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The Impact of Natural Resources on Innovation

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Abstract

Nowadays, innovation considered as the most important factor, which can affect economic growth extraordinary. Therefore, investigating the effect of variables affecting innovation has priority. In this study, we try to investigate 1) the natural resource curse hypothesis and 2) the effect of institutional quality on the way in which natural resources affects innovation. To investigate these goals, we choose countries that categorized as the efficiency-driven based on the global competitiveness report (2017) during the period 2011-2016 and use GMM estimator to estimate the model. The results show that while the effect of natural resources on innovation is negative in those countries, which confirms the resource curse hypothesis, but the impact of natural resources interaction with institutional quality is positive. These results emphasizing the importance of institutional quality as a groundwork for the way in which other variables can be effective.

Keywords: Natural Resources, Institutional Quality, Innovation.

JEL Classification: E02, O13, P28.

1. Introduction

Based on the discussion of Gylfason (2008), the impact of natural resources on economic growth can be divided into direct and indirect one. While the direct effect is supposed to be positive, the indirect effect is expected to be negative. The reason for this is due to the impact of natural resources on the other factors, which affects economic growth. In the other words, natural resource abundance's negative effect on the other factors of production influences the

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economic growth negatively at the end of the causal chain. For example, based on a discussion of Cockx and Francken (2016), there is an inverse relationship between natural resource dependence and education spending. Therefore, the final effect of natural resources on economic growth is vague. Nowadays, innovation is one of the most important factors of production and the effect of natural resources on this factor is determinative on the growth of countries with natural resource abundance. Therefore, in this paper, we try to investigate the impact of natural resources on innovation separately and also through the governance indicator. In fact, our main question concerning the effect of natural resources in a situation that institutional quality improved. To investigate this question, we choose a sample to consist of countries which categorized as efficiency-driven in the global competitiveness report (2017) during the period 2011-2016. The reason behind this sample choosing is related to the importance of these countries in developing process. The global competitiveness report categorize countries in three stage of development which named as factor-driven, efficiency-driven and innovation-driven. In this classification, the efficiency-driven countries are those that give their best to move to the next level. Therefore, the obstacles in front of their developing process are more important than other categories. The main contribution of this study can be divided in to two parts. First, investigating the effect of natural resources on innovation through institutional framework is not considered by the similar studies. Second, the results of this study can weaken or support the Gylfason (2008) theory about the negative effect of natural resources on GDP through other factors of production.

The rest of this study organized as follows: In section 2 literature review is presented and in section 3 we investigate theoretical framework. In section 4 the methodology of data analyzing process is represented. Section 5 dedicated to the nature of datasets, and construction of the sample. The estimation results represent in section 6 and the study's conclusions discuss in section 7.

2. Literature Review

Natural resources considered to be the blessing for the development process. Notwithstanding, the experience of countries like Nigeria and

Sierra Leon shows the opposite. In fact, countries with natural resource abundance may be engaged with the "natural resource curse" phenomenon which can destroy the production factors in those countries. Nowadays, innovation considered as one of the most important factors in economic growth. However, based on the study of Welsch (2008), natural resource abundance had an inverse effect on innovation in 77 countries in the period 1965-1998. Papyrakis and Gerlagh (2005) emphasize the negative effect of natural resources on innovation. In their model, natural resources reduce the incentive of innovators to engage in innovative activities for two reasons: first, the discovery of resource reserve reduces the need to support consumption through labor income and therefore increase leisure and reduces work effort. Secondly, resource wealth negatively affects the allocation of entrepreneurial activity between the manufacturing and the innovative sector in favor of the former. Also, according to Olsson (2007), natural resource abundance might lead to a crowding-out of labor from the formal sectors, such as innovative activities, to the appropriative struggle, which depresses growth. This viewpoint is matched with the study of Sachs and Warner (2001) which shows that profits generated by abundant natural resources will inspire potential entrepreneurs engaged in the primary market and resource industries to become natural resource rent-seekers rather than creators. On the other hand, Guo et al. (2016) identify that the negative impact of resource curse on economic growth transmitted through lowering the innovation and technological progress.

The negative effect of natural resources on innovation is obvious from the above studies. Still, how some countries, like Norway, did not experience such negativity is the absent concept in those studies. To answering this question we consider the interaction of natural resources with institutional quality to test whether institutions are an important factor to prevent the negative effect of a resource curse. This viewpoint is the major difference between our study and those we discussed above.

3. Theoretical Framework

The framework used in this paper is an extension of Romer (1990) which made by Welsch and Eisenack (2002) and Welsch (2008). In this model we consider an economy consists of a manufacturing sector, a technology sector, a resource sector and an immortal household. The innovation process carried out by the technology sector which its outcome shows up as an expansion of the number of capital in different types and denoted by A. Therefore, our production function is as follows:

$$Y = L_Y^{\alpha}.N^{\beta}.\int_0^A K_i^{\gamma}\, di \; (\alpha,\beta,\gamma > 0) \tag{1}$$

Where Y= Output, L_Y= Labor employed in production, N= Natural resource input, K_i =input of the capital of type $i\epsilon[0,A]$ and $\alpha + \beta + \gamma = 1$. Parameter β denotes the intensity of natural resources and the larger β, the more heavily the economy relies on natural resources in the production process.

Also, the growth of the capital varieties is described as follows:

$$\dot{A} = \theta.L_A.A \tag{2}$$

Where L_A= Labor employed in research, and $\dot{A} = {dA}/{dt}$. And, it is clear that $L = L_A + L_Y$.

To consider the household we adopt Ramsey rule for the growth of rate of consumption:

$$\hat{C} = {r - \rho}/{\eta} \tag{3}$$

Where $\hat{C} = {\dot{C}}/{C}$ is the growth rate of consumption, r is the interest rate and η is the inverse value of the elasticity of intertemporal substitution, which exhibits a constant elasticity of marginal utility.

While we assuming the perfect competition in the manufacturing sector, but the technology sector is composed of different firms, each identified with one variety of capital good. Therefore, the number of firms in the technology sector changes as A evolves in time.

Therefore, in equilibrium the growth rate of A is as follows:

$$\hat{A} = \frac{u\theta L - \alpha\rho + [\eta - 1]\rho.\beta}{u + \alpha\eta + \left[\left(2 + \frac{u}{\alpha}\right)\eta - 1\right].\beta} \qquad (4)$$

Where $u = \gamma.(1 - \gamma)$.

As it is clear from the equation (4), β has a negative effect on knowledge accumulation only if the elasticity of marginal utility is sufficiently low. In fact, a large value of η implies a declining trajectory of resource utilization whose long-term negative effect on output can only be avoided by knowledge formation. Therefore, a sufficient condition for a negative overall effect of resource intensity on knowledge formation is $(2 + {u}/{\alpha})\eta > 1 > \eta$, i.e., the elasticity of marginal utility is less than unity, but not too small. Outside of this range, the effect may have either sign.

However, As Olsson (2000) mentioned, one of the most important factors which affect the way in which other variables influence the innovation is institutional structure. In fact, the institutional framework is the groundwork that natural resources affect innovation process. Accordingly, it is expectable that improvement in institutional quality leads to improvement in the ways which natural resources hit innovation. Therefore, the interaction of natural resources and institutional quality is the prominent factor.

Now, equation (4) can be written in a concise way as follow:

$$\hat{A} = f(HC, NAT) \qquad (5)$$

Also, to consider the viewpoint of Olsson (2000), equation (5) can be written as following too:

$$\hat{A} = f(HC, NAT * INS) \qquad (6)$$

Where, HC= human capital, NAT= natural resources and INS= institutional quality.

4. Methodology

Based on a discussion of Romer (1990), Weitzman (1998) and Olsson (2000), Innovation is a dynamic process, which means that the lagged value of innovation is an important variable to be considered. Also, because of the limiting period of the data lead us to use GMM estimator in this study. In this method, the general form of the regression equation is as follows:

$$y_{it} = \beta y_{i,t-1} + U_{it} \tag{7}$$

$$U_{it} = \mu_i + \nu_{it} \tag{8}$$

Where $\nu_{it} \sim IID(0, \sigma_\nu^2)$ and $\mu_i \sim IID(0, \sigma_\mu^2)$ are independent of each other and among themselves. Since y_{it} is a function of μ_i, it follows that $y_{i,t-1}$ is also a function of μ_i. Therefore, the OLS estimator will be biased and inconsistent even if the ν_{it} are not serially correlated (Baltagi, 2008).

To overcome this problem Arellano and Bond (1991) used the first difference of (7). Hence, our new equation will be:

$$y_{it} - y_{i,t-1} = \beta\left(y_{i,t-1} - y_{i,t-2}\right) + \left(\nu_{it} - \nu_{i,t-1}\right) \tag{9}$$

Also, they suggest using instrument variables to resolve the correlation between error term and fitted value of the dependent variable. Therefore, if T=3, then y_{i1} can be a valid instrument because of its intense correlation to $(y_{i3} - y_{i2})$. Continuing this process, it is clear that $\left(y_{i1}, y_{i2}, \dots, y_{i,T-2}\right)$ are valid instruments for t=T. Also, to include differential error terms in (9), the W_i matrix can be defined as follows:

$$W_i = \begin{bmatrix} [y_{i1}] & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & \left[y_{i1}, \dots, y_{i,n-2}\right] \end{bmatrix} \tag{10}$$

In this case, the matrix of instrument variables are $W = [W_1', \dots, W_k']'$ (Baltagi, 2008).

Nevertheless, Blundell and Bond (1998) found that the first-difference-estimator of GMM is biased with small T. To fix this problem, Arellano and Bover (1995) and Blundell and Bond (1998) suggesting the GMM system estimator. This estimator combines the standard set of equations in first difference with lagged levels as instruments, with an additional set of equations in levels with lagged first differences as instruments which suggest that the inclusion of current and lagged values of regressor in the instruments will improve the results (Bond et al., 2001). And it is more efficient than GMM difference estimator and reduces the bias of limited samples. Therefore, the GMM system estimator's matrix is as follows:

$$W_i^+ = \begin{bmatrix} W_i & 0 & 0 & 0 & \dots & 0 \\ 0 & \Delta y_{i2} & 0 & 0 & \cdots & 0 \\ 0 & 0 & & \ddots & \vdots & \vdots \\ \vdots & \vdots & & & & \\ \cdot & \cdot & & \dots & & \Delta y_{i,T-1} \end{bmatrix} \tag{11}$$

Where W_i in (11) is the matrix of equation (10).

For running the system GMM estimator, we use xtabond2 command (Roodman, 2009) in Stata 14. Although, Sargan and Hansen's test is used to test the over-identification restrictions under the null of instrument validity.

5. Data and Model Specification

Innovation: Based on the definition of Mortensen and Bloch (2005), innovation can define in four categories as follows:

- **Product Innovation:** A good or service that is new or significantly improved. This includes significant improvements in technical specifications, components and materials, software in the product, user-friendliness or other functional characteristics.
- **Process Innovation:** A new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software.
- **Marketing Innovation:** A new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing.
- **Organizational Innovation:** A new organizational method in business practices, workplace organization or external relations.

In this study, we choose output sub-index of Global Innovation Index (GII) as a proxy of innovation because of 1) its knowledge creation and distribution measurement within economies which is the suitable index for innovation and 2) it covers the product and process innovation definition of Mortensen and Bloch (2005). Global Innovation Index (GII) is the widest dataset which covers 127 economies since 2009. This dataset combines different variables to produce input and output sub-indexes which can be considered as the factor of innovation production and outcome this process respectively. However, because of the methodological changes which made since 2011, the previous data is useless. Therefore, our studying period starts from 2011.

Natural Resources: In this study, we use total natural resource rent data which produce by WDI as a proxy of natural resources. Based on the definition of WDI, Total natural resources rents are the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents. Based on the study of Welsch (2008) and Papyrakis and Gerlagh (2005) we expect the negative effect of this variable on the innovation process.

World Governance Indicator: World Bank define governance as follow: Governance consists of the traditions and institutions by which authority in a country is exercised. This includes the process by which governments are selected, monitored and replaced; the capacity of the government to effectively formulate and implement sound policies; and the respect of citizens and the state for the institutions that govern economic and social interactions among them. As it is clear, this dataset coverage almost all the aspects of government activities and therefore could be an appropriate proxy for institutional structure. Based on the discussion of Olsson (2000), improvement in the institutional quality improved the impact of natural resources on the innovation process.

Financial Soundness Indicators (FSIs): As IMF defined, financial soundness indicators (FSIs) provide insight into the financial health and soundness of a country’s financial institutions as well as corporate and household sectors. FSIs support economic and financial stability analysis. This variable is an important variable for innovation. Innovators cannot engage in such activities without financial institutions’ support. Indeed, healthy and stable financial system can facilitate the innovative process. Based on the study of Efthyvoulou and Vahter (2016), Gorodnichenko and Schnitzer (2013) and Hottenrott and Peters (2012) financial access constraint has the negative effect on the innovation process. Therefore, we expect that the better financial soundness lead to innovation.

Human Capital: This kind of capital refers to the skills, knowledge, and experience possessed by an individual who can use them in the production process. Human capital is one of the most prominent factors of knowledge production. Therefore, the presence of this factor is necessary for Innovation within countries. In this paper, to follow Sun (2017), Danquah and Amankwah-Amoah (2017) and d'Amore & Iorio (2016), we used human capital as the control variable with the expectation of positive effect. In addition, we use the simple average of general and tertiary education of the GII dataset as a proxy of human capital.

FDI Stocks: As Olsson (2000) mentioned, knowledge inflow from the other countries is the important source of innovation process as well as the inner efforts. Foreign direct investment is the main source which knowledge can flow between countries (Papageorgiadis and Sharma, 2016 and Gorodnichenko et al., 2015). Therefore, a stock of the FDI within a country can be an important factor in the Innovation with an expectation of positive sign. The data of this variable is obtained from the United Nations Industrial Development Organization (UNIDO).

Therefore, the specified models can be introduced as follow:

$$LINN_{it} = LFDIS_{it} + LFSI_{it} + LHC_{it} + LNAT_{it} + \varepsilon_{it} \quad (12)$$

$$LINN_{it} = LFDIS_{it} + LFSI_{it} + LHC_{it} + LNAT_{it} * LINS_{it} + \varepsilon_{it} \quad (13)$$

Where, L=logarithm of the variable, INN= innovation, FDIS= the stock of foreign direct investment, FSI= financial soundness index, HC= human capital, NAT=natural resource rent and INS= institutional index. It should be noted that the institutional index is the average of six dimensions of the World Governance Indicator and its indicators consist of voice and accountability, political stability and absence of violence, government effectiveness, regulatory quality, rule of law, and control of corruption, which creates 7-regression equation.

6. Estimation Results

Table 1 represents the Estimations' results. As it is clear in the first column, the effect of natural resources on innovation is negative and significant. Based On the discussion of Auty (1994), Sachs and Warner (1995, 1997, 1999a, 1999b), Leite and Weidmann (1999), Rodrigueze and Sachs (1999), Gylfason (2000, 2001a, 2001b, 2008) the effect of natural resources on economic growth is negative through the negative impact of this variable on the production factors, such as human capital, social capital, innovation, etc. The estimated result of this paper supports the resource curse hypothesis for efficiency-driven countries. This result specially aligns with the study of Welsch (2008) and Papyrakis and Gerlagh (2005).

However, based on the viewpoint of Olsson (2000), to check the impact of institutional improvement on innovation, the effect of natural resource rent interaction with six dimensions of world governance indicator and their average tested in column 2-8 of the table1.

As it is clear, in all the estimations the effect of natural resource rent on innovation through different kinds of governance aspects is positive and significant. Which means that the improvement in institutional quality, and especially governance quality, is an important factor that makes natural resources to be "curse" or "bless". This result emphasizing the importance of institutions, especially the importance of government soundness, for utilization of the natural resource. This result aligns with the study of Papyrakis and Gerlagh (2004). They suggest that the impact of natural resources on economic variables depends on the quality of institutions.

The impact of human capital on innovation is positive and significant which aligns with the study of Sun (2017) and Danquah and Amankwah-Amoah (2017). Because of its importance in knowledge creation and innovation process, it is not surprising that its effect is positive.

Table 1: Estimation Results

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
L(LINN)	0.414	0.263	0.379	0.202	0.270	0.296	0.280	0.288

	[0.000]	[0.015]	[0.004]	[0.034]	[0.001]	[0.006]	[0.006]	[0.003]
LFDIS	0.190	0.101	0.070	0.085	0.119	0.089	0.94	0.124
	[0.000]	[0.001]	[0.011]	[0.000]	[0.000]	[0.002]	[0.000]	[0.000]
LFSI	0.429	0.285	0.227	0.254	0.269	0.313	0.314	0.246
	[0.001]	[0.002]	[0.022]	[0.099]	[0.001]	[0.000]	[0.000]	[0.006]
LHC	0.368	0.156	0.196	0.275	0.114	0.131	0.148	0.100
	[0.000]	[0.020]	[0.008]	[0.002]	[0.000]	[0.045]	[0.026]	[0.002]
LNAT	-1.109							
	[0.001]							
LNAT*INS		0.071						
		[0.079]						
LNAT*CON			0.065					
			[0.087]					
LNAT*GOV				0.084				
				[0.010]				
NAT*POL					0.036			
					[0.000]			
LNAT*REG						0.069		
						[0.019]		
LNAT*RUL							0.056	
							[0.056]	
LNAT*VOI								0.022
								[0.019]
NO. Observation	92	92	92	92	92	92	92	92
NO. Groups	23	23	23	23	23	23	23	23
NO. Instruments	20	14	14	14	15	14	14	15
AR(1)	[0.005]	[0.018]	[0.010]	[0.019]	[0.012]	[0.014]	[0.015]	[0.017]
AR(2)	[0.158]	[0.815]	[0.370]	[0.710]	[0.759]	[0.649]	[0.607]	[0.756]
Hansen test	[0.646]	[0.215]	[0.194]	[0.485]	[0.387]	[0.212]	[0.144]	[0.375]
Hansen diff	[0.881]	[0.561]	[0.575]	[0.647]	[0.581]	[0.389]	[0.401]	[0.524]

Source: The results of the research.

Notes:

- System GMM method used to estimate the models. Syntax xtabond2 two-step robust small noconstant

- All the variables considered as endogenous. The dependent variable second lagged value used in GMM style and independent variables used in IV style by their levels.
- Sample period 2011-2016. The only countries, which have at least three data, the minimum period to estimate GMM-SYS, have been chosen.
- In the first row, “l(LINN)” means lagged value of innovation. Also, the abbreviations from 6-12 rows meaning are as follows: INS= average of WGI indicators, CON= control of corruption, GOV= government effectiveness, POL= political stability and absence of violence, REG= regulatory quality, RUL= rule of law and VOI= voice and accountability.

Also, the coefficient of financial soundness is positive and significant in all the equations. Indeed, the more efficient and stable financial system facilitates the financial access. The estimated result aligns with the study of Efthyvoulou and Vahter (2016), Gorodnichenko and Schnitzer (2013) and Hottenrott and Peters (2012).

As it is apparent from the table 1, the effect of FDI stock on innovation is positive and significant which is aligned with the study of Papageorgiadis and Sharma (2016) and Gorodnichenko et al. (2015). Therefore, the knowledge inflows from the other countries had a positive impact on innovation.

7. Conclusion

After the appearance of growth disasters in countries with rich natural resources, studies like Auty (1994), Sachs and Warner (1995, 1997, 1999a, 1999b), Leite and Weidmann (1999), Rodrigueze and Sachs (1999) and Gylfason (2000, 2001a, 2001b, 2008) introduce the hypothesis which named as “resource curse”. Based on this hypothesis, countries with extraordinary natural resources experience the negative effect on their growth rate. These negativities are due to the indirect effects of natural resources on other factors of production. In fact, natural resources’ affect factors of production negatively and in the final chain, those negative effects influence the growth rate. However, some resource-rich-countries such as Norway, Botswana, Alaska, US, etc. did not experience these negative effects. These examples bring this idea that the effects of natural resources could depend on structural variables. Based on the discussion of Olsson (2000), institutional structure is the groundwork which influences other variables' effect on the innovation process. Therefore, in this study, besides the testing the natural resources hypothesis, we test the effect of institutional quality interaction with natural resources in efficiency-driven countries. The results of our study show a negative effect of natural resource rent on Innovation in efficiency-driven countries that confirm the resource curse hypothesis. Also, the effect of natural resources interaction with institutional quality on innovation is positive. This result emphasizing the importance of institutional quality on the effect of natural resource rent on the innovation process. Admittedly, better institutions lead to better natural resource management and hence, make a natural resource curse to blessing. Indeed, improvement in natural resource management, because of the improvement in institutional quality, can change the non-reproducible resources to reproducible wealth, such as innovation, and move the countries from resource-based to knowledge-based economies.

Based on the results of this study, improvement in institutional quality is the most prominent factor, which 1) control the negative effect of natural resources on Innovation and 2) make natural resource rent's negative effect to positive impact.

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Appendix

Table A1: List of Countries in the Sample

Argentina	Colombia	Latvia	Poland
Bosnia and Herzegovina	Croatia	Lithuania	Romania
Botswana	Ecuador	Malaysia	Russia
Brazil	Guatemala	Mexico	Slovakia
Chile	Hungary	Panama	South Africa
China	Iran	Peru	Thailand