OIL RENTS, INSTITUTIONAL DEVELOPMENT, AND TOTAL FACTOR PRODUCTIVITY

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ABSTRACT

This paper investigates the determinants of total factor productivity (TFP) using a panel data model involving 15 petroleum exporting countries during the period 2008-2019. The econometric evidence, based on the Arellano-Bond generalized method of moments, shows that: 1) education raises TFP, which suggests that highly qualified workers are more able to develop new technologies and absorb existing technologies, 2) oil rents lower TFP, which is consistent with the natural resource curse (NRC) hypothesis and, therefore, with the view that rent-seeking and corruption prevent some oil-rich nations from prospering, and 3) the interaction term involving oil rents and institutional development yields a positive effect on TFP, which means that imposing the rule of law, eradicating corruption, and improving regulatory quality can effectively contribute to reversing the negative effect of oil abundance on TFP.

Keywords: Total factor productivity, oil rents, education, institutional development.

JEL Classification: C23, O47, Q33.

RENTA PETROLERA, DESARROLLO INSTITUCIONAL Y PRODUCTIVIDAD TOTAL DE LOS FACTORES

RESUMEN

Este trabajo evalúa los determinantes de la productividad total de los factores (PTF), empleando un modelo de datos en panel que involucra a 15 naciones exportadoras de petróleo durante el periodo 2008-2019. La evidencia, basada en el método generalizado de momentos en la versión del estimador Arellano-Bond, demuestra que: 1) la educación eleva la PTF, pues permite a la fuerza laboral desarrollar tecnologías propias y asimilar tecnologías foráneas; 2) la renta petrolera disminuye la PTF, lo cual es consistente con la teoría de la maldición de los recursos naturales que se materializa vía la actividad rentista y la corrupción en naciones como México, y 3) la interacción de la renta petrolera y el desarrollo institucional incrementa la PTF, lo cual significa que fortaleciendo el estado de derecho, combatiendo la corrupción y mejorando el entorno regulatorio podría revertirse el efecto negativo de la renta petrolera sobre la PTF.

Palabras clave: productividad total de los factores, renta petrolera, educación, desarrollo institucional.

Clasificación JEL: C23, O47, Q33.

1. INTRODUCTION

This paper analyses the effects of oil rents and institutional development, among other variables, on total factor productivity (TFP). The link between oil rents and TFP lies in the natural resource curse (NRC) hypothesis, which is supported by the evidence that some resource-rich countries, such as Mexico, Nigeria, and Ecuador, have consistently exhibited lower growth rates of Gross Domestic Product (GDP) per capita than some resource-poor countries, such as the four Asian Tigers: Hong Kong, Singapore, South Korea, and Taiwan. Therefore, the curse lies in the counterintuitive finding that natural resource abundance often leads to lackluster economic performance rather than the opposite.

Most investigations within the NRC tradition focus on the link between natural resource abundance and output growth, whereas this paper eval-

uates the relationship between oil rents and TFP growth. On the other hand, most empirical studies about the determinants of TFP have paid little attention to the impact of natural resource wealth. Therefore, this paper contributes to filling this small gap in the empirical literature. Along these lines, we find that:

1. TFP has a predetermined component (or historical inertia) because the lagged value of TFP is a key driver of the current value.
2. Education raises TFP while oil rents lower it. To the extent that oil rents themselves have a negative influence on TFP, we find some evidence in favor of the NRC hypothesis.
3. However, when oil rents interact with institutional development the effect on TFP is positive, which indicates that the NRC can be reversed by improving the different dimensions of governance (corruption control, the rule of law, regulatory quality, and the like). The rationale of this finding is that institutional development prevents rent-seeking behavior, patronage, and other forms of corruption.

In contrast, when the institutional framework is weak, the huge money inflows generated by oil abundance, induce private agents and government officials to engage in rent-seeking activities (Oomes and Kalcheva, 2007). This is because rent-seeking activities are sometimes more profitable than entrepreneurial endeavors, so oil-rich nations find themselves over-whelmed by individuals and corporations trying to obtain much more than what they give to society in return. By extracting undue benefits, rent-seekers drive down TFP and thus economic growth.

Our empirical evidence is based on a panel data model consisting of 15 petroleum exporting countries over the 2008-2019 period[1]. The model is estimated through the Arellano-Bond dynamic panel Generalized Method of Moments (GMMs), which is consistent, free of endogeneity problems (which makes it unbiased), and basically needs no information regarding residual behavior (Arellano and Bond, 1991; Baltagi, 2008, pp. 147-155).

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[1] The countries included are Angola, Bahrain, Ecuador, Gabon, Indonesia, Iran, Iraq, Kuwait, Malaysia, Mexico, Nigeria, Norway, Qatar, Russian Federation, and Saudi Arabia.

The rest of this paper is organized as follows. Section 2 is a brief review of the literature on the NRC, whereas Section 3 deals with the determinants of TFP growth. Section 4 describes the data and performs the econometric analysis. Finally, we summarize the findings and formulate some policy recommendations.

2. NATURAL RESOURCE ABUNDANCE AND ECONOMIC GROWTH

In the postwar period, the mainstream view among economists was that natural resource endowments were a blessing rather than a curse, as they could pave the way for the industrialization process (Lewis, 1955; Rostow, 1959, pp. 4-5). This notion was based on the experience of countries such as Australia, Norway, and the United States, which have been able to benefit from their natural resource wealth through sound institutional frameworks and policies (Frankel, 2010, pp. 12-13). In this context, Prebisch (1950) highlights a negative aspect of resource wealth that could lessen economic development, which is that commodity prices are volatile and exhibit a downward trend *vis-à-vis* manufacturing prices. For resource-dependent governments, price volatility, in turn, leads to sizeable variations in export proceeds and public revenues (Gylfason, 2011, p. 8). Under these circumstances, when commodity prices are high, resource-rich nations tend to overborrow and set the stage for severe financial crises, which materialize as falling prices erode their payment capacity (Mansoorian, 1991).

A stronger wave of disagreement with the natural resource blessing (NRB) theory emerged in the early 1980s, mainly inspired by the Dutch disease argument (Badeeb, Lean, and Clark, 2017). The term Dutch disease stems from the negative secondary effects of the discovery of vast natural gas reserves in the Netherlands in 1959 (Corden, 1984). As the exports of natural gas grew over the next years, so did the country's cash inflows. The increased cash inflows gave rise to real currency appreciation, thereby making imports cheaper and exports more expensive. In this context, the Dutch manufacturing sector found it harder not only to sell its products abroad but also in the domestic market, so the country's natural gas sector expanded to the detriment of the manufacturing sector (Frankel, 2010; Allcott and Keniston, 2018).

Although the real exchange rate mechanism is a plausible explanation of the Dutch disease, the learning by doing (LBD) theory illustrates why

the expansion of the commodity sector is outweighed by the contraction of the manufacturing sector. Put simply, the manufacturing sector entails more LBD activities, generates more positive externalities, provides stronger forward and backward production chains, and has more potential for export growth and for attracting foreign direct investment (FDI) than the commodity sector (Sachs and Warner, 1995; Gylfason and Zoega, 2006).

The NRC theory generalized the findings of the Dutch disease to a wide range of countries. The seminal paper of Sachs and Warner (1995) shows that countries specialized in oil and natural gas tend to grow slower than countries specialized in manufacturing. In the NRC strand of the literature, we can also pinpoint the following papers: Ross (2001), Gylfason and Zoega (2006), Papyrakis and Gerlagh (2007), Bornhorst, Gupta, and Thornton (2009), Bekkers and Pennink (2018), and Asif *et al.* (2020).

In this manner, Ross (2001) estimates a panel data model involving 113 countries over the 1971-1997 period to show that oil-rich countries are prone to patronage and corruption. By studying the behavior of 85 nations from 1965 to 1998, Gylfason and Zoega (2006) provide evidence that natural resource wealth lowers savings, investment, and economic growth, whereas well-developed institutions may alleviate the curse by enhancing efficiency. Using data from 1986 through 2001 for the US economy, Papyrakis and Gerlagh (2007) find that as the ratio of primary sector production to GDP rises, investment, human capital, and international openness go down.

Using panel data involving 30 countries over the period 1992-2005, Bornhorst, Gupta, and Thornton (2009) provide robust evidence that higher government revenues generated by the energy sector may lead to lower revenues from other sectors of the economy. In the case of Tanzania, Bekkers and Pennink (2018) conduct semi-structured interviews with numerous agents involved in the natural gas industry. Their conclusion is that seven factors must be addressed to avoid the NRC: Government quality, education and knowledge, local participation, revenues, transparency, the rule of law, and financial management. Lastly, Asif *et al.* (2020) evaluate the impact of different measures of natural resource rents on the financial development of Pakistan, using time series observations from 1975 to 2017. Their results support the financial resource curse

hypothesis, which means that oil and natural gas rents reduce private sector domestic credit in the long run.

Another strand of the literature is the one finding no evidence of the NRC. In this regard, the following papers stand out: Alexeev and Conrad (2009), Allcott and Keniston (2018), Bjørnland, Thorsrud, and Torvik (2019), and Abdulahi, Shu, and Khan (2019). Alexeev and Conrad (2009) estimate a series of cross-section regressions for the year 2000, using a sample of 64-to-82 countries. After including a set of geographical dummy variables and an indicator of institutional quality (*i.e.*, the rule of law) to reduce the omitted-variable bias, they conclude that oil and other mineral resources have a positive impact on GDP per capita.

To properly analyze the case of Norway over the 1982-2016 period, Bjørnland, Thorsrud, and Torvik (2019) separate the effects of oil price booms from the effects of oil production increases. While simply collecting windfall gains arising from higher prices may replicate the Dutch disease, oil production expansions can raise productivity levels in many industries. Therefore, according to these authors, oil abundance can be a major driver of GDP growth to the extent that the natural resource sector crowds in other industries through production linkages and knowledge spillovers. Combining data regarding oil and gas endowments with microdata on manufacturing firms from 1969 through 2014, Allcott and Keniston (2018) find no evidence that the recent progress in the US oil industry, which is mainly associated with the use of new techniques for drilling and fracking, has been at the expense of the manufacturing sector. In short, they reject the NRC hypothesis for the US economy.

Lastly, Abdulahi, Shu, and Khan (2019) resort to panel data regarding 14 nations over the 1998-2016 period. All these nations belong to sub-Saharan Africa and are rich in natural resources. In this context, through the bootstrap methodology, they identify the existence of threshold effects associated with institutional quality. Put differently, when institutional quality is beyond a certain threshold, resource endowments are a blessing rather than a curse. Mehlum, Moene, and Torvik (2006) reach a similar conclusion; that is, strong institutions are the key for natural resource abundance to be a blessing. The rationale is that sound institutions and policies allow the necessary resources to be allocated to the development of the commodity industries, mainly by preventing rent-seeking practices, patronage, and other forms of corruption.

In a detailed survey of the literature, Badeeb, Lean, and Clark (2017) analyze the different measures of resource wealth and their impact on different indicators of economic performance, other than GDP growth. They analyze a total of 17 empirical papers assessing the influence of resource abundance on variables such as human capital, education, investment, and savings. Among those papers, only Farhadi, Islam, and Moslehi (2015) place productivity as a dependent variable. So, there is a lack of research about the link between natural resource endowments and TFP. In this regard, Farhadi, Islam, and Moslehi (2015) specify TFP growth equations and proceed to evaluate the interaction between five different types of government intervention and resource rents. To that end, these authors rely on a sample of 99 countries and quinquennial observations over a forty-year interval (1970-2010). The five different channels of government intervention considered are economic freedom, corruption control, per capita stock of paved roads, government consumption as a share of GDP, and political rights. Our paper differs from Farhadi, Islam, and Moslehi (2015) in at least two respects:

1. We include human capital formation as an explanatory variable, which proves to be a source of TFP growth and thus a key factor to forestall the curse.
2. Farhadi, Islam, and Moslehi (2015) assess the influence of one channel of government intervention at a time. While this is good to reduce multicollinearity, it can give rise to miss-specification problems because all the channels of government intervention operate simultaneously. In contrast, our research considers several channels at the same time.

3. CONCEPT AND DETERMINANTS OF TOTAL FACTOR PRODUCTIVITY

3.1. The concept of TFP

First, to give some insight regarding TFP and TFP growth, we resort to a Cobb-Douglas production function similar to that of Mankiw, Romer, and Weil (1992):

$$Y = A(\mathbf{Z})K^{\alpha}H^{\beta}L^{\gamma} \qquad [1]$$

Where Y is aggregate output, L is labor, and K and H are physical and human capital, respectively. While labor relates to the number of workers

or number of hours worked, human capital has to do with the qualifications of the labor force. Moreover, A is TFP and $\mathbf{Z}$ denotes a vector of variables, which are assumed to be the main drivers of TFP. Solow (1956) defines the TFP level as the part of output that is unaccounted for by the production inputs. In this context, the level of TFP reflects the extent to which the inputs of production are properly used (Comin, 2010). The next step is to divide both sides of Equation [1] by L:

$$y = \frac{A(\mathbf{Z})}{L}\left(\frac{K}{L}\right)^{\alpha} H^{\beta} L^{\gamma} L^{\alpha} = A(\mathbf{Z})k^{\alpha}H^{\beta}L^{(\gamma+\alpha-1)} \qquad [2]$$

Where y is output per worker and k is capital stock per worker or the capital-labor ratio. Taking logs on both sides of the equation yields:

$$\ln y = \ln A(\mathbf{Z}) + \alpha \ln k + \beta \ln H + (\gamma + \alpha - 1)\ln L \qquad [3]$$

By differentiating each variable with respect to time we get:

$$\frac{\dot{y}}{y} = \frac{\dot{A}(\mathbf{Z})}{A(\mathbf{Z})} + \alpha\frac{\dot{k}}{k} + \beta\frac{\dot{H}}{H} + (\gamma + \alpha - 1)\frac{\dot{L}}{L} \qquad [4]$$

From Equation [4], we can infer two things: First, the growth rate of output per worker ($\dot{y}/y$) depends on TFP growth [$\dot{A}(Z)/A(Z)$], the growth rate of the capital-labor ratio (*i.e.*, capital deepening), and the growth rate of the other two production inputs: Human capital and labor. Second, TFP growth (TFPG) explains the growth rate of output per worker beyond the contribution of capital deepening and the growth in human capital and labor. In this context, if we assume constant returns to scale and perfect competition in the input markets (Comin, 2010), TFPG can be computed through the Solow residual (SR):

$$SR = TFPG = \frac{\dot{A}(\mathbf{Z})}{A(\mathbf{Z})} = \frac{\dot{y}}{y} - S_k\frac{\dot{k}}{k} - S_H\frac{\dot{H}}{H} - S_L\frac{\dot{L}}{L} \qquad [5]$$

Where S_k, S_H and S_L stand for the shares of capital deepening, human capital, and labor in aggregate output, respectively. Thus, TFPG accounts for the difference between the growth rate of output per worker and the

weighted average growth rate of human capital, labor, and the capital-labor ratio. Within this framework, two precisions are in order: 1) although Equations [1] through [5] explain how TFP growth can be understood and measured, as we explain below, we rely on the Penn World Tables version 10.0 to gather information about this and some other variables; and 2) Equation [5] is just a growth accounting representation, which means that the drivers of TFP growth must be identified through a review of the empirical literature.

3.2. The determinants of TFP

The next step is to identify the main drivers of TFP growth by reviewing the econometric literature on the subject. Based on a comprehensive literature review, Kim, Loayza, and Meza-Cuadra (2016) and Kim and Loayza (2019) identify five major drivers of TFP growth: Innovation, education, market efficiency, public infrastructure, and institutions. Innovation can be thought of as the generation of a new idea meeting two requirements: 1) it can be given practical use through a technological device, and 2) it can lead to the creation of a new product, service, or process; or to the improvement of the existing ones. In empirical work, innovation has been measured by research and development (R&D) expenditure, or by the number of patents granted, among other variables. Moreover, Turyareeba *et al.* (2018) shows that innovation is an important source of TFP growth.

By the same token, education influences TFP growth by facilitating not only the assimilation and diffusion of foreign technologies but also the development of domestic technologies. Such a conclusion has been substantiated by several investigations, which measure education through average years of schooling (Bronzini and Piselli, 2009), through school attainment (Barro and Lee, 2013), and through the ratio of education expenditure to GDP (Kim and Loayza, 2019). In fact, Turyareeba *et al.* (2018) also point out the importance of education as a source of TFP growth.

Market efficiency is another determinant of TFP growth because it allows enterprises and workers to shift out of low-productivity industries and into high-productivity industries at a reasonable adjustment cost. According to Blanes (2002), the adjustments costs comprise three types

of costs: 1) the costs of moving production inputs from one industry to another, 2) the costs of putting capital and labor to a different use, and 3) the unemployment of capital and labor resulting from price and wage inflexibilities. The leading indicator of market efficiency is the World Bank Doing Business Score, which measures the extent to which the laws and the regulatory environment of a country allow economic agents to set up new businesses, obtain construction permits, have access to credit, fulfill fiscal obligations, enforce contracts, file bankruptcy, and the like (Djankov, McLiesh, and Klein, 2004). Along these lines, Turyareeba *et al.* (2018) show that excessive regulations and rigorous employment protection legislations bring down allocative efficiency and, therefore, discourage productivity growth.

The provision of public infrastructure is another determinant of productivity growth, given that well-functioning highways, airports, power generation and transmission facilities, telecommunications networks, water supply systems, and so on, are essential for firms to operate efficiently and for households to satisfy their needs. Loayza and Odawara (2010) provide empirical evidence regarding the positive effects of infrastructure expenditure on the Egyptian GDP per capita, even though a portion of that expenditure is not properly used due to rent-seeking activities, poor supervision of infrastructure works, unfavorable concession agreements to the private sector, and other forms of corruption.

Finally, the quality of public institutions bears a positive influence on productivity and GDP growth (Kim and Loayza, 2019). To measure the strength of an institutional framework, the World Bank and the Political Risk Group rely on six indicators (or six dimensions of governance): Voice and accountability, political stability and absence of violence, government effectiveness, regulatory quality, the rule of law, and corruption control.

4. EMPIRICAL ANALYSIS OF TFP GROWTH

The next step is to specify the model, describe the data, and perform the econometric analysis. To specify the model, we rely on economic theory, the recent empirical literature, and the availability of suitable data. Therefore, our benchmark specification takes the following form:

$$TFP_{it} = \gamma TFP_{it-1} + \mathbf{X}'_{it}\beta + \mu_i + v_{it} \qquad [6]$$

Where the subscripts i and t stand for the country and the year, TFP_{it} is total factor productivity, γ is a first-order autoregressive parameter, $\mathbf{X}'_{it}$ is a row vector of six explanatory variables, β is a column vector containing the corresponding parameters, μ_i is a cross-section error term capturing the heterogeneity among countries, and v_{it} is a combined error term that changes across countries and across time. The presence of the lagged dependent variable (TFP_{it-1}) in Equation [6] implies that we are dealing with a dynamic panel data model and, therefore, the effects of the regressors contained in $\mathbf{X}'_{it}$ are conditional on the past behavior of TFP. Moreover, the variables included in vector $\mathbf{X}'_{it}$ are the following:

1. H_{it} = Human capital index as a proxy for education. Such an index measures the average years of schooling and returns to education.

2. ID_{it} = Composite variable of institutional development, which captures the changes in the performance of six dimensions of governance: Government effectiveness, regulatory quality, the rule of law, corruption control, voice and accountability, and political stability and absence of violence. According to Feenstra, Inklaar and Timmer (2015), regulatory quality is a measure of the government's talent to generate laws, regulations, and policies to stimulate private investment and entrepreneurial activities in general. Therefore, regulatory quality captures de "ease of doing business" and works better than the Ease of Doing Business Score because for the latter there is not enough data. On the other hand, our composite variable of institutional development includes the other five dimensions of governance, which is useful to bring down multicollinearity problems[2] and thus to improve efficiency. Lastly, the composite variable reflects the countries´ rank, with 100 representing the highest rank and 0 the lowest.

3. OR_{it} = Oil rents as a share of GDP, which is our measure of oil abundance. According to the World Development Indicators, oil rents are the difference between the value of crude oil production at current prices and the cost of producing it. Such a difference is then expressed as a share of the country's GDP.

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[2] Put differently, the use of a composite variable allows us to reduce the number of variables of the model, so as to keep it parsimonious.

4. K_{it} = Gross capital formation as a share of GDP, which captures the expansion of all fixed assets of the economy together with the net changes in inventories. It includes improvements in machinery, equipment, and infrastructure such as roads, railways, airports, industrial and commercial facilities, and so on. This variable was selected because it captures changes in two determinants of TFP: Capital stock and infrastructure. Therefore, it allows us to lessen multicollinearity problems.

5. $OR_{it} * ID_{it}$ = An interaction term involving the previous two variables: Oil rents and institutional development. This is aimed at assessing whether and, if so, to what extent, institutional development is helpful in taking advantage of oil abundance. As Bjørnland, Thorsrud, and Torvik (2019) point out, oil production expansions can raise productivity levels in many sectors. In this context, our interaction term is intended to evaluate the degree to which institutional development can contribute to preventing rent-seeking behavior and corruption, which in turn could be helpful to improve technology in the oil industry, create production chains, generate positive externalities, and, ultimately, "crowd in" other industries.

6. $TECH_{it}$ = Value added by the medium- and high-tech manufacturing industries as a share of the overall manufacturing sector value added. This variable turned out to be a better proxy for innovation than the other two alternatives: R&D expenditure as a share of GDP, on the one hand, and the number of patent applications, on the other. Unfortunately, in the case of these two variables, there is no data for all the countries of the sample, and/or there is no data for some of the years of the reference period.

For each variable of the model, we gathered annual data from 2008 to 2019 for 15 petroleum exporting nations. To estimate Equation [6], we resort to the Arellano-Bond GMMs, which is designed for a dynamic panel data model. In this context, Equation [6] has three potential problems: 1) the dependent variable (TFP_{it}) tends to be correlated with μ_i, so the lagged dependent variable (TFP_{it-1}) may also be correlated with μ_i; 2) the lagged dependent variable (TFP_{it-1}) may be correlated with v_{it}, and 3) one or more variables in vector $\mathbf{X}'_{it}$ may be endogenous and hence correlated with v_{it}. Any of these problems would result in biased and presumably inconsistent estimations. To eliminate the correlation

between TFP_{it-1} and μ_i, Arellano and Bond reformulate the model in first differences:

$$\Delta TFP_{it} = \gamma \Delta TFP_{it-1} + \Delta \mathbf{X}'_{it}\beta + \Delta v_{it} \qquad [7]$$

Where Δ denotes the first difference operator. To remove the possible correlation between any of the explanatory variables in [7] and the new disturbance term (Δv_{it}), the Arellano-Bond GMMs generates a series of instruments, which are given by the appropriate lags of the explanatory variables "in levels" (*i.e.*, the lags of TFP_{it-1} and the lags of $\mathbf{X}'_{it}$). These instruments meet the requirement of being highly correlated with the regressors and, at the same time, uncorrelated with Δv_{it}. Through this procedure, the endogeneity problem is eradicated. Furthermore, when the number of cross-section units (N) is greater than the number of time periods (T) in the panel, the Arellano-Bond estimator is not only a good remedial measure to endogeneity problems, but it is also consistent and, to a certain degree, needs no information regarding the behavior of the error term (Arellano and Bond, 1991; Baltagi, 2008, pp. 147-155). Notwithstanding all these advantages, as can be seen in Tables 1 and 2, we resort to remedial measures addressing both serial correlation and heteroscedasticity.

Along these lines, in the case of each variable, we gathered annual data from 2008 to 2019 for the 15 petroleum exporting countries previously mentioned. Appendix 1 displays all the information regarding data sources and measurement units. Table 1 reports the unadjusted estimated panel regression model.

According to Table 1, only the estimated coefficients of the following variables are statistically significant: The lagged dependent variable (ΔTFP_{it-1}), education (ΔH_{it}), and the interaction term involving oil rents and institutional development ($\Delta OR_{it}*\Delta ID_{it}$). However, the estimated model depicted in Table 1 is an unadjusted model and, to a certain degree, the number of explanatory variables gives rise to multicollinearity problems, which in turn raise the estimated standard deviations of the estimated parameters and, therefore, lower the t-statistics (in absolute value) and raise the probability values. Therefore, multicollinearity problems reduce the statistical significance of some estimated coefficients. Moreover, we are dealing with measurement errors and distortionary

Table 1. Unadjusted dynamic panel data model

Dependent variable: ΔTFP_{it}

Econometric method: The Arellano-Bond GMMS complemented with a white period instrument weighting matrix and white period coefficient standard errors and covariance (degrees of freedom corrected)

Variable	Coefficient	Standard error	t-Statistic	Probability values
ΔTFP_{it-1}	0.564829	0.126731	4.456919	0.0000
ΔH_{it}	0.559727	0.234098	2.390992	0.0179
ΔID_{it}	−0.008879	0.008163	−1.087716	0.2782
ΔOR_{it}	−0.003155	0.005690	−0.554567	0.5799
ΔK_{it}	0.004469	0.003614	1.236471	0.2180
$\Delta OR_{it}*\Delta ID_{it}$	0.000603	0.000204	2.948465	0.0036
$\Delta TECH_{it}$	0.000239	0.004075	0.058664	0.9533

Notes: 1/ Δ is the first difference operator. 2/ A probability value lower than 0.10 indicates that the estimated coefficient is statistically significant.

Source: Own estimations based on data from Penn World Table (PWT), version 10.0, the World Bank Development Indicators, the World Bank Worldwide Governance Indicators, and The Competitive Industrial Performance (CIP) database of the United Nations Industrial Development Organization (UNIDO).

effects. For instance, the impact of gross capital formation as a share of GDP (ΔK_{it}) is difficult to evaluate due to ineffective regulation of infrastructure works, inefficient (or disadvantageous) concession contracts to private enterprises, and rent-seeking activities in general (Loayza and Odawara, 2010). Along these lines, we conducted a battery of redundant (and even omitted) variable tests, which allowed us to arrive at an adjusted panel regression model (see Table 2).

Although the Arellano-Bond estimator is consistent, robust to endogeneity problems, and basically requires no information concerning the behavior of the residuals (Arellano and Bond, 1991; Baltagi, 2008, pp. 147-155), to further improve efficiency we utilized a white period instrument weighting matrix and white period coefficient standard errors and covariance. A white period instrument weighting matrix

Table 2. Adjusted dynamic panel data model

Dependent variable: ΔTFP_{it}

Econometric method: The Arellano-Bond GMMs complemented with a white period instrument weighting matrix and white period coefficient standard errors and covariance (degrees of freedom corrected)

Variable	Coefficient	Standard error	t-Statistic	Probability values
ΔTFP_{it-1}	0.477806	0.032660	14.62978	0.0000
ΔH_{it}	0.103752	0.061779	1.679415	0.0949
ΔOR_{it-1}	−0.002412	0.001017	−2.370437	0.0189
$\Delta OR_{it}*\Delta ID_{it}$	0.000308	1.48E-05	20.85300	0.0000

Notes: 1/ Δ is the first difference operator. 2/ A probability value lower than 0.10 indicates that the estimated coefficient is statistically significant.

Source: Own estimations based on data from Penn World Table (PWT), version 10.0, the World Bank Development Indicators, the World Bank Worldwide Governance Indicators, and The Competitive Industrial Performance (CIP) database of the United Nations Industrial Development Organization (UNIDO).

combined with a white period coefficient covariance method is a good remedial measure for any remaining problems of serial correlation and heteroscedasticity. So, we obtained an even more efficient estimation of the parameter estimates.

From Table 2, we can infer that the panel data model is indeed dynamic, given that the coefficient of the lagged dependent variable (ΔTFP_{it-1}) is statistically significant at the 1% level. Therefore, the effect of the other regressors on TFP is conditional on the historical trajectory of the dependent variable. In this context, education (ΔH_{it}) rises TFP, given that its estimated coefficient is positive and statistically significant at the 10% level. Furthermore, oil rents (ΔOR_{it-1}) have a negative estimated parameter, which is statistically significant at the 5% level. Thus, oil rents lower TFP. The negative impact of oil rents on TFP takes some time to materialize and that is the reason why this variable is lagged one period. In any event, the negative relationship between oil rents and TFP is consistent with the NRC hypothesis.

Another important finding is that the interaction term involving oil rents and institutional development ($\Delta OR_{it}{}^{\star}\Delta ID_{it}$) has a positive estimated coefficient, which is statistically significant at the 1% level. This evidence strongly indicates that the NRC can be reversed by improving the different dimensions of governance (corruption control, the rule of law, government effectiveness, regulatory environment, and the like). The rationale of this evidence is that institutional development is effective in preventing rent-seeking behavior, patronage, and other forms of corruption.

5. CONCLUSIONS AND POLICY IMPLICATIONS

This paper makes use of a dynamic panel data model to study the main drivers of TFP. The panel consists of annual observations from 2008 to 2019 for 15 petroleum exporting countries. The model is estimated through the Arellano-Bond GMMs, which means that: 1) the estimator is robust to endogeneity problems (*i.e.*, it is an unbiased estimator), 2) it is consistent, and 3) it basically requires no information about the behavior of the model's residuals (Arellano and Bond, 1991; Baltagi, 2008, pp. 147-155). Nonetheless, to further improve efficiency (*i.e.*, to address any remaining problems of serial correlation and heteroscedasticity) we employed a white period instrument weighting matrix coupled with a white period coefficient covariance method.

Most papers addressing the NRC are focused on the relationship between natural resource abundance and GDP growth, whereas our paper is aimed at the link between oil rents and TFP growth. On the other hand, the literature review shows that most investigations regarding the determinants of TFP pay little attention to the role played by oil rents or even natural resource abundance. Therefore, our paper is intended to fill this small gap in the empirical literature. In this context, our main findings are the following:

1. TFP seems to have a strong predetermined component, given that current TFP strongly depends on past TFP.
2. Education increases TFP, which is consistent with the view that a more qualified labor force is more able to develop domestic technology and absorb foreign technology. This econometric evidence highlights the

need to invest more in formal education and in short- and long-term training programs. In fact, rather than being wasted through rent-seeking activities, patronage and corruption, a portion of the oil proceeds could be systematically invested in formal education, training, and the whole system of knowledge transfer. Such a policy could contribute to building a more diversified economy and to reducing the reliance on the energy sector, given that oil prices are inherently unstable and that oil deposits are limited.

3. Oil rents discourage TFP, which is consistent with the NRC hypothesis. The rationale behind this finding is that when the rule of law is compromised and anti-corruption policies are ineffective, the money inflows stemming from oil price increases, or even from oil production expansions, induce individuals and firms to engage in rent-seeking behavior (Oomes and Kalcheva, 2007). This, in turn, may lead to the NRC.

4. Finally, as Table 2 shows, the estimated coefficient of the interaction term involving oil rents and institutional development is positive and statistically significant at the 1% level. Put differently, oil rents raise TFP when they interact with institutional development. This finding is consistent with the fact that some oil-abundant countries, such as Norway, Kuwait, and Qatar, have consistently raised GDP per capita by means of a strong institutional framework, which in turn leads to sound economic policies. Along these lines, it is well established that TFP is a leading source of GDP growth (Mankiw, Romer, and Weil, 1992; Caselli, 2005).

As the reader may recall, to bring down the omitted-variable bias without raising multicollinearity, we make use of a composite variable of institutional development reflecting changes in six different dimensions of governance: Government effectiveness, regulatory quality, the rule of law, corruption control, voice and accountability, and political stability and absence of violence. In this context, improving these dimensions of governance is key to preventing rent-seeking activities and corruption in general, thereby reversing the NRC. Countries need to promote sound anti-corruption policies, which means strengthening the rule of law, accountability, and transparency. At the same time, improving regulatory quality is paramount, given that this dimension of governance is closely related to market efficiency and, therefore, to TFP growth. As

stated before, market efficiency entails low-adjustment costs, which in turn allow firms and workers to switch out of low-productivity sectors and into high-productivity sectors. ◄

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APPENDIX 1

Description of variables, measurement units and data sources

Variable	Measurement unit	Data sources
Total factor productivity (TFP_{it})	Level of TFP at current Purchasing Power Parities (USA = 1)	Penn World Table, version 10.0
Human capital index (H_{it})	Based on years of schooling and returns to education	Penn World Table, version 10.0
Institutional development (ID_{it})	Composite variable averaging the performance of six dimensions of governance	World Bank Worldwide Governance Indicators
Oil rents (OR_{it})	Percentage of GDP	World Bank Development Indicators
Gross capital formation (K_{it})	Percentage of GDP	World Bank Development Indicators
Value added by medium and high-tech manufacturing ($TECH_{it}$)	Percentage of manufacturing value added	The Competitive Industrial Performance (CIP) database of the United Nations Industrial Development Organization (UNIDO)