted for by initial income and increase in exports is explained by the ECI.

With regards to the control variables, as expected there is a negative and statistically significant coefficient on initial GDP per capita across all specifications, as well as a positive coefficient on the increase in exports as a share of initial income. The other control variables – increase in natural resource exports and population – do not appear statistically significant and have a negligible impact on the overall variance explained by the model. The coefficient on the dummy variable for GCC countries is negative and significant –being a GCC country is associated with a lower GDP per capita compared to the rest of the sample – and its interaction term with the ECI is positive and statistically significant.

Turning to the 10-year growth periods, Table 2 presents the results. The first five columns show the cross-country pooled OLS estimation, following the same specifications as before, the results are aligned with those for the 20-year period, with the exception of the interaction term between the GCC dummy variable and the ECI that loses significance. The fixed effects estimation, in columns (6) and (7), analyses the association between economic complexity and income growth within countries. Unlike what found by some existing papers, our analysis shows no association between ECI and growth in GDP per capita, regardless of the control variables included in the models (this might be due to several reasons, such as the different periods, or the sample of countries included in the analysis). The coefficients for the control variables follow the same patterns as before, though in this case the increase in natural resource exports is the most dominant export-based variable.[10]

Table 3 shows regression results for the 5-year growth period, mirroring the previous

[10] To attenuate concerns over the results being driven by the 10-year periods selected, for instance due to the 2008 financial crisis, we tried alternative cut-offs; the results were in line with the ones presented here.

specifications, though in this case we report the increase in natural resource exports, as it is statistically significant and has larger coefficients than the increase in exports. The results are otherwise fully aligned with those for the 10-year period.

Overall, our results confirm a positive association between ECI and income growth across countries, but in contrast with existing research, we do not find such an association for changes within countries. The interaction term between the GCC dummy variable and the initial ECI was statistically significant only in the 20-year growth regression, suggesting that the positive association between the ECI and growth in GDP per capita does not differ for GCC countries vis-a-vis the rest of the sample, and that in the long term such an association is stronger for them.

Table 1: Economic complexity and 20-year growth in GDP per capita, full sample

	GDPpc growth (2000-2019)				
Variables	(1)	(2)	(3)	(4)	(5)
Initial ECI	0.115***	0.104***	0.117***	0.143***	
	(0.0296)	(0.0274)	(0.0279)	(0.0287)	
Initial GDPpc (log)	-0.113***	-0.105***	-0.116***	-0.150***	-0.0796***
	(0.0309)	(0.0275)	(0.0281)	(0.0282)	(0.0222)
Increase in exports (share of initial GDP)	0.119***	0.135***	0.136***	0.127***	0.113***
	(0.0289)	(0.0230)	(0.0225)	(0.0209)	(0.0203)
Increase in NR exports (share of initial GDP)	0.0438				
	(0.0464)				
Exports to GDP (initial)	0.0348				
	(0.124)				
Initial population (log)	0.0221	0.0211			
	(0.0155)	(0.0150)			
GCC	-0.419***	-0.404***	-0.408***		
	(0.0797)	(0.0775)	(0.0748)		
GCC * Initial ECI	0.245***	0.228***	0.267***		
	(0.0769)	(0.0685)	(0.0686)		
Constant	0.960**	0.915**	1.342***	1.643***	1.027***
	(0.379)	(0.367)	(0.259)	(0.258)	(0.213)
Observations	164	164	164	164	164
R-squared	0.412	0.408	0.399	0.357	0.257
Adjusted R-square	0.382	0.385	0.380	0.344	0.248

Robust standard errors in parentheses

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

Table 2: Economic complexity and 10-year growth in GDP per capita, full sample

	GDPpc growth (2000-2009 and 2010-2019)						
	Pooled OLS					Fixed Effects	
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Initial ECI	0.0509***	0.0515***	0.0583***	0.0694***		-0.0104	-0.0829
	(0.0166)	(0.0173)	(0.0175)	(0.0169)		(0.0273)	(0.0519)
Initial GDPpc (log)	-0.0542***	-0.0561***	-0.0623***	-0.0765***	-0.0385***	-0.548***	-0.767***
	(0.0165)	(0.0163)	(0.0167)	(0.0162)	(0.0108)	(0.0740)	(0.114)
Increase in exports (share of initial GDP)	0.214***	0.214***	0.213***	0.211***	0.192***	0.0398	
	(0.0452)	(0.0231)	(0.0227)	(0.0220)	(0.0242)	(0.0361)	
Increase in NR exports (share of initial GDP)	0.00652					0.171***	
	(0.0522)					(0.0469)	
Exports to GDP (initial)	-0.0353					-0.0874	
	(0.0667)					(0.0647)	
Initial population (log)	0.0128*	0.0134*				0.0788	
	(0.00730)	(0.00718)				(0.105)	
GCC	-0.202***	-0.202***	-0.207***				
	(0.0532)	(0.0519)	(0.0507)				
GCC * Initial ECI	0.145	0.140	0.152				
	(0.106)	(0.105)	(0.107)				
Constant	0.431**	0.429**	0.698***	0.819***	0.486***	3.897*	7.135***
	(0.193)	(0.192)	(0.152)	(0.147)	(0.103)	(2.033)	(1.025)
Observations	332	332	332	332	332	332	332
R-squared	0.365	0.364	0.354	0.332	0.279	0.722	0.543
Adjusted R-square	0.347	0.350	0.342	0.323	0.272	0.716	0.539
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	No	No	No	No	No	Yes	Yes

Robust standard errors in parentheses

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

Table 3: Economic complexity and 5-year growth in GDP per capita, full sample

	GDPpc growth (2000-2004, 2005-2009, 2010-2014, 2015-2019)						
	Pooled OLS					Fixed Effects	
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Initial ECI	0.0247***	0.0252***	0.0282***	0.0329***		0.00712	-0.00810
	(0.00850)	(0.00861)	(0.00882)	(0.00839)		(0.0112)	(0.0213)
Initial GDPpc (log)	-0.0253***	-0.0264***	-0.0291***	-0.0363***	-0.0176***	-0.222***	-0.321***
	(0.00799)	(0.00786)	(0.00813)	(0.00791)	(0.00490)	(0.0315)	(0.0443)
Increase in exports (share of initial GDP)	0.203***	0.195***	0.191***	0.196***	0.213***	0.115**	
	(0.0654)	(0.0564)	(0.0567)	(0.0568)	(0.0592)	(0.0567)	
Increase in NR exports (share of initial GDP)	0.241***	0.244***	0.246***	0.226***	0.162**	0.314***	
	(0.0693)	(0.0658)	(0.0666)	(0.0659)	(0.0680)	(0.0716)	
Exports to GDP (initial)	-0.0204					0.0296	
	(0.0303)					(0.0438)	
Initial population (log)	0.00496	0.00526				-0.0521	
	(0.00354)	(0.00342)				(0.0393)	
GCC	-0.102***	-0.103***	-0.105***				
	(0.0221)	(0.0223)	(0.0212)				
GCC * Initial ECI	-0.0146	-0.0149	-0.00942				
	(0.0455)	(0.0455)	(0.0470)				
Constant	0.212**	0.212**	0.320***	0.382***	0.213***	2.877***	2.990***
	(0.0898)	(0.0902)	(0.0737)	(0.0723)	(0.0467)	(0.752)	(0.401)
Observations	668	668	668	668	668	668	668
R-squared	0.318	0.317	0.312	0.287	0.251	0.470	0.230
Adjusted R-square	0.306	0.306	0.302	0.280	0.244	0.463	0.224
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	No	No	No	No	No	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5.2.2 ECI and economic growth in oil-dependent countries

We saw above that the ECI has a positive association with economic growth across countries that does not appear to differ for the case of the GCCs: here we investigate this association for oil-dependent countries: Table 4 replicates our analysis with ten-year growth periods for their subsample. The positive association between the ECI and economic growth is confirmed, in some of the specifications showing a much stronger coefficient than in the case of the full sample (along with higher adjusted R-squares). Turning to the within-country association, once again no significant association emerges between initial ECI and growth in GDP per capita: results follow the same patterns for both the 20-year and 5-year growth regressions.

Overall, and generally in line with existing research, economic complexity shows a positive association with growth in GDP per capita across the full sample, including the GCCs and oil-dependent countries alike. Nevertheless, once we look at within-country associations, we do not find a statistically significant association between the ECI and economic growth.

While the latter finding contradicts the existing literature, it is perhaps not entirely surprising, given the oscillations observed in the descriptive analysis. Furthermore, even though the association between economic complexity and economic growth is in line with the existing literature, some of our concerns are still present – from the research context, we know that the GCCs had relatively low (and in some cases negative) economic complexity levels and that they observed a decrease in GDP per capita (experiencing negative economic growth, though due to rising population) over the period. Thus, overall, questions remain on the limitations of the ECI concept and measure in the GCCs and other oil-dependent countries. The next section explores this question further, by looking at the links between economic complexity and oil and natural gas dependence.

Table 4: Economic complexity and 10-year growth in GDP per capita, oil-dependent countries

	GDPpc growth (2000-2009 and 2010-2019)						
	Pooled OLS					Fixed Effects	
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Initial ECI	0.119***	0.113***	0.116***	0.118***		0.0110	-0.111
	(0.0302)	(0.0289)	(0.0321)	(0.0340)		(0.0529)	(0.0859)
Initial GDPpc (log)	-0.104**	-0.104**	-0.119***	-0.145***	-0.0988***	-0.655***	-1.161***
	(0.0500)	(0.0412)	(0.0415)	(0.0368)	(0.0260)	(0.132)	(0.164)
Increase in exports (share of initial GDP)	-0.135	0.215***	0.207***	0.207***	0.182***	0.0475	
	(0.301)	(0.0311)	(0.0265)	(0.0269)	(0.0291)	(0.477)	
Increase in NR exports (share of initial GDP)	0.368					0.146	
	(0.312)					(0.514)	
Exports to GDP (initial)	0.0178					-0.221*	
	(0.185)					(0.111)	
Initial population (log)	0.0263	0.0248				0.223*	
	(0.0158)	(0.0177)				(0.111)	
GCC	-0.0891	-0.113*	-0.126*				
	(0.0695)	(0.0637)	(0.0632)				
GCC * Initial ECI	0.0817	0.101	0.133				
	(0.108)	(0.108)	(0.107)				
Constant	0.725	0.730	1.266***	1.483***	1.001***	2.808	11.04***
	(0.589)	(0.589)	(0.395)	(0.361)	(0.250)	(2.421)	(1.511)
Observations	60	60	60	60	60	60	60
R-squared	0.674	0.667	0.655	0.641	0.547	0.907	0.804
Adjusted R-square	0.615	0.622	0.616	0.615	0.523	0.894	0.794
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	No	No	No	No	No	Yes	Yes

Robust standard errors in parentheses

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

6 Further analysis – ECI and oil dependence

To explore the impact that oil and natural gas products have in complexity measures for the GCC countries, we constructed an alternative measure, based on a network that excludes oil and natural gas products.

The ECI is based on a binary matrix of countries and products, based on RCA calculations, taking the threshold of 1.[11] In the RCA calculation itself, total exports enter twice in the denominator. Since oil and related products make up a very large share of these countries' exports, when there is an increase in the value of those exports (which could be caused by both an increase in export volume or simply in the oil price), the denominator will increase a lot and it will become harder for countries to achieve a threshold of 1 in the RCA, leading to a decrease in diversity, and ultimately to a lower ECI. Thus, removing the five key oil and natural gas products from the ECI calculations allows us to investigate what happens to ECI levels and changes over time in the GCC countries, as well as to explore the correlations with other key variables.

Figure 9 shows ECI values over time, mirroring the previous plots. Here, we see that the GCCs tend to show higher levels of ECI on average and that, while there are still some oscillations, they are not as sharp as they were before, particularly if we look at the examples of Kuwait and Saudi Arabia (whereas Qatar, for example, still experiences significant fluctuations); rankings (not shown here) follow the same patterns.

In addition, Figure 10 plots diversity calculated from the network excluding oil products over time for the GCCs. As we are simply looking at the number of products in which countries are competitive, based on the $RCA \geq 1$ cut-off, and given the mechanism outlined above, there are sharp differences between this plot and our original one, as expected. Diversity is higher overall across all GCCs. While the UAE displays again the highest diversity, Kuwait is no longer at the bottom of this group (and is much further away from the bottom vis-a-vis the rest of the world, plotted in grey), and Saudi Arabia has also seen a relative increase compared to the GCC group; in contrast, Bahrain saw a relative decrease, whilst Qatar confirms the lowest levels of diversity.

Overall, the descriptive analysis of these plots points to some differences, particularly for the GCCs with the highest oil dependence, such as Kuwait and Saudi Arabia. Nevertheless, this does not appear to always be the case – for instance, Qatar also has a very high share of oil and natural gas exports (0.88 in 2019, as shown in the country summary tables) and while it had an increase in diversity when oil was excluded from the indicators, it still remains relatively less diverse vis-a-vis the other GCC countries.

Finally, we explore the correlation between both ECI measures and key variables in the GCC group. Figure 11 shows the correlation values and scatter plots between ECI, ECI excluding oil, GDP per capita, oil and gas exports share and oil price. In each case, it shows the overall

[11] Formally, where X_{cp} represents exports of product p by country c, the RCA that country c has in product p is expressed as: $RCA_{cp} = \frac{X_{cp}}{\sum_c X_{cp}} / \frac{\sum_p X_{cp}}{\sum_{cp} X_{cp}}$.

correlation and the correlation in each country.

Unsurprisingly, there is a strong positive correlation between the standard ECI and the ECI measure excluding oil and natural gas products. This is the case for the overall correlation as well as for each individual country, with the exception of Kuwait where the correlation is nearly nonexistent.

Regarding the ECI and GDP per capita, the picture is more mixed, with positive and negative correlations across countries; in the most oil-dependent– Qatar and Kuwait –no correlation is found. A similarly mixed pattern emerges for the association between ECI excluding oil and GDP per capita – once again, there are positive and negative correlations and overall there appears to be no correlation for the case of the group; interestingly, both Qatar and Kuwait have positive correlations, in contrast to what observed for the standard ECI.[12] A positive relationship emerges between both ECI measures and the oil and gas exports share and oil price; for the standard ECI measure, this is particularly strong in Bahrain and Qatar with both oil variables.

Overall, while we found above a cross-country association between the ECI and subsequent economic growth, in the GCC context a substantial influence on the ECI appears from oil price volatility and large shares of oil and related exports. This provides some support towards our hypothesis that the ECI may not be reflecting accurately economies heavily reliant on natural resources, particularly those with highly volatile prices.

[12] The correlation between the ECI and GDP per capita across the full sample of countries shows a positive correlation as seen before, though the higher relative levels of the ECI in the GCCs are evident and they are closer to the linear correlation.

Figure 9: ECI (excl. oil) value, 1995 to 2019, 179 countries (GCCs highlighted)

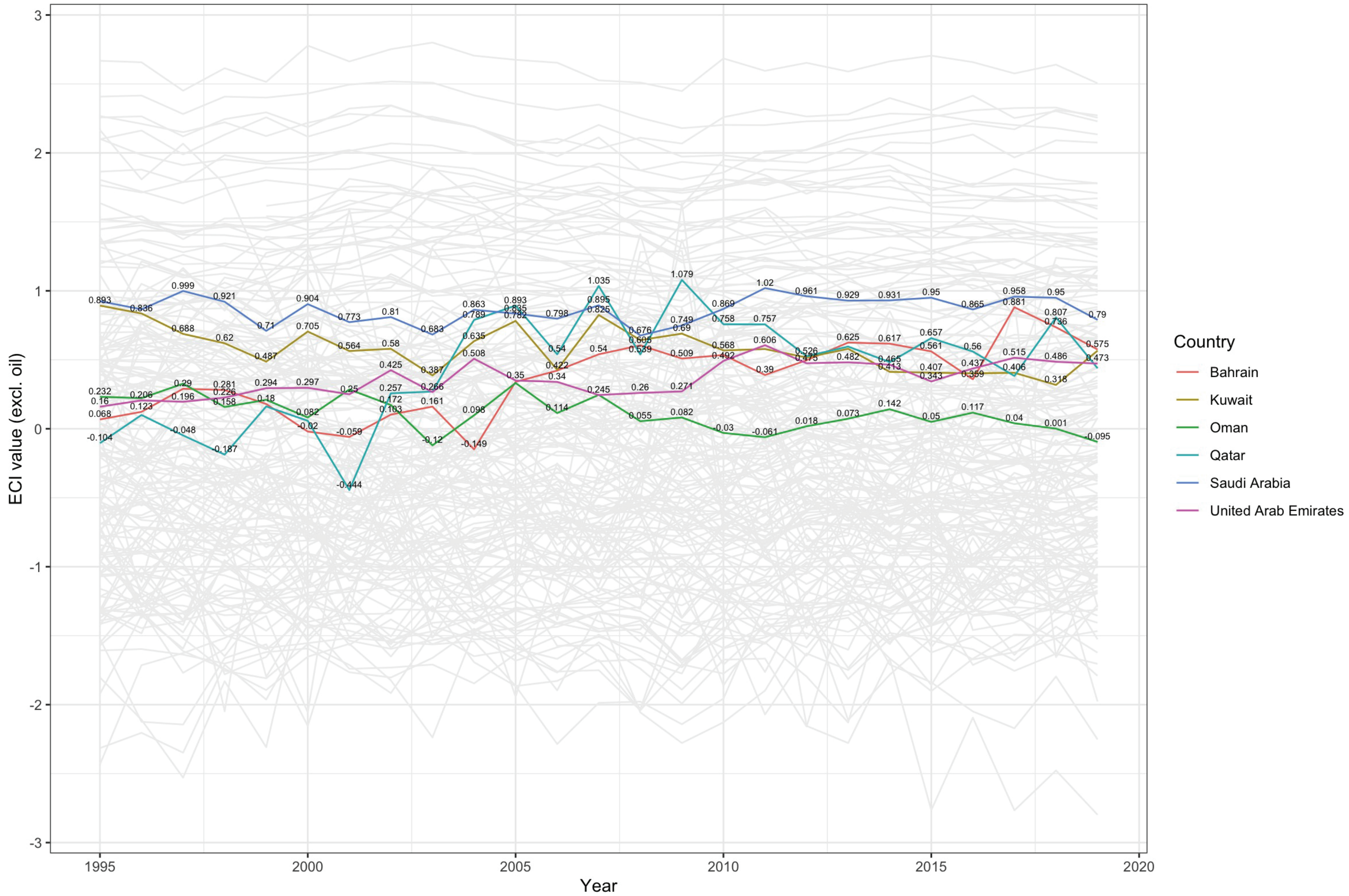


Figure 10: Diversity (excl. oil), GCCs, 1995 to 2019

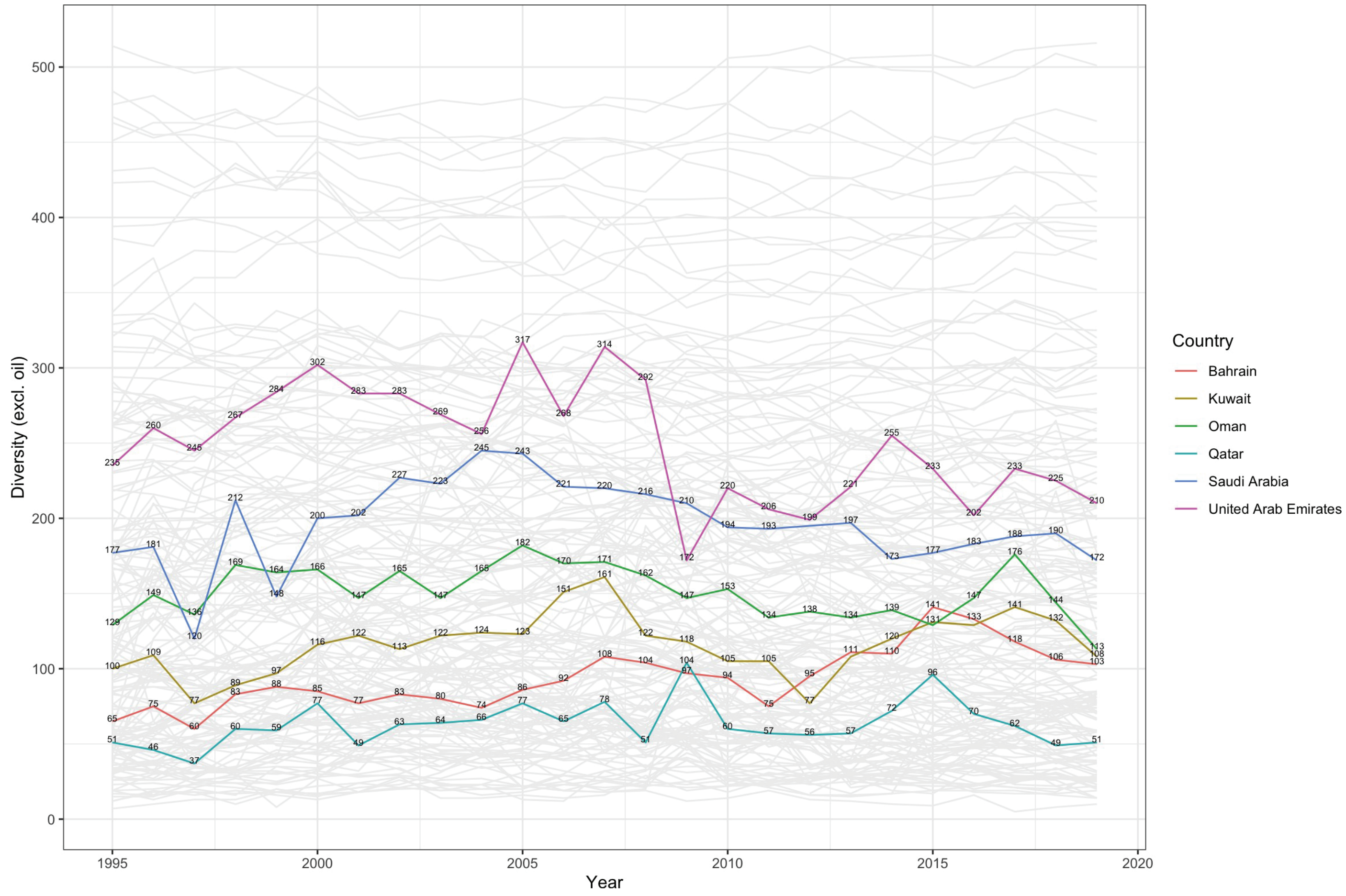
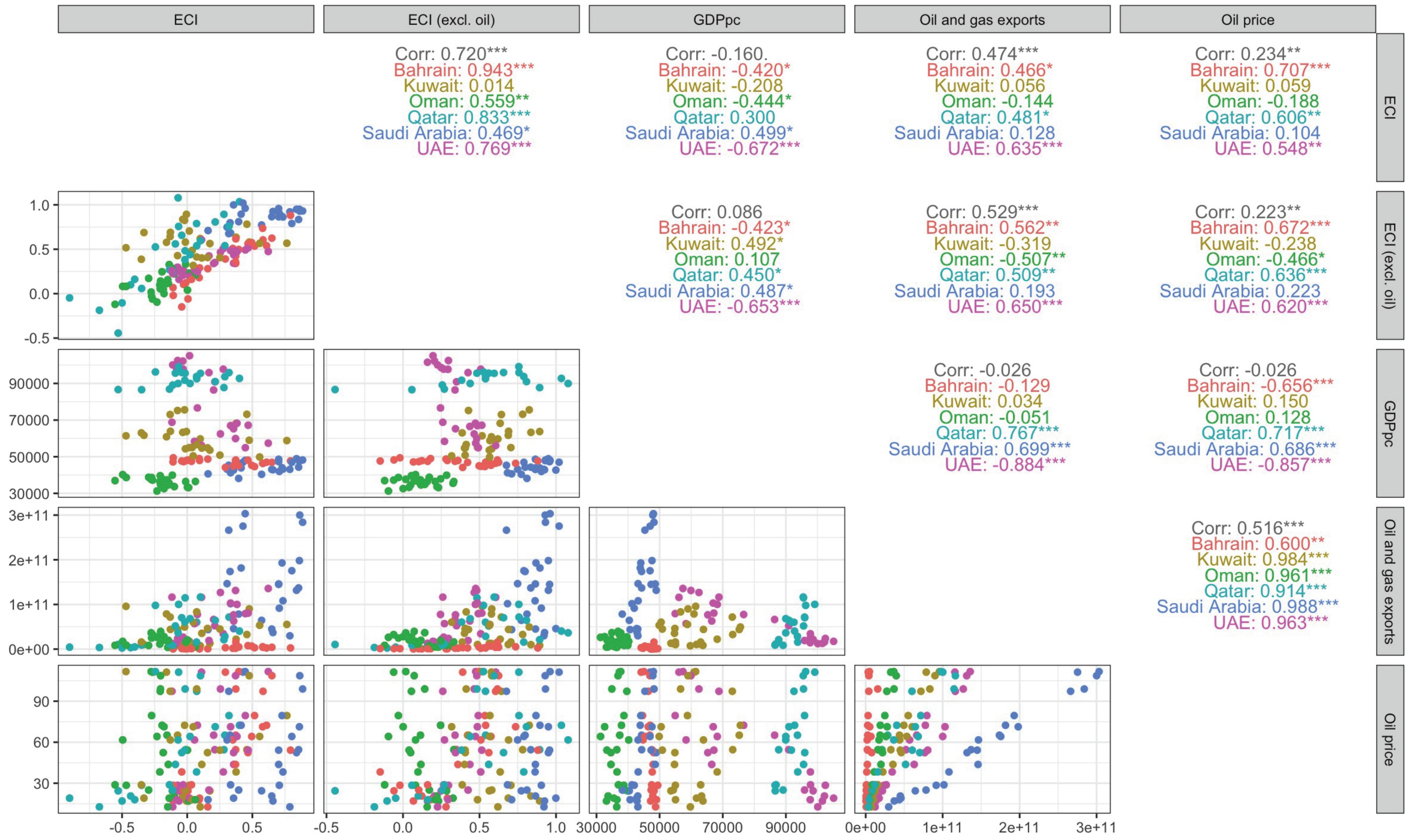


Figure 11: Correlations and scatter plots between selected variables, 1995 to 2019



7 Conclusions

This paper has investigated exports-based economic complexity indicators in the context of the GCC countries, which are highly dependent on oil and natural gas products. While we found that the link between the ECI and subsequent economic growth observed across countries holds for the GCC and other oil-dependent countries, our analysis exposed important ways in which these measures are affected by the high dependence on oil and its price volatility. We found no association between economic complexity and economic growth within countries over time, which we argue presents challenges for policy. Our analysis points to the need for more caution in the use of economic complexity measures and highlight the need for additional and more granular analysis of different contexts, particularly in oil-dependent countries.

For policymakers, tracking progress over time is vital – beyond simply assessing the relative position vis-a-vis all world economies, policymakers want and need to understand changes over time within their own country. The oscillations observed in the ECI, along with the impact that oil and related products have in economic complexity levels, mean that changes over time may be meaningless in oil-dependent countries due to the volatility in oil prices, along with changes in demand and political aspects that have a big impact on exports.

Even if some specific issues with the ECI can be addressed – there have been attempts, for example, of measuring the ECI with value-added exports in order to better capture underlying capabilities (Koch, 2021) – there are broader important questions unanswered in the context of ECI measures, such as the long-standing question in economic development of 'how'. In particular, policy and practical implications derived from ECI analyses may be too high level and not place-based – even if we know that diversification is beneficial, and that countries should move into more complex production, this disregards existing, and often longstanding, context- dependent issues such as natural resources dependence, institutional constraints, and lack of or incomplete national and local systems of innovation, among others.

Indeed, the GCCs have long recognised the need for diversification away from oil. In his analysis of such efforts, Hvidt (2013) notes a high level of uniformity in the assessment of the challenges and recommendations for the GCCs in their development paths – which he argues may be related to the role of international consultancy in advising countries – and questions whether indeed there are no alternative pathways for them, beyond the dominant discourse in development strategies.

As argued in the literature, the GCCs need a wider set of actors, relationships and institutions to evolve and manage to diversify into different activities. Economic complexity, as an indicator and concept, has been argued as capturing these underlying interactions and linkages and reflect them neglecting investigation into local capabilities and conditions (often more costly and longer-term). This has led to a certain attractiveness for policymakers to rely on such indicators, prioritizing approaches unlikely to provide specificity for effective policy action.

While some of the issues identified with the ECI are unique to its construction and data employed, the broader issues and challenges with employing such an approach are present in other cases. For example, the World Bank's Knowledge Economy Index is also used in other reports on the GCCs and the MENA region more broadly and has been criticised in similar ways. Brinkley et al. (2012) provides a good summary of some of the issues – in particular, the fact that they are based on several indicators with different degrees of volatility and sensitivity to economic cycles, and as a result they can move in odd and unpredictable ways, making their use limited for analysis and policy guidance in developing or emerging contexts. Furthermore, if used in isolation such indicators do not provide enough insights into economic and innovation systems, with limited guidance for policymakers on the changes required to achieve a sustainable development trajectory (Brinkley et al., 2012).

Here, we addressed the specific case of oil and related products, which make up an important share of world exports, experience high price volatility, and are susceptible to changes in economic and political conditions across the world. While we looked at the GCC countries in detail, the broad lessons apply to other oil-dependent countries. In terms of other natural resources, the implications may be different – natural resources are highly diversified and, while our call for caution might apply more broadly, other natural resources are not as impacted by highly volatile prices or political economy conditions (for instance, diamonds have seen steady increases in price and less pronounced oscillations), thus their impact on ECI is likely to be more moderate.

Finally, our study has some limitations. A key aspect missing is a more explicit consideration of the natural resource curse in the GCC context which, have managed to achieve high income levels, which can have important implications in assessing the link between economic complexity and economic growth. We tried to address this by looking at alternative indicators beyond GDP per capita, such as the HDI, the implications and results were the exact same, likely because GDP plays a large role in the HDI. We also explored the possible use of alternative skills measures, but availability is very limited, particularly over time and for a significantly large sample that includes the six GCCs. Further research could investigate the links between economic complexity and different natural resources, to try and assess the applicability of the ECI to other contexts. Moreover, it could assess the links between economic complexity and the natural resource curse, exploring not just income growth but broader aspects of economic development.

References

Apergis, N., & Payne, J. E. (2014). The oil curse, institutional quality, and growth in MENA countries: Evidence from time-varying cointegration. *Energy Economics*, *46*, 1–9. https://doi.org/10.1016/j.eneco.2014.08.026

Arman, H., Iammarino, S., Ibarra-Olivo, J. E., & Lee, N. (2021a). *Breaking out of the innovation trap? Towards promoting private R&D investment in Kuwait*. London School of Economics. http://eprints.lse.ac.uk/109010/

Arman, H., Iammarino, S., Ibarra-Olivo, J. E., & Lee, N. (2021b). Systems of innovation, diversification, and the R&D trap: A case study of Kuwait. *Science and Public Policy*, 1–12.

Auty, R. (1993). *Sustaining Development in Mineral Economies: The Resource Curse Thesis*. Routledge. https://doi.org/10.4324/9780203422595

Avom, D., Keneck-Massil, J., Njangang, H., & Nvuh-Njoya, Y. (2022). Why are some resource-rich countries more sophisticated than others? The role of the regime type and political ideology. *Resources Policy*, *79*, 103067. https://doi.org/10.1016/j.resourpol.2022.103067

Badeeb, R. A., Lean, H. H., & Clark, J. (2017). The evolution of the natural resource curse thesis: A critical literature survey. *Resources Policy*, *51* (October 2016), 123–134. https://doi.org/10.1016/j.resourpol.2016.10.015

Bahar, D., Rapoport, H., & Turati, R. (2020). Birthplace diversity and economics complexity: Cross-country evidence. *Research Policy*, 103991. https://doi.org/10.1016/j.respol.2020.103991

Balassa, B. (1965). Trade liberalisation and "revealed" comparative advantage. *The Manchester School*, *33* (2), 99–123.

Beblawi, H. E. (2011). Gulf industrialization in perspective. In J. F. Seznec & M. Kirk (Eds.), *Industrialization in the Gulf: A Socioeconomic Revolution* (pp. 185–97). London: Center for Contemporary Arab Studies. Georgetown University/Routledge.

Bjorvatn, K., Farzanegan, M. R., & Schneider, F. (2012). Resource Curse and Power Balance: Evidence from Oil-Rich Countries. *World Development*, *40* (7), 1308–1316. https://doi.org/10.1016/j.worlddev.2012.03.003

Bodea, C., Higashijima, M., & Singh, R. J. (2016). Oil and civil conflict: Can public spending have a mitigation effect? *World Development*, *78*, 1–12. https://doi.org/10.1016/j.worlddev.2015.09.004

Brinkley, I., Hutton, W., Schneider, P., & Ulichsen, K. (2012). *Kuwait and the Knowledge Economy*. London School of Economics.

Can, M., & Gozgor, G. (2017). The impact of economic complexity on carbon emissions: Evidence from France. *Environmental Science and Pollution Research*, *24* (19), 16364–16370. https://doi.org/10.1007/s11356-017-9219-7

Canh, N. P., Schinckus, C., & Thanh, S. D. (2020). The natural resources rents: Is economic complexity a solution for resource curse? *Resources Policy*, *69* (July), 101800. https://doi.org/10.1016/j.resourpol.2020.101800

Chamberlain, T. W., & Kalaitzi, A. S. (2020). Fuel-mining exports and economic growth: Evidence from the UAE. *International Advances in Economic Research*, *26* (1), 119– 121. https://doi.org/10.1007/s11294-020-09766-4

Corden, W. M. (1984). Booming sector and Dutch disease economics: Survey and consolidation. *Oxford Economic Papers*, *36* (3), 359–380. Retrieved August 25, 2022, from http://www.jstor.org/stable/2662669

Corden, W. M., & Neary, J. P. (1982). Booming sector and de-industrialisation in a small open economy. *The Economic Journal*, *92* (368), 825–848. https://doi.org/10.2307/2232670

Davis, G. A., & Tilton, J. E. (2005). The resource curse. *Natural Resources Forum*, *29*, 233–242. https://doi.org/10.1111/j.1477-8947.2005.00133.x

Demir, F. (2019). IMF conditionality, trade structure and economic complexity: What did structural adjustment programs really adjust. *University of Oklahoma*.

Ennis, C. A. (2015). Between trend and necessity: Top-down entrepreneurship promotion in Oman and Qatar. *The Muslim World*, *105* (1), 116–138. https://doi.org/10.1111/muwo.12083

Frankel, J. A. (2010). *The natural resource curse: A survey*. http://www.nber.org/papers/w15836

Frankel, J. A. (2012). *The natural resource curse: A survey of diagnoses and some presctiptions*. John F. Kennedy School of Government, Harvard University. http://nrs.harvard.edu/urn-3:HUL.InstRepos:8694932

Gelb, A. H. (1988). *Oil windfalls: Blessing or curse?* Oxford University Press.

Gylfason, T. (2001). Natural resources, education, and economic development. *European Economic Review*, *45* (4-6), 847–859. https://doi.org/10.1016/S0014-2921(01)00127-1

Gylfason, T., & Zoega, G. (2006). Natural resources and economic growth: The role of investment. *The World Economy*, *29* (8), 1091–1115. https://doi.org/10.1111/j.1467-9701.2006.00807.x

Hartmann, D., Guevara, M. R., Jara-Figueroa, C., Aristarán, M., & Hidalgo, C. A. (2017). Linking economic complexity, institutions and income inequality. *World Development*, *93*, 75–93. https://doi.org/10.1016/j.worlddev.2016.12.020

Hausmann, R., Hidalgo, C. A., Bustos, S., Coscia, M., Simoes, A., & Yildirim, M. A. (2014). *The atlas of economic complexity: Mapping paths to prosperity*. MIT Press. http://atlas.cid.harvard.edu/%0Ahttps://mitpress.mit.edu/books/atlas-economic-complexity

Hausmann, R., Santos, M. A., & Obach, J. (2017). *Appraising the economic potential of Panama: Policy recommendations for sustainable and inclusive growth*. CID Working Paper No. 334.

Hidalgo, C. A. (2021). Economic complexity theory and applications. *Nature Reviews Physics*. https://doi.org/10.1038/s42254-020-00275-1

Hidalgo, C. A., & Hausmann, R. (2009). The building blocks of economic complexity. *PNAS*, *106* (26), 10570–10575. https://doi.org/10.1073/pnas.0900943106

Humphreys, M., Sachs, J. D., Stiglitz, J. E., Humphreys, M., & Soros, G. (2007). *Escaping the resource curse*. Columbia University Press.

Hvidt, M. (2011). Economic and Institutional Reforms in the Arab Gulf Countries. *Middle East Journal*, *65* (1), 85–102. Retrieved August 9, 2022, from http://www.jstor.org/stable/23012095

Hvidt, M. (2013). *Economic diversification in GCC countries: Past record and future trends*.

Kalaitzi, A. S., & Chamberlain, T. W. (2019). Further evidence on export-led growth in the United Arab Emirates: Are non-oil exports or re-exports the key to economic growth? *Review of Middle East Economics and Finance*, *15* (2), 1–16. https://doi.org/10.1515/rmeef-2019-0007

Kalaitzi, A. S., & Chamberlain, T. W. (2020). Merchandise exports and economic growth: Multivariate time series analysis for the United Arab Emirates. *Journal of Applied Economics*, *23* (1), 163–182. https://doi.org/10.1080/15140326.2020.1722384

Kalaitzi, A. S., & Chamberlain, T. W. (2021). The validity of the export-led growth hypothesis: Some evidence from the GCC. *Journal of International Trade and Economic Development*, *30* (2), 224–245. https://doi.org/10.1080/09638199.2020.1813191

Kalaitzi, A. S., & Cleeve, E. (2018). Export-led growth in the UAE: Multivariate causality between primary exports, manufactured exports and economic growth. *Eurasian Business Review*, *8* (3), 341–365. https://doi.org/10.1007/s40821-017-0089-1

Koch, P. (2021). Economic complexity and growth: Can value-added exports better explain the link? *Economics Letters*, *198*, 109682. https://doi.org/10.1016/j.econlet.2020.109682

Koren, M., & Tenreyro, S. (2010). *Volatility, diversification and development in the Gulf Cooperation Council countries*. Research Paper, Kuwait Program on Development, Governance, and Globalization in the Gulf States, London School of Economics.

Kumar, K. B., & van Welsum, D. (2013). *Knowledge-based economies and basing economies on knowledge: Skills a missing link in GCC countries*. Rand Corporation.

Lapatinas, A. (2019). The effect of the Internet on economic sophistication: An empirical analysis. *Economics Letters*, *174*, 35–38. https://doi.org/10.1016/j.econlet.2018.10.013

Lapatinas, A., Kyriakou, A., & Garas, A. (2019). Taxation and economic sophistication: Evidence from OECD countries. *PLoS ONE*, *14* (3), 1–21. https://doi.org/10.1371/journal.pone.0213498

Lee, K. K., & Vu, T. V. (2020). Economic complexity, human capital and income inequality: A cross-country analysis. *Japanese Economic Review*, *71* (4), 695–718. https://doi.org/10.1007/s42973-019-00026-7

Mewes, L., & Broekel, T. (2020). Technological complexity and economic growth of regions. *Research Policy*. https://doi.org/10.1016/j.red.2006.12.001

Neagu, O., & Teodoru, M. C. (2019). The relationship between economic complexity, energy consumption structure and greenhouse gas emission: Heterogeneous panel evidence from the EU countries. *Sustainability*, *11* (2). https://doi.org/10.3390/su11020497

Neary, J. P., & van Wijnbergen, S. (1986). *Natural resources and the macroeconomy*. MIT Press.

Poncet, S., & Starosta de Waldemar, F. (2013). Export upgrading and growth: The prerequisite of domestic embeddedness. *World Development*, *51*, 104–118. https://doi.org/10.1016/j.worlddev.2013.05.010

Rosser, A. (2009). Natural resource wealth, development and social policy: Evidence and issues. In K. Hujo & S. McClanahan (Eds.), *Financing Social Policy* (pp. 165–182). Palgrave Macmillan UK. https://doi.org/10.1057/9780230244337 7

Rostow, W. (1961). *The stages of economic growth: A non-communist manifesto*. Cambridge University Press.

Sachs, J. D. (2007). How to handle the macroeconomics of oil wealth. In *Escaping the Resource Curse*. Columbia University Press.

Sachs, J. D., & Warner, A. M. (1995). *Natural resource abundance and economic growth*. National Bureau of Economic Research.

Sachs, J. D., & Warner, A. M. (1999). The big push, natural resource booms and growth. *Journal of Development Economics*, *59* (1), 43–76. https://doi.org/10.1016/S0304-3878(99)00005-X

Sachs, J. D., & Warner, A. M. (2001). The curse of natural resources. *European Economic Review*, *45*, 827–838.

Sala-i-Martin, X., & Subramanian, A. (2013). Addressing the natural resource curse: An illustration from Nigeria. *Journal of African Economies*, *22* (4), 570–615. https://doi.org/10.1093/jae/ejs033

Samans, R., & Zahidi, S. (2017). *The future of jobs and skills in the Middle East and North Africa: Preparing the region for the Fourth Industrial Revolution*. World Economic Forum.

Stojkoski, V., Utkovski, Z., & Kocarev, L. (2016). The impact of services on economic complexity: Service sophistication as route for economic growth. *PLoS ONE*, *11* (8), 1–29. https://doi.org/10.1371/journal.pone.0161633

Sweet, C. M., & Maggio, D. S. E. (2015). Do stronger intellectual property rights increase innovation? *World Development*, *66*, 665–677. https://doi.org/10.1016/j.worlddev.2014.08.025

Tabash, M. I., Mesagan, E. P., & Farooq, U. (2022). Dynamic linkage between natural resources, economic complexity, and economic growth: Empirical evidence from Africa. *Resources Policy*, *78*, 102865. https://doi.org/10.1016/j.resourpol.2022.102865

Tacchella, A., Mazzilli, D., & Pietronero, L. (2018). A dynamical systems approach to gross domestic product forecasting. *Nature Physics*, *14* (8), 861–865. https://doi.org/10.1038/s41567-018-0204-y

Valenta, M., & Jakobsen, J. (2016). Moving to the Gulf: An empirical analysis of the patterns and drivers of migration to the GCC countries, 1960–2013. *Labor History*, *57* (5), 627–648. https://doi.org/10.1080/0023656X.2016.1239885

Van der Ploeg, F. (2011). Natural resources: Curse or blessing? [Publisher: American Economic Association]. *Journal of Economic Literature*, *49* (2), 366–420. Retrieved August 26, 2022, from http://www.jstor.org/stable/23071620

Van der Ploeg, F., & Poelhekke, S. (2009). Volatility and the natural resource curse. *Oxford Economic Papers*, *61* (4), 727–760. https://doi.org/10.1093/oep/gpp027

Venables, A. J. (2016). Using natural resources for development: Why has it proven so difficult? *Journal of Economic Perspectives*, *30* (1), 161–184. https://doi.org/10.1257/jep.30.1.161

Vu, T. V. (2019). *Does institutional quality foster economic complexity?* University of Otago Economics Discussion Paper No. 1909.

Vu, T. V. (2020). Economic complexity and health outcomes: A global perspective. *Social Science & Medicine*. https://doi.org/10.1016/j.socscimed.2020.113480

World Bank. (2022). World Bank country and lending groups. Retrieved August 11, 2022,from https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups

Yalta, A. Y., & Yalta, T. (2021). Determinants of Economic Complexity in MENA Countries. *Journal of Emerging Economies and Policy*, *6* (1), 5–16.

Appendix

Table A1: Country summary tables, GCCs, 1995 and 2019

1995						
Country	**GDP per capita**	**Oil rents (% GDP)**	**Oil & gas export share**	**Population**	**ECI**	**ECI Rank**
Saudi Arabia	42 855.8	29.6	0.80	18 638 790	0.658	38
Oman	33 168.5	32.4	0.74	2 204 267	0.011	81
Kuwait	63 724.7	39.0	0.95	1 605 907	-0.006	83
UAE	101 571.0	17.5	0.75	2 415 099	-0.063	87
Bahrain	47 157.2	3.6	0.26	563 698	-0.109	89
Qatar	86 566.3*	28.0	0.85	513 447	-0.500	115

* GDP per capita value reported is from 2000, the earliest year for which GDP data is available in Qatar

2019						
Country	**GDP per capita**	**Oil rents (% GDP)**	**Oil and gas export share**	**Population**	**ECI**	**ECI Rank**
Saudi Arabia	46 962.1	24.2	0.75	34 268 529	0.803	40
Kuwait	49 853.7	42.1	0.85	4 207 077	0.556	53
Bahrain	45 311.9	2.2	0.41	1 641 164	0.495	56
UAE	68 263.7	16.2	0.39	9 770 526	0.382	63
Qatar	89 966.4	16.9	0.88	2 832 071	0.022	88
Oman	31 284.0	24.9	0.69	4 974 992	-0.232	105

Data on GDP per capita (expressed in PPP, constant international $), oil rents and population originate from the World Bank, while oil and gas exports share, ECI and ECI rank are based on exports data downloaded from the Observatory of Economic Complexity and own calculations (see Section 4.1).

Table A2: Description and source of variables. All available for the period 1995-2019.

Variable	Definition	Source
ECI	Economic Complexity Index based on HS-92 classification. Own calculations.	The Observatory of Economic Complexity
PCI	Product Complexity Index based on HS-92 classification. Own calculations.	The Observatory of Economic Complexity
Exports	Total merchandise exports (USD value)	The Observatory of Economic Complexity
NR exports	Natural resource exports (total USD value). Own calculation based on HS section V (mineral products) covering Chapters 25-27.	The Observatory of Economic Complexity
Oil and gas exports share	Exports in oil and natural gas products divided by total merchandise exports. Own calculation based on HS products 2709, 2710, 2711, 2712 and 2713.	The Observatory of Economic Complexity
GDP per capita	GDP per capita, PPP (constant 2017 international $)	World Bank Open Data
Population	Total population (counts all residents regardless of legal status or citizenship)	World Bank Open Data
Natural resource rents	Total natural resources rents (% of GDP)	World Bank Open Data
Oil rents	Oil rents (% of GDP)	World Bank Open Data
Employment share in industry	Employment in industry (% total employment)	World Bank Open Data
Employment share in services	Employment in services (% total employment)	World Bank Open Data

Table A3: Descriptive statistics, 20-year growth regression variables

Variables	N	Mean	SD	Min	Max
GDPpc growth	164	0.428	0.358	-0.406	1.609
Initial ECI	176	-1.14e-05	1.000	-3.737	2.527
Initial ECI (excl. oil)	176	-1.14e-05	1.000	-2.154	2.778
Initial GDPpc (log)	164	9.006	1.241	6.447	11.54
Increase in exports (share of initial GDP)	171	0.999	1.227	-0.211	8.402
Increase in NR exports (share of initial GDP)	171	0.301	0.693	-0.206	5.442
Exports to GDP (initial)	171	0.326	0.234	0.0123	1.291
Initial population (log)	176	15.80	1.741	11.87	20.96

Table A4: Descriptive statistics, 10-year growth regression variables

Variables	N	Mean	SD	Min	Max
GDPpc growth	332	0.198	0.222	-0.630	1.273
Initial ECI	354	1.69e-05	0.999	-3.737	2.558
Initial ECI (excl. oil)	354	2.82e-06	0.999	-2.154	2.778
Initial GDPpc (log)	332	9.134	1.223	6.447	11.68
Increase in exports (share of initial GDP)	345	0.297	0.551	-0.521	6.675
Increase in NR exports (share of initial GDP)	345	0.104	0.451	-0.389	6.286
Exports to GDP (initial)	345	0.313	0.213	0.0123	1.291
Initial population (log)	354	15.87	1.733	11.87	21.01

Table A5: Descriptive statistics, 5-year growth regression variables

Variables	N	Mean	SD	Min	Max
GDPpc growth	668	0.0882	0.120	-0.614	0.954
Initial ECI	709	8.46e-06	0.998	-3.737	2.558
Initial ECI (excl. oil)	709	1.13e-05	0.998	-2.765	2.778
Initial GDPpc (log)	668	9.183	1.219	6.447	11.69
Increase in exports (share of initial GDP)	692	0.114	0.185	-0.949	2.530
Increase in NR exports (share of initial GDP)	692	0.0361	0.128	-0.302	2.431
Exports to GDP (initial)	692	0.313	0.214	0.00955	1.513
Initial population (log)	709	15.91	1.729	11.87	21.05

Table A6: List of countries included in the analysis

Afghanistan	Djibouti	Lesotho	Russia (*)
Albania	Dominican Republic	Liberia	Rwanda
Algeria (*)	Ecuador (*)	Libya (*)	Sao Tome and Principe
Angola (*)	Egypt (*)	Lithuania	Saudi Arabia (*)
Argentina	El Salvador	Luxembourg	Senegal
Armenia	Equatorial Guinea (*)	Macau	Serbia
Australia	Estonia	Madagascar	Sierra Leone
Austria	Eswatini	Malawi	Singapore
Azerbaijan (*)	Ethiopia	Malaysia	Slovakia
Bahamas	Fiji	Maldives	Slovenia
Bahrain (*)	Finland	Mali	Solomon Islands
Bangladesh	France	Malta	Somalia
Barbados	French Polynesia	Mauritania	South Africa
Belarus	Gabon (*)	Mauritius	South Korea
Belgium	Gambia	Mexico	South Sudan
Belize	Georgia	Moldova	Spain
Benin	Germany	Mongolia	Sri Lanka
Bhutan	Ghana	Montenegro	Sudan (*)
Bolivia (*)	Greece	Morocco	Suriname
Bosnia and Herzegovina	Guatemala	Mozambique	Sweden
Botswana	Guinea	Myanmar	Switzerland
Brazil	Guinea-Bissau	Namibia	Syria (*)
Brunei (*)	Guyana	Nepal	Tajikistan
Bulgaria	Haiti	Netherlands	Tanzania
Burkina Faso	Honduras	New Caledonia	Thailand
Burundi	Hong Kong	New Zealand	Timor-Leste (*)
Cambodia	Hungary	Nicaragua	Togo
Cameroon (*)	Iceland	Niger	Trinidad and Tobago (*)
Canada	India	Nigeria (*)	Tunisia
Cape Verde	Indonesia	North Korea	Turkey
Central African Republic	Iran (*)	North Macedonia	Turkmenistan (*)
Chad (*)	Iraq (*)	Norway (*)	Uganda
Chile	Ireland	Oman (*)	Ukraine
China	Israel	Pakistan	United Arab Emirates (*)
Chinese Taipei	Italy	Palestine	United Kingdom
Colombia (*)	Jamaica	Panama	United States
Comoros	Japan	Papua New Guinea	Uruguay
Costa Rica	Jordan	Paraguay	Uzbekistan
Cote d'Ivoire	Kazakhstan (*)	Peru	Vanuatu
Croatia	Kenya	Philippines	Venezuela (*)
Cuba	Kuwait (*)	Poland	Vietnam
Cyprus	Kyrgyzstan	Portugal	Yemen (*)
Czechia	Laos	Qatar (*)	Zambia
Democratic Republic of the Congo	Latvia	Republic of the Congo (*)	Zimbabwe
Denmark	Lebanon	Romania	

Countries in *Italics* have some early years of export data, and therefore complexity variables, missing.

Countries marked with (*) are included in the oil-dependent group.