Export Concentration in Oil-Producing Economies: An Empirical Analysis of a Large Panel

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Abstract

The largest oil-producing countries are some of the world's most concentrated economies, and their economic development is primarily reliant on oil exports. The low carbon transition threatens to cut their export revenues as we gradually shift to the consumption of low carbon energy sources, forcing these countries to diversify into other sectors. This bachelor's degree final project aims to study whether oil-producing countries have more concentrated exports than other countries. To answer this question, a large unbalanced panel of 154 countries is collected for the years 1995-2014, and a fixed-effects model is estimated using two different approaches that identify the major oil-producing countries. The results of this study suggest that export concentration is a concern in the main oil-producing economies and must be addressed in order to ensure sustainable long-term economic growth.

Keywords

Export Concentration, Low Carbon Transition, International Trade

Contents

1 Introduction

Low carbon transition has become inevitable as the World tries to find successful policy measures against global warming. This means that energy use and production output would gradually turn away from polluting fossil fuels into renewable sources. However, while the speed at which this transition occurs is still unclear, the European Union is attempting to set the pace by becoming the first climate-neutral continent by the year 2050. As more than 75% of the unions' greenhouse gas emissions are related to energy, current policies aim to increase energy efficiency and eventually replace fossil fuels with renewables. According to some estimations, this would decrease the European Union's oil and gas import dependence from 55% to 20% in 2050, making fossil fuel exporters potentially lose part of their market (European Commission, 2018). However, the European Union is not the only party that is gradually switching to renewable energy; in 2015, 196 countries signed the Paris agreement on climate change (UNFCCC, n.d.).

Oil-producing countries have historically been among the World's most specialized economies. "In 2010 the fifteen countries with the highest export concentration scores in the World were all petroleum exporters" (Ross, 2019). Therefore, the low carbon transition does not come cost-free to countries whose economic growth is highly dependent on the performance of these fossil fuel exports or where these revenues are a significant source of fiscal revenues. To give an example of the extreme, export revenues from oil and natural gas in Iraq and Kuwait represented around 40% of their GDP and almost 70% of the fiscal revenues of Saudi Arabia in 2017 (Tagliapietra, 2019). If part of these export revenues are lost and cannot be compensated by growth in other sectors, it can have severe consequences on the economic development of these economies and may result in geopolitical instability (Bradshaw et al., 2019). Thus, to guarantee sustainable growth in the future, the countries that are currently heavily dependent on fossil fuel revenues are gradually forced to diversify their economies. As it is quite evident that the export concentration has become a significant problem in some of the biggest oil-producing countries, one may question whether this problem extends to all oil-producing economies in general.

Following the practices used in the previous empirical literature, this bachelor's degree final project will study whether oil-producing economies have a comparatively more concentrated export structure in relation to other countries. To study this question, I will estimate a fixed-effects model using an unbalanced panel data that consists of 154 countries and ranges from 1995 to 2014. The idea of using a fairly large panel is to include both oil producers that are heavily dependent on these revenues, together with relatively smaller and more diversified producers in the analysis.

The rest of the document will be structured as follows: In Section 2, I will introduce the related empirical research with an emphasis on the determinants of export diversification. Then in Section 3, I will present the research methodology and the methods used in this study, as well as the data that was gathered for these purposes. Finally, Section 4 will present and discuss the results obtained using the fixed-effects model(s), and Section 5 will conclude the study.

2 Previous empirical research

A thorough understanding of how export diversification has been studied in the past is needed to determine if oil-producing countries have comparatively more concentrated (less diversified) exports. This section will review the relevant empirical literature of the possible determinants of export diversification and other relevant papers that have studied the relationship between export concentration and income volatility. The aim is to summarize the key results of the empirical papers that serve as the foundation for this final project's econometric analysis.

2.1 The determinants of export diversification

The possible determinants of export diversification have been studied in the past by many authors (Agosin et al., 2012; Giri et al., 2019; Osakwe & Kilolo, 2018; Parteka & Tamberi, 2011). Although the focus has been on identifying possible variables that affect the degree of export diversification, the empirical methods used by the authors have varied. The researchers have primarily used various standard index measures of export diversification as the dependent variables (e.g. Gini, Theil and Herfindahl-Hirschmann), but other approaches have also been taken. It has also become a common practice to carry out robustness checks by estimating the same models using more than one measure of export diversification.

The domestic market size is thought to be related to the degree of export diversification because of its effect on the level of domestic demand and the number of companies. Parteka and Tamberi (2011) studied the possible determinants of export diversification by estimating a fixed-effects regression model with instrumental variables approach. The authors used the relative Theil index as their primary measure of export diversification but tested for the robustness of their findings by repeating the estimations with the relative Gini index. Their findings indicated that small economies (in terms of population) were, on average, associated with a lower degree of export diversification (higher export concentration). More recent research has supported the findings of Parteka and Tamberi (2011). Osakwe and Kilolo (2018) studied the export diversification of developing countries using the relative Theil index and the number of export lines as the measures of export diversification. The authors' fixed-effects IV[1] estimates revealed a positive relationship between domestic market size and export diversification, and its effect was statistically significant on both measures of export diversification. Later, Giri et al. (2019) analyzed a panel of 92 countries and performed the analysis on different subsamples of countries according to their characteristics. The authors estimated their models using Bayesian Model Averaging and pooled OLS with the total, within and between Theil index as the measures of export diversification and found evidence that smaller economies were predisposed to have more concentrated exports.

The GDP per capita of a country has been thought to have a similar effect on the degree of export diversification as population. It has been often included as a proxy for economic development and domestic demand. Parteka and Tamberi (2011) found evidence that poor economies (measured with GDP and GDP per capita) were on average associated with lower levels of export diversification. Similar results were obtained by Giri et al. (2019) as they reported a negative relationship between GDP per capita and export concentration when the full sample of 92 countries was used. However, its effect was not statistically significant.

In this area of research, other factors related to economic development have also been regarded as possible factors affecting export diversification. The production structure of an economy proved to be the most significant driver of export diversification in the models of Osakwe and Kilolo (2018). The authors' regressions showed a positive association with manufacturing value-added as a percent of GDP with export diversification. Also, the effect of infrastructure quality on export diversification was studied by Osakwe and Kilolo (2018) and Giri et al. (2019). Osakwe and Kilolo (2018) used fixed telephone subscriptions and the level of energy consumption as proxies for infrastructure. Their findings revealed that infrastructure quality positively affects export diversification, implying that countries with better infrastructure have a more diverse export base. These findings were later confirmed by Giri et al. (2019), who used both fixed and mobile telephone subscriptions as infrastructure proxies. The authors found a negative relationship in most of their regressions between these variables when using the full

[1] Instrumental variables

sample. While the empirical evidence obtained by Osakwe and Kilolo (2018) and Giri et al. (2019) seems to agree that infrastructure quality can be important for export diversification, the use of telephone connectivity as a sole measure to capture this relationship may be questionable. Furthermore, Giri et al. (2019) also discovered that higher institutional quality (proxied by the quality of governance) was associated with higher export diversification. Therefore, low quality of infrastructure and high levels of corruption may contribute to the ability of a country to diversify its exports efficiently.

The connection between openness and export diversification has also attracted the attention of some researchers. The theoretical relationship between openness and economic concentration is somewhat related to the international trade theories of Adam Smith and David Ricardo, where specialization is encouraged due to differences in the relative production capabilities. Using a dynamic panel model approach and testing for the robustness of their findings using three different measures of export diversification, Agosin et al. (2012) discovered that export diversification was negatively and robustly linked to trade openness, meaning that trade liberalization could contribute to export concentration. However, more recent literature finds little support to the findings of Agosin et al. (2012) as Osakwe and Kilolo (2018) and Giri et al. (2019) both found proof of a positive relationship between trade openness and export diversification. Therefore, it appears that the relationship between export diversification and trade openness is dependent on the sample and estimation methods used.

One of the factors that can influence a country's degree of export diversification is human capital accumulation. Agosin et al. (2012) found out that human capital accumulation (education) has a positive effect on export diversification and argued that with higher human capital accumulation, countries could shift from the production of commodities to more human capital-intensive industries, such as manufactured goods and services, which can foster better possibilities for diversification. Giri et al. (2019) used three levels of human capital accumulation in their models to see if different levels of human capital accumulation have different effects on export diversification. According to the results obtained in Giri et al. (2019), depending on the characteristics of the economy, different levels of human capital accumulation proved to be more significant in relation to export diversification. For example, in the case of emerging and developing commodity exporters, the increase in secondary school enrollment was the most significant factor driving diversification. In the case of diversified emerging and developing exporters, tertiary school enrollment proved to be the most significant. When these authors used the full sample, primary education was the most important factor driving export diversification. Therefore, according to Giri et al. (2019), economies should focus on different levels of human capital accumulation depending on their individual characteristics if they wish to diversify their export base. These findings of Giri et al. (2019) seem to agree with the hypothesis developed by Agosin et al. (2012), where higher levels of human capital accumulation are linked with higher export diversification.

Other factors that may force economies to specialize are high export costs that may arise from tariffs or quotas or simply due to unfavorable location with poor logistic chains. The geographical distance from main markets was included in the models of Parteka and Tamberi (2011) and Agosin et al. (2012). In the models of Parteka and Tamberi (2011), a greater distance from the nearest major market was correlated with a higher export concentration. Similarly, in most of their regressions, Agosin et al. (2012) found a positive association between economic distance and export concentration. Parteka and Tamberi (2011) also found out that better trade conditions (low tariffs or quotas, or being an active member in a trade agreement) were associated with higher export diversification. This finding appears to be rational, as export sectors exposed to high tariffs or quotas lose competitiveness compared to local rivals, which can reduce their demand if these costs are not absorbed by profit margins and must be passed on to the end customer as price increases.

Variables that are more closely related to the research question raised in this final project have also been investigated previously. Alsharif, Bhattacharyya, and Intartaglia (2017) studied the diversification trends of 35 petroleum exporter countries between 1962 and 2012. Instead of using an index measure of export diversification, these authors took a different approach by regressing non-oil exports (as a percentage of total exports) and non-oil private sector employment against the logarithm of oil rents per capita. The researchers discovered a statistically significant negative relationship between oil rents and non-oil exports, suggesting that countries with higher oil rents have lower non-oil export shares. Oil rents were also negatively correlated with non-oil export employment in their regressions. The research methods used in Alsharif et al. (2017) received some critique from Ross (2019), as the authors failed to report the basis on which the petroleum exporters were chosen for their analysis. According to (Ross, 2019), the exclusion of some major oil producers from the study makes it difficult to draw conclusions about global oil production trends.

In relation to other natural resources, Giri et al. (2019) found evidence that natural resourceabundant countries (proxied by total natural resource rents % of GDP) tend to have less diversified exports. Similarly, Osakwe and Kilolo (2018) included mineral rents in their regressions as a proxy for natural resource endowments. In the models that used the relative Theil index to measure export diversification, the authors discovered a positive and statistically significant relationship between mineral rents and export concentration. However, their findings from regressions using the number of export products as the dependent variable contradicted these findings, as they discovered a positive but statistically insignificant relationship between mineral rents and export diversification. As a result, their research yielded no conclusive evidence of the effect of natural resource endowments on the degree of export diversification.

2.2 Export concentration, income instability and economic growth

Another closely related field of research has focused on studying the relationship between export concentration and macroeconomic volatility. Jansen (2004) studied the income volatility of small and developing economies. She argued that export concentration has an impact on terms of trade volatility, which in turn affects income volatility. Her empirical findings revealed a statistically significant positive association between export concentration and terms of trade volatility, with the effect being stronger for exporters focused on commodities such as oil. She obtained a statistically significant and positive relationship between terms of trade volatility and income volatility in her other regression. Thus, the results obtained by Jansen (2004) indicate that export concentration can lead to higher terms of trade volatility, which can translate to higher income volatility.

Furthermore, Jansen (2004) found out that the size and poorness also matter in terms of income volatility. According to her econometric results, microstates and poorer economies are predisposed to have higher income volatility. Jansen (2004) argued that in the case of small economies, this could be possibly explained by their limited opportunities to diversify their export base and greater reliance on foreign trade (openness). A closer examination of her data revealed that while both small and poor economies have high levels of export concentration, poor economies are less open to trade. As a result, higher income volatility in poor economies appears to be driven by their higher export concentration.

Lederman and Maloney (2012) reported similar results as Jansen (2004). In their paper, the authors studied the relationship between macroeconomic volatility and export concentration. Their hypothesis was based on the idea that commodity dependency is often related to export concentration, which can lead to terms of trade volatility, causing intensified macroeconomic uncertainty. In line with the results obtained by other authors (e.g., Giri et al., 2019; Jansen, 2004; Osakwe & Kilolo, 2018), the estimations of Lederman and Maloney (2012) indicated that smaller economies were predisposed to have more concentrated exports. Also, poorer and mineral-abundant economies (economies that depend on mining exports) were significantly associated with higher export concentration. Furthermore, their estimations revealed a positive and statistically significant relationship between export concentration and terms of trade volatility and trade volatility with GDP per capita growth volatility. Therefore, according to Lederman and Maloney (2012), higher export concentration could increase terms of trade volatility, which then affects GDP per capita growth volatility. These results clearly support their initial hypothesis that links commodity dependency with macroeconomic volatility and are in line with the results obtained by Jansen (2004).

Export diversification and its relationship to economic growth have also received some attention in the past. Lederman and Maloney (2007) found a negative relationship between export concentration and economic growth. In contrast to previous econometric results, Lederman and Maloney (2007) found no evidence of the natural resource curse and argued that export concentration rather than natural resource abundance is the factor driving lower economic growth. Thus, following their argument, natural resource abundance by itself may not be bad for growth, but rather how they are utilized to support the economic growth in a given country.

The estimations of Agosin (2007) also show a positive relationship between export diversification and economic growth. According to Agosin (2007), one of the benefits of export diversification is similar to the portfolio effect known in the financial economics literature. By diversifying its exports, a country can decrease the volatility of export earnings, which ultimately can contribute to less volatile economic growth. The econometric estimations of Agosin (2007) gave statistically significant proof of the existence of this portfolio effect.

Similarly, Hesse (2008) found strong evidence that export concentration has negatively affected economic growth in developing countries. According to Hesse (2008), one possible reason for the negative relationship could be due to their dependence on commodity exports, which are characterized by volatile prices. Volatile prices could induce uncertainty of prospective future income and result in non-investment decisions from risk-averse agents in the economy, ultimately leading to lower rates of economic growth.

Similar results have been obtained by performing time series analysis on a single country basis. In the case of Chile, which is heavily reliant on natural resource exports, Herzer and Nowak-Lehmann D. (2006) found out that export diversification had played a key role in contributing positively to its economic growth during the last half of the 20th century. The authors' findings support their hypothesis in which export diversification can generate positive externalities for the economy as a result of learning by doing and learning by exporting effects associated with competing in international markets.

3 Methodology

In this final project, I estimate a fixed-effects regression model to study whether oil producers have relatively more concentrated exports than other countries. I use two different approaches in order to answer this question. The first approach uses a dummy variable that identifies the major oil producers using a production per capita value criteria. A dummy variable approach has been used before by Jansen (2004). However, in her study, the dummy variables were assigned only for the 20 major oil exporters according to the definition of UNCTAD, which leaves out other smaller, but still significant oil producers. The second approach uses oil rents as the independent variable in the fixed-effects regression models and is used to verify the results that are obtained using the dummy variable approach. This approach is similar to the one in Alsharif et al. (2017). The models are estimated for both the Theil index of export diversification and the Herfindahl-Hirschmann index of product export concentration to ensure that the results are robust across alternative measures of export diversification. Following the approaches used in the previous literature, the dependent variables are log-transformed in all of the models.

Even though these approaches have been used before in this area of research, there are two key elements that distinguish the empirical strategy used in this study from the existing literature. First, I use a large unbalanced panel of 154 countries that includes both developed and least developed economies.[2] Most of the research done in the past has used relatively smaller panels or focused solely on developing economies (e.g. Osakwe & Kilolo, 2018; Jansen, 2004). Secondly, to identify the oil producers, a dummy variable is assigned to countries with oil and natural gas production valued at over \$300 per capita in a given year. This criterion was used by Ross (2019) when analyzing the historical trends of export diversification in oil-producing countries. Following the logic of Ross (2019), this low-level criterion is used to avoid only identifying the

[2]However, since the data used in the analysis is unbalanced, the estimations that use all independent variables are obtained using 115 cross-sections (countries).

most oil-dependent producers as producer economies and excluding other minor producers with a possibly higher level of export diversification. Table 5 in appendix A provides a list of the countries that were assigned a dummy variable in a given year according to this criterion.

The fixed-effects regression model is estimated as follows;

$$y_{it} = \alpha_i + \lambda_t + X_{it}\beta + u_{it} \tag{1}$$

where y_{it} is the dependent variable in logarithms (measure of export diversification), X_{it} is the vector of independent variables, β is the vector of parameters, α_i and λ_t account for country and time fixed effects respectively and u_{it} is the error term.

There are 11 independent variables in both models. Some of the independent variables used in the models were shown to have a statistically significant relationship with export diversification by previous empirical research. Other independent variables included in the models have been used to either capture the effect of oil production on export diversification or are included as omitting them could cause bias in the estimations. Section 3.1.1 briefly explains the origins of the variables and the reason for their inclusion in the models.

The country fixed-effects are used to account for unobserved variables that are different across countries but do not change over time. In contrast, time fixed-effects are used to capture unobserved variables that are the same across countries but change over time.

The models are estimated using the software package *'plm'* in R. However, as this package does not currently support any convenient method to obtain standard errors that are robust to both heteroskedasticity and autocorrelation (HAC), the results obtained by using the *'plm'* function are complemented by HAC (Arellano) standard errors obtained in gretl.

3.1 Data

As there was no existing dataset containing all of the variables used in the econometric models, the data of the different variables had to be combined from different sources. Naturally, the data sets used were of different lengths, and the countries included were conditional on the source of the data. For convenience and to ensure the validity of the robustness checks between different measures of export diversification, mutual inclusiveness of countries was used as the main criteria when combining and cleaning the data. Thus, countries that were not included in all individual datasets were discarded from the analysis. The combined unbalanced panel data consists of 154 countries and ranges from 1995 to 2014 (see appendix A, table 4 for the complete list of countries included in the analysis).

3.1.1 Independent variables

Most of the independent variables used in the fixed-effects regression models are based on the results obtained in the previous literature. The variables that are included in the models and are based on existing literature include; oil rents, population, openness to trade, real GDP per capita, quality of government, fixed telephone subscriptions, manufacturing exports and human capital. The inclusion of these variables in the models estimated in this study has two specific goals; to verify the results of the previous literature and to avoid model misspecification.

Oil rents are the sum of oil and natural gas rents and are used to identify the effect of oil value-added on export concentration following the approach of Alsharif et al. (2017), and to verify the results obtained using the dummy variable approach. The population is used as a proxy for the domestic market size, following the approach of some authors (e.g. Giri et al., 2019; Parteka & Tamberi, 2011; Osakwe & Kilolo, 2018), and is expected to have a negative relationship on export concentration. Openness to trade is proxied by trade (% GDP) and has been used before by Agosin et al. (2012), Osakwe and Kilolo (2018) and Giri et al. (2019). As was briefly discussed in the literature review, the empirical evidence does not seem to agree with the relationship between trade openness and export diversification, as both negative and positive correlations have been found with the two variables. However, I anticipate a positive relationship between these two variables, implying that trade openness increases export concentration. The logic behind this hypothesis is based on the very simplistic international trade theory mentioned earlier, where countries can increase their welfare by specializing according to their comparative advantage and importing other goods.

Real GDP per capita was included in the regression models of Giri et al. (2019) and Parteka and Tamberi (2011), but its effect was only statistically significant in the latter. This variable is included assuming that poorer economies might be predisposed to produce a smaller variety of goods due to possible technical restrictions, which obviously can translate to higher export concentration.

The quality of government and fixed telephone subscriptions are used as proxies for corruption and the quality of the country's infrastructure. Quality of government was included in the analysis of Giri et al. (2019) and was proved to have a negative and statistically significant relationship in some of their regressions. This variable is used in the models, as the quality of governments can play a massive role in the dynamic allocation of resources into different sectors, which might also have an effect on the level of export diversification. The effect of government quality may be intensified with countries that are dependent on few sectors with intense lobbying power or where these sectors are a significant source of government revenues. Telephone subscriptions were used by Osakwe and Kilolo (2018) and Giri et al. (2019). The variable is expected to have a negative relationship with export concentration. Although the use of fixed telephone subscriptions as the sole indicator of infrastructure quality may be questionable, the variable is used because it has previously been shown to have a significant impact on some of the models estimated by these authors.

Manufacturing exports, which are measured as a percentage of merchandise exports, are used in order to account for the manufacturing sectors relative importance to external trade. The manufacturing sector can be considered as a possible source of positive externalities because its innovation can often be extended to other industries, which can aid in the emergence of new industries (and thus lower the degree of export concentration). Osakwe and Kilolo (2018) used a similar approach by including the manufacturing value-added as the share of GDP in their regressions. Furthermore, human capital has been used as a possible determinant of export diversification in almost all of the empirical papers summarized in the literature review. I will use primary, secondary and tertiary school enrollment as proxies for human capital following the approach of Giri et al. (2019).

The variables that do not appear in the reviewed literature and are included in the models estimated in this final project are; natural resource rents and the dummy variable for major oil and natural gas producers. Natural resource rents include all other rents from natural resources apart from oil and natural gas. As some economies are also heavily specialized in the production and exports of coal or precious metals, it is possibly relevant to include the variable in the model. As the dummy variable is assigned according to a criterion that recognizes both oil and natural gas production, natural gas rents are included in the second model specification as an independent variable, together with oil rents. This way, the results of the two model specifications can be kept as comparable as possible. The summary statistics of the variables used in the models are shown in Table 1.

Table 1: Summary statistics.

Statistic	N	Mean	St. Dev.	Min	Max
THEIL	3,029	3.352	1.223	1.174	6.417
HHI	3,077	0.322	0.213	0.045	0.983
ICRG	2,515	0.564	0.203	0.139	1.000
Tele	3,077	18.424	18.887	0.000	74.988
oil_gas_valuePOP_2000	3,080	798.916	3,030.446	0.000	40,814.150
PRODUCER	3,080	0.210	0.408	0	1
population	3,080	40,386,545.000	139,990,452.000	217,167	1,364,270,000
PRIMARY	2,635	1.010	0.160	0.209	1.656
SECONDARY	2,214	0.763	0.310	0.053	1.623
TERTIARY	2,065	0.332	0.258	0.002	1.224
OPENNESS	2,988	0.830	0.485	0.0002	4.373
MANUFACTURING	2,655	0.431	0.317	0.00000	3.729
NAT_RENTS	3,056	0.034	0.059	0.000	0.536
GDPPC	3,061	12,647.330	18,198.890	177.130	111,915.000
OIL_RENTS	3,053	0.049	0.113	0.000	0.863

3.1.2 Data sources and further manipulation

The Herfindahl-Hirschmann index of product export concentration was obtained from the United Nations conference on trade and development (UNCTAD) data centre. The Theil index of overall export diversification came from the IMF export diversification and quality database. It should be mentioned here that the Herfindahl-Hirschmann index included both Switzerland and Liechtenstein in the same estimation, whereas in the case of the Theil index, whether the index measure included Liechtenstein in Switzerland's estimation remains unknown. However, assuming that this has little to no implications on the validity of the analysis, the Herfindahl-Hirschmann index estimation of Switzerland and Liechtenstein is included as the measure for Switzerland. In the case of Indonesia, the data was separated into two different rows; Indonesia and Indonesia (...2002) in the Herfindahl-Hirschmann index. When the data was combined, these two rows were joined. Furthermore, both export diversification measures only include data until 2011 in the case of Sudan.[3]

Population and per capita oil and gas production values were obtained from the Oil and Gas Data developed by Ross and Mahdavi (2015). Oil rents, gas rents and total natural resource rents were obtained from the World Bank's World Development Indicators database. The variable NAT_RENTS was obtained by subtracting the sum of oil and gas rents from the total natural resource rents. Therefore, the variable NAT_RENTS includes data on all other natural resources rents, except oil and gas rents.[4] The real GDP and trade (openness) data was obtained from the

[3]In 2011, South Sudan became independent from Sudan.

[4]This arithmetic operation that was performed in order to obtain the other natural resource rents resulted in

World Banks WITS database, and the manufacturing exports share from the World Bank World Development Indicators. Finally, the data on primary, secondary and tertiary school enrollment, quality of government and fixed telephone subscriptions were obtained from the QoG institute's basic dataset. Furthermore, all of the variables that were defined as shares or percentages were divided by 100 in order to express them as fractions of 100. The variables, their descriptions, sources and initial ranges are summarized in Appendix A, table 6.

4 Results and Discussion

4.1 Results with the dummy variable approach

Table 2 summarizes the results obtained using the dummy variable approach. As the data set used in this study is unbalanced, the models that contain all of the independent variables were estimated using 115 cross-sectional units. Eight out of the 11 explanatory variables have the same signs in both models. As was expected, the dummy variable (PRODUCER) that identifies major oil producer economies according to our criteria has a positive sign in both models. Its effect on export concentration is statistically significant (at 5%) in the model that uses the Theil index, but not when export concentration is measured with the Herfindahl-Hirschman index.

The population and GDP per capita have negative signs in both models, but their effects are not statistically significant. Therefore, a larger domestic market and higher demand capacity could provide a better environment for various sectors to develop, ultimately leading to more diversified exports. The negative relationship between these two variables and export concentration is consistent with the findings in the previous research. Openness has the expected positive sign and is statistically significant at 5% in both models, indicating that the more an economy trades internationally, the more concentrated its exports are on average. These results support the hypothesis presented in Section 3.1.1 and are consistent with the findings of Agosin et al. (2012). Manufacturing has a negative sign in both models and is statistically significant at 10% in the model that uses the Herfindahl-Hirschman index as the dependent variable. Therefore, countries with higher shares of manufacturing exports of their merchandise exports have more diversified exports on average, according to our estimations. These findings are consistent with the results obtained in Osakwe and Kilolo (2018).

Furthermore, the effect of human capital on export diversification seems to depend on the

some values that were negative but very close to zero. These negative values were rounded up to zero, as they were assumed to be a result of very small rounding errors in the variables provided by the World Bank.

level of education. Primary school enrollment is not statistically significant and has different signs in the two models. Thus, its effect on export diversification is ambiguous. Secondary school enrollment has negative signs in both models and is statistically significant at 10% in the model that uses the Theil index as the dependent variable. Therefore, countries with higher secondary school enrollment seem to have a more diversified export structure on average. Surprisingly, tertiary education enrollment has a positive sign and is statistically significant at 10% in both models. The effect of infrastructure quality and government quality on export diversification is ambiguous, as they both have differing signs in the two models and lack statistical significance. This may suggest that the variables chosen are poor determinants of the level of export diversification in a country. Therefore, any robust evidence of the effect of infrastructure or government quality on export diversification cannot be concluded from these estimations.

Finally, natural resource rents have the expected positive sign, and its effect is statistically significant at 5% in the model that uses the Herfindahl-Hirschman index as the dependent variable. This indicates that economies that produce other natural resources have, on average, more concentrated exports.

4.2 Results with oil rents approach

Table 3 summarizes the estimation results obtained using the oil rents approach. Again, as we deal with an unbalanced panel, the estimations were obtained using a subset of 115 countries.

The results from the second approach are very similar to the ones that were obtained using the dummy variable. In both models, the variable oil rents has the expected positive sign and is statistically significant, but more so in the model that uses the Theil index as the dependent variable. Thus, according to our estimations, the higher are the rents obtained from oil, the more concentrated are the exports on average. The population has the expected negative sign in both models, and its effect is statistically significant at 10% in the model that uses the Theil index as the dependent variable. GDP per capita also has a negative sign in both models but lacks statistical significance. The variable openness is statistically significant at 5% and has the expected positive sign in both models. Manufacturing's effect is statistically significant at 10% in the model that uses the Herfindahl-Hirschman index as the dependent variable, and it has the predicted negative sign in both models.

As for the human capital, the signs of the variables are the same as they were in the dummy variable model. Therefore, the impact of primary school enrollment on export concentration

Table 2: Estimation results with the dummy variable approach.

	Dependent variable:	
	log(THEIL)	log(HHI)
	(1)	(2)
PRODUCER	0.044**	0.096
	(0.022)	(0.083)
log(population)	−0.137	−0.150
	(0.084)	(0.194)
log(GDPPC)	−0.041	−0.082
	(0.070)	(0.175)
OPENNESS	0.090**	0.187**
	(0.036)	(0.091)
MANUFACTURING	−0.018	−0.201*
	(0.035)	(0.109)
PRIMARY	0.046	−0.035
	(0.118)	(0.234)
SECONDARY	−0.158*	−0.081
	(0.095)	(0.210)
TERTIARY	0.166*	0.431*
	(0.086)	(0.252)
Tele	−0.001	0.001
	(0.001)	(0.003)
ICRG	0.011	−0.282
	(0.106)	(0.210)
NAT_RENTS	0.283	1.308**
	(0.259)	(0.563)
Observations	1,316	1,325
Cross-sectional units	115	115
Time fixed-effects	Yes	Yes
R^2	0.191	0.121
Adjusted R^2	0.092	0.014
F Statistic	2.505*** (df = 11; 114)	2.816*** (df = 11; 114)

Note: Robust (HAC) standard errors in parenthesis. *p<0.1; **p<0.05; ***p<0.01

remains uncertain, while secondary school education has a negative sign in both models. When oil producers are identified using the oil rents approach, however, the statistical significance of secondary school enrollment has vanished from the model that uses the Theil index as the dependent variable. Tertiary education still has a surprisingly positive and statistically significant effect on export concentration. The impact of infrastructure and government quality on export concentration is still unclear, identical to the previous findings in table 2. Finally, other natural resource rents have the expected positive sign in both models, with a statistically significant impact (at 10%) when the Herfindahl-Hirschman is used as the dependent variable.

In conclusion, these estimations obtained by using the oil rents verify the results obtained in the dummy variable approach.

4.3 Limitations of the study

Using a dummy variable to identify the major oil producer countries presents some limitations to the study. As the dummy variable is assigned according to a production value per capita criteria, it establishes a cut off point between which countries are considered as major producers and the rest of the countries. Therefore, the statistical significance of this variable is conditional on the value that is used as the minimum criteria for major oil producers. Due to this reason, the results obtained with the dummy variable approach apply only to oil producers that produce more than $300 per capita in a given year. However, using oil rents may also not be ideal given how this variable is defined. As the demand for oil can be considered to be quite inelastic and the price of oil is volatile, an increase in the price in a given year might artificially make the export shares look larger while at the same time increasing the rents. Therefore, especially when the oil price is high, the export basket of oil producers may look more concentrated than before, even though the quantities exported are the same (Ross, 2019). This may question the practice of using price-sensitive indexes to assess the real level of export diversification in the case of highly concentrated oil-producers.

Furthermore, due to data limitations, not all of the variables that have been statistically important in previous studies could be used in the models. These variables should be included in the models to achieve the most reliable results, as leaving them out can cause bias in the estimation results. Also, many of the independent variables that were used in the models could potentially suffer from endogeneity. However, identifying these variables and finding proper instruments can be difficult, which is why this method was not applied in this analysis.

Table 3: Estimation results with the oil rents approach.

	Dependent variable:	
	log(THEIL)	log(HHI)
	(1)	(2)
OIL_RENTS	0.525**	0.856*
	(0.215)	(0.509)
log(population)	−0.149*	−0.169
	(0.085)	(0.196)
log(GDPPC)	−0.043	−0.082
	(0.069)	(0.175)
OPENNESS	0.086**	0.182**
	(0.036)	(0.091)
MANUFACTURING	−0.014	−0.193*
	(0.035)	(0.107)
PRIMARY	0.034	−0.056
	(0.117)	(0.232)
SECONDARY	−0.157	−0.079
	(0.095)	(0.211)
TERTIARY	0.172**	0.444*
	(0.086)	(0.252)
Tele	−0.001	0.001
	(0.001)	(0.003)
ICRG	0.007	−0.281
	(0.108)	(0.216)
NAT_RENTS	0.307	1.353**
	(0.259)	(0.563)
Observations	1,316	1,325
Cross-sectional units	115	115
Time fixed-effects	Yes	Yes
R^2	0.195	0.122
Adjusted R^2	0.096	0.015
F Statistic	2.636*** (df = 11; 114)	2.957*** (df = 11; 114)

Note: Robust (HAC) standard errors in parenthesis. *p<0.1; **p<0.05; ***p<0.01

Finally, the results obtained in Section 4 do not address the direct causality of oil production on export concentration due to possible confounding effects of oil prices and other variables. As a consequence, at this level of analysis these findings should be regarded as mere correlations between the two variables.

4.4 Discussion, policy implications and future research

The estimation results in tables 2 and 3 show that oil-producing economies' exports are relatively more concentrated than other countries. These findings are robust to two different measures of export diversification, the Theil index and the Herfindahl–Hirschman index and the variable identifying oil producers is statistically significant in three out of four models. Also, with these models, we have been able to verify some of the findings obtained in the previous research.

According to the evidence obtained from the models estimated in this final project, the low carbon transition forces oil-producing economies to apply strict economic diversification policies to guarantee sustainable GDP growth in the future. However, these policies present a trade-off between short and long term well being, as a previously profitable industry has to be gradually abandoned. The decision to move away from oil production will not be easy in the case of countries whose GDP is highly dependent on their export revenues, and the outcome of the diversification process is highly dependent on the relative competitiveness of their other sectors. Therefore, the economic policies needed to support the diversification from oil depend on each country's specific characteristics and abilities.

While using an econometric approach like the fixed-effects models estimated in Section 4 can possibly identify whether oil-producers have relatively more concentrated (less diversified) exports, it makes no contribution to the identification of the oil-producers whose economies are better suited to diversify away from oil. Thus, taking this and the limitations presented in Section 4.3 into account, future research should focus on a case-by-case analysis of heavily oil-dependent economies that assesses the total risk of low carbon transition on their future economic development and seeks to find out possible non-distorting ways to diversify away from oil.

5 Conclusions

The future export revenues of oil-producing economies are threatened by the ambitious goals devoted to the low carbon transition. In some of the biggest oil-producing countries, these export revenues represent significant shares of GDP and fiscal revenues, forcing them to find other sources of income through diversification. However, the underlying question is whether this problem extends to other relatively smaller oil producers.

This bachelor's degree final project has studied the export concentration of oil-producing countries using an unbalanced panel of 154 countries during 1995–2014. Following the practices used in previous literature, the aim of this project was to study whether oil-producing countries have more concentrated exports relative to other countries. A fixed-effects regression model was estimated using two approaches that captured the effect of oil production on export concentration. A dummy variable was assigned to countries whose oil and gas production value exceeded \$300 per capita in the first approach. The idea of using this low-level criterion was to include both the big and small but still relatively important oil producers following the logic developed by Ross (2019). The second approach followed the methods of Alsharif et al. (2017) and was used to verify the results obtained in the first approach. In both approaches, oil production was associated with higher export concentration, and the findings were robust across the two alternative measures of export diversification used. Furthermore, the effect of oil production on export concentration was statistically significant in three out of four models estimated.

These findings indicate that export concentration is a problem in major oil-producing countries that need to be addressed in light of the low-carbon transition's reduced demand for fossil fuels. Thus, these countries have to find other sources of revenues in the future in order to guarantee sustainable economic growth. However, moving away from oil production may not be easy for countries whose economic growth is highly dependent on their export revenues and whose other sectors lack international competitiveness.

As was discussed shortly in Section 4.3, this research is subject to some limitations. First, the results obtained with the dummy variable are conditional on the value that is used as the minimum criteria for major oil producers. Secondly, the second approach may not be ideal when identifying oil producer economies due to the way in how the variable is defined. Other limitations are born from the unavailability and restrictions in the data and the possible endogeneity of some variables. Furthermore, due to the possible confounding impact of oil prices and other variables, the direct causality between higher oil production and export concentration cannot be addressed, making the interpretation of the findings mere correlations at this level of analysis.

Given these limitations and the fixed-effects models' inability to recognize the unique characteristics of individual countries, future research should focus on a case-by-case country analysis that emphasizes the actual risk imposed by the low-carbon transition and the potential policies that can help to achieve more diverse exports in the future.

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A Appendix

Table 4: Full list of countries included in the data.

List of Countries			
1.	Afghanistan	2.	Albania
3.	Algeria	4.	Angola
5.	Argentina	6.	Armenia
7.	Australia	8.	Austria
9.	Azerbaijan	10.	Bahamas, The
11.	Bahrain	12.	Bangladesh
13.	Barbados	14.	Belarus
15.	Belgium	16.	Belize
17.	Benin	18.	Bhutan
19.	Bolivia	20.	Bosnia and Herzegovina
21.	Brazil	22.	Brunei
23.	Bulgaria	24.	Burkina Faso
25.	Burundi	26.	Cambodia
27.	Cameroon	28.	Canada
29.	Cape Verde	30.	Central African Republic
31.	Chad	32.	Chile
33.	China	34.	Colombia
35.	Comoros	36.	Congo, Rep.
37.	Costa Rica	38.	Cote d'Ivoire
39.	Croatia	40.	Cuba
41.	Cyprus	42.	Czech Republic
43.	Denmark	44.	Dominican Republic
45.	Ecuador	46.	Egypt
47.	El Salvador	48.	Eritrea
49.	Estonia	50.	Ethiopia
51.	Finland	52.	France
53.	Gabon	54.	Gambia, The
55.	Georgia	56.	Germany
57.	Ghana	58.	Greece
59.	Guatemala	60.	Guinea
61.	Guinea-Bissau	62.	Guyana
63.	Honduras	64.	Hungary
65.	Iceland	66.	India
67.	Indonesia	68.	Iran
69.	Iraq	70.	Ireland
71.	Israel	72.	Italy
73.	Jamaica	74.	Japan
75.	Jordan	76.	Kazakhstan
77.	Kenya	78.	Korea, Rep.
79.	Kuwait	80.	Kyrgyzstan
81.	Lao P.D.R.	82.	Latvia
83.	Lebanon	84.	Lesotho
85.	Libya	86.	Lithuania
87.	Luxembourg	88.	Madagascar
89.	Malawi	90.	Malaysia
91.	Maldives	92.	Mali

93.	Malta	94.	Mauritania
95.	Mauritius	96.	Mexico
97.	Moldova	98.	Mongolia
99.	Morocco	100.	Mozambique
101.	Myanmar	102.	Namibia
103.	Nepal	104.	Netherlands
105.	New Zealand	106.	Nicaragua
107.	Niger	108.	Nigeria
109.	Norway	110.	Oman
111.	Pakistan	112.	Panama
113.	Papua New Guinea	114.	Paraguay
115.	Peru	116.	Philippines
117.	Poland	118.	Portugal
119.	Qatar	120.	Romania
121.	Russia	122.	Rwanda
123.	Saudi Arabia	124.	Senegal
125.	Sierra Leone	126.	Singapore
127.	Slovakia	128.	Slovenia
129.	Solomon Islands	130.	South Africa
131.	Spain	132.	Sri Lanka
133.	Sudan	134.	Suriname
135.	Sweden	136.	Switzerland
137.	Tajikistan	138.	Tanzania
139.	Thailand	140.	Togo
141.	Tunisia	142.	Turkey
143.	Turkmenistan	144.	Uganda
145.	Ukraine	146.	United Arab Emirates
147.	United Kingdom	148.	United States
149.	Uruguay	150.	Uzbekistan
151.	Venezuela	152.	Vietnam
153.	Zambia	154.	Zimbabwe

Table 5: List of countries with per capita oil and natural gas production valued at over $300 (constant 2000 US$).

Country		**Per capita oil and natural gas production > $300**
1.	Algeria	1995 – 2014
2.	Angola	1995 – 1997, 1999 – 2014
3.	Argentina	2000 – 2014
4.	Australia	1995 – 1997, 2000 – 2014
5.	Azerbaijan	2000 – 2014
6.	Bahrain	1995 – 2014
7.	Belize	2008, 2011 – 2012
8.	Bolivia	2004 – 2008, 2013 – 2014
9.	Brazil	2011 – 2014
10.	Brunei	1995 – 2014
11.	Canada	1995 – 2014
12.	Chad	2005 – 2006, 2008, 2011
13.	Colombia	2005 – 2014
14.	Congo, Rep.	1995 – 2014

15.	Denmark	1995 – 2014
16.	Ecuador	2000, 2003 – 2014
17.	Egypt	2005 – 2008, 2011
18.	Gabon	1995 – 2014
19.	Iran	1995 – 2014
20.	Iraq	1997 – 2014
21.	Kazakhstan	1999 – 2014
22.	Kuwait	1995 – 2014
23.	Libya	1995 – 2014
24.	Malaysia	1995 – 2014
25.	Mexico	1996 – 1997, 2000 – 2014
26.	Netherlands	1995 – 1998, 2000 – 2014
27.	New Zealand	2000 – 2001, 2003, 2005 – 2014
28.	Nigeria	2004 – 2007, 2008, 2010 – 2014
29.	Norway	1995 – 2014
30.	Oman	1995 – 2014
31.	Qatar	1995 – 2014
31.	Russia	1995 – 2014
32.	Saudi Arabia	1995 – 2014
33.	Senegal	1995 – 2001, 2005
34.	Sudan	2008, 2010 – 2011
35.	Suriname	2005 – 2014
36.	Tunisia	2008
37.	Turkmenistan	1995 – 2014
38.	United Arab Emirates	1995 – 2014
39.	United Kingdom	1995 – 2000, 2003 – 2006, 2008
40.	United States	1995 – 1997, 1999 – 2014
41.	Uzbekistan	2000 – 2008, 2010
42.	Venezuela	1995 – 2014

Table 6: Variables, their description, sources and data range.

Variable	Variable description	Source	Range
HHI	Herfindahl-Hirschmann index of export product concentration. A higher value in the index indicates higher export product concentration.	UNCTADStat	1995 – 2018
Theil	Theil index of export diversification (Overall). A higher value in the index indicates lower export diversification (higher concentration).	IMF	1962 – 2014
population	Population, total	Ross, Michael; Mahdavi, Paasha, 2015, "Oil and Gas Data"	1932 – 2014
oil_gas_valuePOP_2000	Oil and gas value per capita in constant 2000 US dollars. Used to obtain the dummy variable 'PRODUCER'.	Ross, Michael; Mahdavi, Paasha, 2015, "Oil and Gas Data"	1932 – 2014
PRODUCER	Dummy variable assigned for countries whose per capita oil and gas production value was higher than 300 (constant 2000 US dollars) in a given year.	Ross, Michael; Mahdavi, Paasha, 2015, "Oil and Gas Data"	1932 – 2014
GDP	Gross Domestic Product, in constant 2010 US dollars.	WITS (World Integrated Trade Solution)	1988 – 2018
GDPPC	Gross Domestic Product Per Capita. Calculated by dividing the real GDP obtained from the WITS database with the population obtained from the Ross & Mahdavi Oil and Gas Data.	See above.	1995 – 2014
MANUFACTURING	Manufactures exports (% of merchandise exports)	World Bank, World Development Indicators	1962 – 2019
Oil rents	Oil rents (% GDP). Difference between the value of crude oil production and costs as a share of GDP.	World Bank, World Development Indicators	1970 – 2018
Gas rents	Natural gas rents (% GDP). Difference between the value of natural gas production and costs as a share of GDP.	World Bank, World Development Indicators	1970 – 2018
Total natural rents	Total natural resource rents (% GDP). The sum of all natural resource rents, including oil, natural gas, coal, mineral and forest rents.	World Bank, World Development Indicators	1970 – 2018
NAT_RENTS	Total natural resource rents excluding oil and gas rents. Calculated by subtracting oil and gas rents from total natural resource rents.	World Bank, World Development Indicators	1970 – 2018
OIL_RENTS	Calculated from the World Bank World Development Indicators data by summing up the oil and gas rents.	World Bank, World Development Indicators	1970 – 2018
PRIMARY	Primary school enrollment (% gross) (wdi_gerp). The variable is used as a proxy for human capital.	The QoG Institute, Basic Dataset	1946 – 2020
SECONDARY	Secondary school enrollment (% gross) (wdi_gers). The variable is used as a proxy for human capital.	The QoG Institute, Basic Dataset	1946 – 2020
TERTIARY	Tertiary school enrollment (% gross) (wdi_gert). The variable is used as a proxy for human capital.	The QoG Institute, Basic Dataset	1946 – 2020
ICRG	Indicator of quality of government (icrg_qog). This indiator rages from 0 to 1, where higher values indicate higher quality of government.	The QoG Institute, Basic Dataset	1946 – 2020
Tele	Fixed telephone subscriptions (per 100 people) (wdi_tele). Used as a proxy for infrastructure quality.	The QoG Institute, Basic Dataset	1946 – 2020
OPENNESS	Trade (% of GDP). The variable accounts for external trade dependency.	WITS (World Integrated Trade Solution)	1988 – 2018