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Assessing the role of the structure of human capital on the export diversification in 39 oil-producing countries

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Abstract

This article analyzes the effect of the human capital structure on export diversification in 39 oil-producing countries between 1995 and 2019. The estimation methods used are MCOs, GMMs, fixed effects, pooled mean group, and the GETS approach. The results show that the number of engineers measured by the number of students enrolled in the engineering, manufacturing, and construction sectors positively affects the export diversification of oil-producing countries with good governance. On the other hand, in countries where governance is bad (government effectiveness), there is a proliferation of professions related to law, commerce, and social sciences, which harms diversification. Oil-producing countries should therefore improve their government effectiveness to encourage young students to specialize more in vocational courses, which will promote diversification. Our results extend those of Murphy et al. (1991) and Ebeke and al. (2015). They are robust to several estimation methods and the alternative measure of the diversification.

1. Introduction

Oil-producing countries tend to have less diversified economies because of their dependence on oil (Auty and Gelb, 2001). According to the International Monetary Fund (IMF), in 2019, resource-rich countries had an average export concentration of 60%, compared with 40% for developed countries (IMF, 2020). Many of these countries often depend on exports of raw materials, such as oil, minerals, and agricultural products (Sachs and Warner, 1997). This explains the low level of sectoral diversification, correlated with a high level of dependence on a few sectors such as agriculture and mining (Hausmann et *al.* 2007). This weakness in the diversification of their exports makes oil-producing countries vulnerable to external economic shocks, such as fluctuations in commodity prices or financial crises (IMF, 2020). This highlights the urgent need to identify the levers needed to promote diversification in these countries. This is all the more important as export diversification has economic, social, and political benefits. On the economic level, successful diversification can boost incomes by reducing dependence on oil and reducing vulnerability to oil price fluctuations (Hesse, 2008; Callen et *al.* 2014). At the social level, jobs can be created, which will improve the quality of life by reducing poverty (Tchitchoua et *al.* 2024). In the political field, diversified countries can benefit from greater political stability (Patey, 2024), but also from greater international influence, by reducing their dependence on foreign powers (Lashitew et *al.* 2021).

Several authors have examined the question of the factors involved in successful export diversification. The conclusions of their work therefore identify structural, geographical, political, and institutional factors as potential determinants of diversification (Imbs and Wacziarg, 2003: Melitz 2003; Argosin et *al.* 2012; Parteka and Tamberi, 2013; Keneck et *al.* 2020). With particular regard to structural determinants, it is accepted that an increase in human capital (measured by the level of education) in a country generally leads to an increase in export diversification in the sense that the accumulation of human capital enables the country to change its specialization towards more sophisticated products (Melitz, 2003; Argosin et *al.* 2012; Parteka and Tamberi, 2013).

On the relationship between human capital and diversification, the economic literature teaches that the skill level of the workforce and the efforts made in education influence a country's ability to diversify its productive base, but also promote the differentiation of products (Gullstrand, 2000). Human capital facilitates the diversification of production and encourages the growth of new activities thanks to innovation. Likewise, Parteka and Tamberi (2013); and Manuel and Paula (2010) show that a high level of education is associated with a strong diversification in the production of industrial goods and services. Certainly, the previous authors are interested in the role played by human capital in the process of economic growth and diversification of exports, but none of them examines the composition of this. We must go back to the work of Murphy et *al.* (1991) to find that growth is encouraged when the most talented people become entrepreneurs rather than rent seekers because they stimulate innovation and technological development. In their empirical analysis, the authors associate entrepreneurship with engineering science training and rent-seeking activities, training in law schools. The authors find that more engineers positively affect growth, while more majors tend to reduce economic growth.

Ebeke et *al.* (2015) follow the approach of Murphy et *al.* (1991) but, unlike the latter who limited themselves to dividing human capital between entrepreneurs and rent-seekers, they show that the quality of governance in each of these countries is at the origin of the allocation of talents in this or that sector of activity. Thus, oil-producing countries with weak institutions tend to orient individuals into training aimed at capturing the oil rent while oil-rich countries

with good institutions encourage individuals to become entrepreneurs (engineers). Following these authors, we assume that the effect of the structure of human capital (number of engineers and number of lawyers) on diversification depends on the quality of the country's institutions or governance.

Admittedly, the above studies maintain that human capital (education) positively affects the diversification of exports, but none provides an empirical measure of the quality, much less the structure of education as a determinant of this diversification. This article is the first to take into account specialization in higher education as an important factor in the diversification of exports. Following the work that explains diversification in terms of human capital, our study also takes this line. Unlike these studies, which have simply measured human capital by the level of education, our analysis breaks down education by considering the influence of educational orientation on diversification. Indeed, we postulate that education systems that emphasize skills in science, technology, engineering, and mathematics can produce more productive and innovative workers, which can improve export diversification, in contrast to education systems that place more emphasis on social science training, as is the case in oil-producing countries. The expected effect of educational orientation on diversification is only possible if the institutional framework and governance system in these countries improve considerably.

In our article, we specifically analyze the effect of the structure of education on the export diversification of 39 oil-producing countries from 1995 to 2019. The estimation methods used are MCOs, GMMs, fixed effects, mean group pools, and the GETS approach. The results show that the number of engineers measured by the number of students enrolled in the engineering, manufacturing, and construction sectors positively affects the export diversification of oil-producing countries with good institutions. On the other hand, in countries where institutions are bad (government inefficiency particularly), there is a proliferation of professions related to law, commerce, and social sciences; which hurts diversification. Our results extend those of Murphy et *al.* (1991) and Ebeke et *al.* (2015).
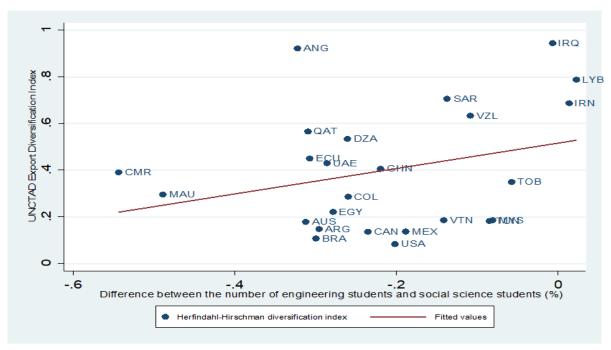
The rest of the article is structured as follows: Section two presents stylized facts, and section three states the transmission channel through which the structure of human capital influences diversification. Section four presents the data and the empirical approach. Section five discusses the results and Section 5 concludes the article.

2. Stylized facts between school orientation and export diversification

In terms of stylized facts, the figure below shows the growing relationship between the average number of engineers and the concentration (versus diversification) index of exports. In other words, when the average number of engineers increases in a country more than the average number of lawyers, there is an increase in the export concentration index; the country becomes more and more concentrated.

However, we argue that this positive relationship that we observe between engineers and the level of concentration of exports is explained by the poor quality of the institutions found in each country. The favorable effect of an increase in the number of engineers on the concentration of exports is accentuated in countries with poor institutions, while this effect is mitigated in countries with good institutions. Thus countries such as Canada, the United States, and Australia which are full of good institutions according to Kaufmann et *al.* (2009) report a negative effect of the increase in the number of engineers on the concentration of exports. In contrast, countries like Mauritius, Cameroon, Colombia, Ecuador, Angola, and many others have bad institutions and a small number of engineers combined with a high number of lawyers.

Figure I: Correlation between export diversification and the structure of human capital in oil-producing countries.

Source: The author based on UNCTAD (2020) and UNESCO (2020) data

The correlation table below links the human capital structure (number of engineers and number of lawyers) to the six quality indicators of the World Bank institutions. These indicators vary between -2.5 (poor governance) and 2.5 (better governance). We note that the correlations are signed following our expectations. We observe that the number of lawyers is negatively correlated with the government effectiveness, this means that the ineffectiveness of the government leads to an increase in the number of lawyers (Lawy.).

The number of engineers is of negative sign. We explain this observation by the fact that almost all the countries in our sample have bad governance (Kaufman et *al.* 2009). A significant number of engineers in oil-producing countries favor diversification if and only if the quality of governance is good. Otherwise (bad governance) the link between these two variables is negative.

Table I: Matrix of correlations between the structure of human capital and institutional variables

Variables	Eng.	Lawy.	St. Pol	Vx. Cit.	Corrupt.	Eff. Gov.	Reg.	RL
Eng.	**1.000**							
Lawy.	**-0.113**	**1.000**						
St. Pol	**-0.367**	**0.186**	1.000					
Vx. Cit.	**-0.320**	**0.242**	0.562	1.000				
Corrupt.	**-0.290**	**0.097**	0.811	0.727	1.000			
Eff. Gov.	**-0.254**	**-0.010**	0.726	0.696	0.929	1.000		
Reg.	**-0.330**	**0.155**	0.745	0.787	0.927	0.881	1.000	

| RL | **-0.330** | **0.055** | 0.840 | 0.698 | 0.973 | 0.874 | 0.930 | 1.000 |

3. Government effectiveness as a transmission channel of the effect of the structure of human capital on export diversification

In their study, Hanushek and Woessmann (2023) found that educational orientation affects government effectiveness. They argue that education systems emphasizing science, technology, engineering, and mathematics skills can produce more productive and innovative workers, improving government effectiveness. On the other hand, Acemoglu et *al.* (2001) argue that government effectiveness is a key factor in export diversification. These authors argue that efficient governments can implement policies to encourage export diversification. Similarly, Gylfason (2005) for example, shows that political pluralism strengthens economic diversification because democracies naturally evolve towards modern diversified production and service-oriented societies. Cuberes and Jerzmanowski (2009) show that in non-democratic countries, there are barriers to entry for new businesses which are seen as destabilizing agents of the political powers in place. Thus, countries with a low level of democracy have a higher level of sectoral concentration. Recently, Aghion et *al.* (2014) find that government effectiveness is related to innovation. They argue that efficient governments can put in place policies to encourage innovation, which can lead to export diversification.

Based on the previous analyses, we assume that educational orientation can affect export diversification through government effectiveness, by encouraging innovation and producing more productive and innovative workers.

4. Data and empirical methodology

4.1. Data

The empirical test of our previous hypothesis is based on the work of Murphy et *al.* (1991). Our variable of interest (Difference) is obtained by calculating the difference between the number of people "engineers" and the number of people "lawyers". To be more precise, engineers represent the professions of engineering, manufacturing, and construction, and "Lawyers" the professions of law, commerce, and social sciences. The variable of interest "Difference" is calculated using the following formula:

Difference = Number of engineers-Number of lawyers

The "Difference" variable is therefore defined as enrollments in engineering, manufacturing, and construction minus enrollments in law, commerce, and social sciences, and is expressed as a percentage of total enrollments in tertiary education. As Murphy et *al.* (1991), registration in law is considered in our work as an approximation of career choice in rent-seeking activities while registration in engineering is a proxy for career choice in productive activities. The variables Number of engineers and Number of lawyers are taken from the UNESCO Statistical Yearbook (2020) database. The other variables that are used in this study come mainly from WDI (2020) and WGI (2020).

4.2. Empirical methodology: the model

The specification of the model we use is inspired by the work of Omgba (2014). The functional form of the model is as follows:

$$H = f(Difference, X)$$

With X which is the matrix of control variables; H, the Herfindahl-Hirschman export concentration index. Concretely, the model to be estimated is written.

$$HH_i = \alpha + \beta Difference_i + \gamma Gov.effec * Difference_i + X'_i\delta + \mu_i + \varepsilon_i$$

The endogenous variable HH_i is the average concentration index (versus diversification) of Herfindahl-Hirschmann exports from country i between 1995 and 2019. The choice of this indicator to capture diversification is inspired by the literature (Lederman and Maloney, 2007, Omgba, 2015). The HH index is taken from the UNCTAD database (2020) and covers the 1995 to 2019 period. This index is calculated using the formula:

$$HH_i = \frac{\sqrt{\sum_{j=1}^{n}\left(\frac{x_j}{X}\right)^2}-\sqrt{1/n}}{1-\sqrt{1/n}}$$

x_j represents the value of exports of product j such that $X = \sum_j^n x_j$ and n the number of product groups taken into account according to the Standard International Trade Classification in its 3rd revision.

$Difference_i$ measures the number of engineers in the country i minus the number of lawyers in the same country. The expected sign of the coefficient **β** attached to the Difference variable is positive. $Gov.effec * Difference_i$ denotes the variable crossed between government effectiveness and our "Difference" variable of interest in country i. The expected sign of the coefficient attached to this interaction variable **γ**, should be negative. Briefly, we show that the effect of talent allocation (human capital structure) on diversification is not direct. This effect depends on the quality of governance, more precisely on the government effectiveness. A country that combines a large number of engineers and bad governance records a low level of export diversification while a country that has good governance records a low level of concentration. The analysis is symmetrical when we take the side of the "Lawyers". A state in which the governance is bad therefore tends to direct the training of individuals in the fields of law and social sciences (Ebeke et *al.* 2015).

ε_i and μ_i denote respectively the error term and the region-fixed effects which capture the unobservable heterogeneity specific to the regions.

The matrix X consists of the standard control variables used to explain diversification in economic theory. These are economic, historical, institutional, and socio-cultural variables. All of these control variables are taken from WDI (2020).
Regarding institutional (or governance) variables, we have retained the six indicators of institutional quality that can be found in the WGI database (2020).

Table II presents descriptive statistics for all of the variables used in the regressions. We observe that on average, the countries in our sample have more "lawyers" than "engineers", 13.88 and 26.03 respectively. The comparison of the values of the mean and the standard deviation of each job category shows a great heterogeneity in the observations because the differences between means and standard deviation are considerable. These differences are respectively 7.029 for engineers and 16.468 for lawyers. In other words, the variance of observations in each category (lawyers and engineers) is very large from one country to another in the sample. About the six governance indicators that we have retained, we find that on average the countries in our sample have bad institutions when we disregard the USA, Canada, and Australia. Whether it is the rule of law, government efficiency, regulation, corruption control, political stability, or the citizen's voice, all of these indicators are bad on average with average values of -0.44; -0.40; -0.38; -0.39; -0.53, and -0.59 respectively.

Table II: Descriptive statistics

VARIABLES	Obs	Average	Std. deviation	Minimum	Maximum
		Economic variables			
Diversification index Exp. H-H	39	0.46	0.26	0.08	0.94
GDP/head in logarithm	38	8.99	1.19	6.11	11.72
GDP per capita^2 in logarithm	38	82.28	21.62	37.40	137.4
Commercial opening	39	4.24	0.54	3.16	5.47
Investment	39	3.70	3.69	2.32	26.07
Mineral rent	38	15.60	15.53	0	48.11
IDE	39	3.73	4.49	-0.00	26.82
		Historical. political and geographical variables			
Malaria	37	5.11	7.51	0.00	23.33
Latitude	37	0.20	0.14	0.011	0.66
Legal origin	39	0.30	0.46	0	1
French colonial origins	39	0.17	0.38	0	1
British colonial origins	39	0.20	0.40	0	1
		Governance variables			
Control of corruption	39	-0.38	0.94	-2.01	1.66
Government effectiveness	39	-0.40	0.89	-1.68	1.85
Corruption control	39	-0.39	0.90	-1.54	2.00
Rule of law	39	-0.44	0.94	-1.68	1.76
Citizens' Voice	37	-0.59	0.92	-1.98	1.49
Political stability	39	-0.53	0.94	-2.28	1.02
		Socio-cultural variables			
Engineers	**26**	**13.88**	**6.851**	**3.722**	**31.29**
Lawyers	**26**	**26.03**	**9.562**	**11.25**	**51.53**
Language	39	0.42	0.30	0.01	0.89
Religion	39	0.43	0.28	0.00	0.82
Ethnic fragmentation	31	0.38	0.29	0.01	0.85
Log education	39	14.0	1.67	9.97	16.9
Log population density	39	16.6	1.51	13.36	19.52

Source: The author

5. Presentation and discussion of results

5.1. Baseline results of the conditional effect of the structure of human capital on diversification.

Now we are empirically testing the hypothesis that the effect of the structure of human capital on diversification is a function of the quality of governance in general and the government effectiveness in particular. Table III presents the results obtained when our interest variable is crossed with the government effectiveness indicator. To implement this technique we were inspired by Ebeke et *al.* (2015) which, to analyze the conditional effect of oil rent on the allocation of talent between different business sectors, interacts with the indicator of the level of governance and the variable that measures oil rent .

Table III: Conditional effect of the structure of human capital on diversification: the role of government effectiveness

	UNCTAD concentration (versus diversification) index				
VARIABLES	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*
Gov.effec*Difference	-0.016***	-0.008*	-0.009*	-0.011**	-0.011*
	(0.005)	(0.005)	(0.005)	(0.004)	(0.006)

Difference	**0.008*****	**0.008*****	**0.008*****	**0.009*****	**0.013*****
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Log GDP/head^2	-0.209***	-0.261***	-0.279***	-0.283***	-0.230***
	(0.039)	(0.036)	(0.038)	(0.042)	(0.054)
Log GDP/head		0.062***	0.064***	0.059**	0.068**
		(0.019)	(0.020)	(0.024)	(0.022)
Commercial opening			0.091	0.086	0.162
			(0.073)	(0.104)	(0.108)
Investment			-0.011***	-0.010***	-0.013*
			(0.001)	(0.002)	(0.006)
Mineral rent				0.020	0.049
				(0.027)	(0.031)
Population density				0.003	-0.340
				(0.030)	(0.198)
IDE					-0.038
					(0.021)
Education					0.362*
					(0.192)
SSA	0.329**	0.459***	0.377***	0.398***	0.385**
	(0.145)	(0.123)	(0.119)	(0.116)	(0.132)
ASIA	0.183*	0.175**	0.102	0.107	0.117
	(0.047)	(0.345)	(0.397)	(1.007)	(1.255)
Constant	0.245***	-1.726	-1.921	-2.104	0.137
	(0.0414)	(1.564)	(1.783)	(2.342)	(2.392)
Observations	39	39	39	39	39
R^2	0.624	0.742	0.801	0.807	0.870

Standard deviations are in brackets; $***p < 0.01$, $**p < 0.05$, $*p < 0.1$.
Source: The author

The results show that, the sign attached to the coefficient of the interaction variable (*Gov. effec* * *Difference)* is in line with our expectations. This coefficient is negative and significant at 1% (column 1) and then 5% (columns 2 to 4); which means that an increase in the average number of engineers in a country improves the level of diversification of exports when the government is efficient. Government effectiveness here measures the quality of public service; the quality of the civil service and its degree of independence from political pressure; the quality of the formulation and implementation of economic policies and the degree of credibility of the government in such policies. Our results extend those of Murphy et *al.* (1991) and de Ebeke et *al.* (2015)

Table IV: Conditional effect of the structure of human capital on diversification: control of institutional variables.

VARIABLES	UNCTAD concentration index (versus diversification)				
	(1)	(2)	(3)	(4)	(5)
Gov.effec*Difference	**-0.002****	**-0.010****	**-0.001**	**-0.002****	**-0.001**
	(0.001)	**(0.001)**	**(0.001)**	**(0.001)**	**(0.001)**
Difference	**0.273*****	**0.314****	**0.230**	**0.220****	**0.218**
	(0.077)	**(0.154)**	**(0.169)**	**(0.108)**	**(0.132)**
Rule of Law	-0.245***				
	(0.063)				
Citizen's voice		-0.241***			
		(0.070)			
Regulation			-0.238***		
			(0.055)		
Corruption				-0.306***	
				(0.073)	
Political Stability					-0.240**

					(0.092)
Log GDP/head^2	-0.540	-0.010	-0.275	-0.728	-0.622
	(0.364)	(0.331)	(0.379)	(0.440)	(0.530)
Log GDP/head	0.039*	0.008	0.025	0.051*	0.042
	(0.020)	(0.018)	(0.021)	(0.025)	(0.029)
Commercial Opening	0.195*	0.018	0.129	0.175	0.116
	(0.107)	(0.096)	(0.132)	(0.122)	(0.129)
Investment	-0.015***	-0.008**	-0.006	-0.013***	-0.010**
	(0.003)	(0.003)	(0.004)	(0.003)	(0.004)
Mineral rents	0.052**	0.046	0.033	0.045	0.017
	(0.021)	(0.027)	(0.029)	(0.031)	(0.034)
Population density	-0.514**	-0.584**	-0.493**	-0.418**	-0.574*
	(0.197)	(0.256)	(0.197)	(0.182)	(0.287)
IDE	-0.041**	-0.011	-0.015	-0.037	-0.022
	(0.018)	(0.021)	(0.024)	(0.024)	(0.030)
Education	0.550**	0.599**	0.513**	0.456**	0.540
	(0.198)	(0.246)	(0.210)	(0.189)	(0.305)
SSA	0.283***	0.344**	0.250***	0.270**	0.228
	(0.077)	(0.154)	(0.069)	(0.108)	(0.132)
ASIA	0.080	-0.025	0.096	0.050	0.162*
	(0.106)	(0.119)	(0.087)	(0.101)	(0.086)
Constant	1.768	0.583	0.975	2.319	3.698
	(1.904)	(2.361)	(1.745)	(2.133)	(3.131)
Observations	39	39	39	39	39
R^2	0.895	0.877	0.882	0.879	0.835

Standard deviations are in brackets; $***p < 0.01$, $**p < 0.05$, $*p < 0.1$.

Source: The author

The previous analysis only considered one governance indicator among the six that we selected. Now, we take into account each of the indicators to identify among the 05 others remaining (except the efficiency of the government) those whose not taken into account could somewhat bias our first results. Table IV's results show that the coefficient associated with the interaction variable *"Gov.effec * Difference"* is negative and significant at 5% when we control by rule of law, citizen voice, and corruption control. In other words, the improvement in these three indicators of the quality of institutions in one of the countries in our sample translates into a positive effect of the average increase in the number of engineers on the diversification of its exports. In summary, in addition to the government effectiveness, the rule of law, the citizen voice, and the control of corruption are indicators of governance that each oil-producing state must imperatively and as a priority to improve to register an increase. The number of engineers is relatively higher than the increase in the number of lawyers. This increase will have the effect of promoting the diversification of exports from these States.

5.2. Sensitivity test

We study the sensitivity of our results by taking into account historical, geographical, and socio-cultural variables, which according to empirical studies are likely to directly or indirectly influence the diversification of exports. These include latitude (Gallup et *al.* 1999; Sachs, 2001), religion, language, ethnic fragmentation (Alesina et *al.* 2003); malaria (Acemoglu et *al.* 2001), and finally colonial and legal origin (Laporta et *al.* 1999; Beck et *al.* 2003).

The results that we obtained are recorded in Table V from column 1 to column 8 of this table, we gradually introduce legal origin, political stability, colonial origin, latitude, malaria, religion, ethnic fragmentation, and language. We observe that the coefficient of our variable of interest does not change sign, it remains negative and significant at 1% (columns 1, 5, 6, 7, 8) and 5% (columns 2,3,4).These sensitivity tests therefore show that the coefficient associated with our variable of interest retains not only its sign but also its level of significance thus validating our hypothesis.

Table V: Sensitivity tests of the effect of the human capital structure on the H-H concentration index of exports.

VARIABLES	UNCTAD concentration index (versus diversification)							
	Legal/colonial origin			Geography		Socio-cultural		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Gov.effec*Difference	**-0.014****	**-0.014****	**-0.015****	**-0.013****	**-0.015*****	**-0.014****	**-0.014****	**-0.015****
	(0.005)	**(0.006)**	**(0.005)**	**(0.006)**	**(0.004)**	**(0.005)**	**(0.006)**	**(0.006)**
Difference	0.001	0.002	0.002	0.001	0.003	0.001	0.001	0.003
	(0.003)	(0.004)	(0.004)	(0.004)	(0.003)	(0.004)	(0.004)	(0.004)
Gov.effec	-0.183***	-0.150*	-0.0917	-0.191***	-0.178***	-0.183***	-0.174***	-0.141***
	(0.049)	(0.078)	(0.084)	(0.043)	(0.033)	(0.046)	(0.036)	(0.046)
British Colonies			-0.228**					
			(0.099)					
French colonies			-0.197					
			(0.141)					
Legal origin	0.005							
	(0.130)							
Political stability		-0.041						
		(0.075)						
Latitude				0.177				
				(0.276)				
Malaria					-0.030***			
					(0.007)			
Language						0.040		
						(0.235)		
Ethnic fragmentation							0.172	
							(0.190)	
Religion								-0.287
								(0.202)
Basics variables	**yes**	**yes**	**Yes**	**Yes**	**Yes**	**Yes**	**yes**	**yes**
Fixed effects Region	**yes**	**yes**	**Yes**	**Yes**	**Yes**	**Yes**	**yes**	**yes**
Constant	0.332***	0.319***	0.535***	0.272**	0.353***	0.326***	0.276***	0.378***
	(0.073)	(0.073)	(0.108)	(0.123)	(0.069)	(0.086)	(0.095)	(0.087)
Observations	39	39	39	39	39	39	39	39
R^2	0.643	0.648	0.722	0.650	0.784	0.644	0.660	0.682

Standard deviations are in brackets; $***p < 0.01$, $**p < 0.05$, $*p < 0.1$.
Source: The author

5.3. Robustness Analysis

5.3.1. Estimation using the General-to-specific approach (GETS)

According to Ding and Knight (2011), the GETS (General-to-Specific) approach is an econometric and statistical method used for modeling model uncertainty in the same way as BMA. We specify that we implement this method by drawing on the work of Clarke (2014). In addition, we estimate two models. The former has as its endogenous variable the UNCTAD export diversification index or Herfindahl-Hirschmann index, while the latter has the endogenous variable the IMF diversification index or Theil index.

The results contained in Table VI confirm the solidity of our initial hypothesis, namely: the effect of the structure of human capital (number of engineers and number of lawyers) on diversification depends on the quality of the country's institutions. Our main variable of interest is significant at 1%. We have introduced all the control variables (economic, institutional, geographic, socio-cultural, and political) likely to explain diversification. Only the significant variables appear in the result recorded below.

Table VI: Robustness with the GETS approach

	UNCTAD diversification index IMF's index(Theil)	
VARIABLES	(1)	(2)

Goveffec*Difference	**-0.010***	**-0.059***
	(0.003)	**(0.014)**
Difference	**0.188***	**1.310***
	(0.036)	**(0.199)**
Population density	0.105**	
	(0.041)	
Education	-0.174***	-0.829***
	(0.038)	(0.227)
Investment	0.005**	0.065***
	(0.002)	(0.012)
Log GDP/head^2		-0.065***
		(0.011)
Settler mortality	0.259***	1.757***
	(0.028)	(0.155)
Legal origin	-0.214***	-1.544***
	(0.057)	(0.256)
Corruption	0.159***	1.028***
	(0.036)	(0.219)
Citizens' Voice	-0.269***	-1.726***
	(0.040)	(0.250)
Political Stability	-0.153***	-0.619***
	(0.022)	(0.154)
Mineral rents		0.308***
		(0.094)
IDE		-0.043**
		(0.019)
Log GDP/head	0.162***	
	(0.043)	
Constant	-1.371***	-3.616*
	(0.459)	(1.863)
Observations	39	38
R^2	0.951	0.964

Standard deviations are in brackets; $***p < 0.01$, $**p < 0.05$, $*p < 0.1$.
Source: The author

We observe that the variables that explain diversification vary depending on the index used to measure it (see Table VI, columns 1 and 2). We therefore consider that a variable is relevant if it appears in the 2 columns; in other words, it has a 100% chance of explaining diversification. The variables that appear in one of the two columns then have a 50% chance only of explaining the diversification of exports. The significant variables in the 2 columns are *Goveffec * Difference*, Education, Investment Mortality settlers, Legal origin as well as the six governance indicators which are political stability, the rule of law, corruption control, the citizen voice, government effectiveness, and regulation. These results then reflect the persistent effect of the structure of human capital (our variable of interest) which has a 100% chance of explaining diversification in the same way as investment, the mortality of the settlers, and the institution's quality indicators.

5.3.2. Correction of endogeneity problems

We can be criticized for not having taken into account the variability between the individuals in the panel (country) which, generally, is the origin of the bias of the variables omitted in the cross-section regressions. In addition, endogeneity problems can arise from the omission of certain important explanatory variables from the possible correlation between our exogenous variables or even from double causality. To this end, we propose to carry out a panel estimation. Table VII gives the results obtained from a pooled estimate (column 1), fixed effects (column 2), and GMM (column 3).

We note that the sign of the coefficient attached to our variable of interest (*Gov. effec * Difference*) is always negative and significant at 1 (column 1) and 5% (columns 2, 3), which means that the effect of an increase in the number of engineers on the concentration (diversification) of exports remains positive (negative). When students from oil-producing countries specialize in engineering and civil engineering, this has a positive effect on the diversification of exports for countries with good governance. We explain this result by the bad institutions that these countries have. It should also be noted that all the control variables introduced into the regression have the expected signs. Our results are robust to the change in econometric estimation techniques. They extend the results of Murphy et *al.* (1991) and Ebeke et *al.* (2015). All control variables have the expected values.

Table VII: Conditional effect of the structure of human capital on diversification: panel estimates, fixed effect, and GMM

	Concentration index (versus diversification) of CNUCED		
	Pool	Fixed effect	GMM
VARIABLES	(1)	(2)	(3)
Gov.effec*Difference	-0.278***	-0.538**	-0.012**
	(0.092)	(0.238)	(0.005)
Difference	0.094***	0.321***	0.059*
	(0.023)	(0.106)	(0.0294)
Goveffec	-0.314***	0.111**	-0.249***
	(0.055)	(0.049)	(0.072)
Log GDP/head^2	-1.546***	-5.759***	-1.003*
	(0.441)	(1.947)	(0.521)
Log GDP/head	0.008*	0.002	0.005
	(0.004)	(0.003)	(0.004)
Commercial opening	0.087	0.099	0.051
	(0.087)	(0.071)	(0.110)
Investment	-0.007***	0.067	-0.005**
	(0.002)	(0.053)	(0.002)
Mineral annuity	0.035	0.015	0.068*
	(0.033)	(0.028)	(0.036)
Population density	-0.001*	0.008**	-0.015*
	(0.007)	(0.003)	(0.007)
IDE	0.020**	-0.012**	0.006
	(0.009)	(0.005)	(0.010)
Constant	6.397**	34.87***	4.564
	(2.602)	(11.73)	(2.711)
Observations	966	962	969
Regional fixed effect	Yes	Yes	Yes
R^2	0.772	0.994	
AR1			0.052
AR2			0.83
Number of instruments			70
Number of id			39

Standard deviations are in brackets; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
Source: The author

6. Conclusion

In this article, we analyze the conditional effect of the structure of human capital on the diversification of exports from 39 oil-producing countries from 1995 to 2019. To this end, we are carrying out several sensitivity tests by taking into account historical, institutional, and

socio-cultural variables. Robustness tests are also carried out by first using a GETS approach in which we also used an alternative diversification index. Secondly, we take into account endogeneity problems. To do this, we estimate our model by the GMM method. The hypothesis advanced is robust and consistent with the abundant literature on the effect of human capital on economic performance.

This study finds its originality as being one of the first which, based on the work of Murphy et *al. (*1991) and Ebeke et *al.* (2015) provides empirical evidence of the composition of human capital on diversification. In addition, this article presents the potential channel through which the structure of human capital is measured here as enrollments in engineering, manufacturing, and construction minus enrollments in law, commerce, and social sciences, (expressed as a percentage of total enrollments in tertiary education) can affect the level of diversification of oil-producing countries: it is the quality of institutions and particularly the efficiency of government.

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Appendices

Appendix 1: Description of variables and data sources

Variables	Description	Data source
H-H concentration index	Herfindahl-Hirschmann export concentration (diversification) index (0 = low concentration and 1= high concentration)	UNCTAD, (2020)
Theil concentration index	Theil export concentration (diversification) index (Cadot et al.2011)	World Economic Outlook database
The population density in 1500	The population density in 1500	(Acemoglu et al.(2001)
Legal origin	Legal origin: 1 if civil law legal origin and 0 otherwise	La Porta (1999)
French colonial origin	Colonial origin: 1 if France and 0 otherwise	La Porta (1999)
British colonial origin	Colonial origin: 1 if Great Britain and 0 otherwise	La Porta (1999)
Language	The probability that two people taken at random do not speak the same language	Alésina et al, (2003)
Religion	The probability that two people taken at random are not of the same religion	Alésina et al, (2003)
Ethnic fragmentation	The probability that two people taken at random do not belong to the same ethnic group	Alésina et al, (2003)
Latitude	Distance from the equator	Acemoglu et al (2002).
IDE	Foreign direct investment as % of GDP	WDI, (2020)
Oil rent	Oil rent as a percentage of GDP	WDI, (2020)
Income annuity	Natural resource rents as a percentage of GDP	WDI, (2020)
Education	Enrolment rate in secondary education as a percentage	WDI, (2020)
Investment	Gross fixed capital formation as a percentage of GDP	WDI, (2020)
Government effectiveness	Government effectiveness (-2.5 = poor and 2.5 = good)	WGI, (2020)
Corruption	Measures the quality of corruption control in the country (-2.5=poor and 2.5=good)	WGI, (2020)

Rule of law	Quality of law (-2.5=poor and 2.5=good)	WGI, (2020)
Citizens' Voice	Citizens' vote (-2.5=poor and 2.5=good)	WGI, (2020)
Political stability	Political stability (-2.5=poor and 2.5=good)	WGI, (2020)
Commercial opening	Measures the share of foreign trade in Gross Domestic Product	WDI, (2020)
Population density (logarithmic)	Measures the size of the total population in a country each year	WDI, (2020)
GDP/head in logarithm	GDP per capita in logarithm (in purchasing power parity)	WDI, (2020)

Source: The author

Appendix 2: List of countries

Algeria, Angola, Argentina, Saudi Arabia, Australia, Brasilia, Cameroon, Colombia, Tchad, Rep. Of Congo, Central African Republic, Ecuador, Emirats Arabe Unis, Equatorial Guinea, Rep. Dem. Of Congo, Egypt, Gabon, Ghana, Iran, Iraq, Kazakhstan, Kuwait, Libya, Mexico, Malaysia, Nigeria, Peru, Qatar, Sudan, Syria, Thailand, Trinidad and Tobago, Turkmenistan, Tunisia, United Arab Emirates, Venezuela, Vietnam and Yemen.

Appendix 3 : Justification of the study period

We have limited our study period between 1995 and 2019 for two main reasons. Concerning the lower limit, i.e. 1995, the UNCTAD export diversification index that we use is only calculated and available from 1995 onwards. Moreover, the 1990s marked a decisive turning point in terms of the democratization of the majority of African countries. This can therefore explain the level and quality of governance in these countries. In this study, given that we show that the effect of the structure of human capital on diversification depends on the quality of governance and that the latter is dependent on the waves of democratization recorded in African countries from 90 onwards, this is why we have chosen 1995 as the lower bound of our study. The upper bound, 2019, was chosen because the data on the structure of human capital in terms of education (schooling orientation) provided by UNESCO are only available up to that date. For some years now, this international institution has been undergoing restructuring; as a result, some of its activities have slowed down somewhat, but should resume at the end of this restructuring phase.