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NATURAL RESOURCES, INCENTIVES AND HUMAN CAPITAL: REINTERPRETING THE CURSE

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Abstract

We offer an alternative mechanism for the curse of natural resources. In this mechanism, natural resource rents, when distributed as lump sum transfers to individuals, retard economic growth by their distortive adverse effect on the incentive to invest in human capital. Extending an OLG model for this purpose, we show that if this resource-transfer effect occurs when the country's technology level is marginal, the chance that the country will converge to a low-level equilibrium trap is greatly increased and the chance that it will converge to a high-income equilibrium in the long run is similarly reduced. We find empirical support for the model in both cross sectional and dynamic panel regressions.

JEL Classification: O1, O4, I2, D9, J2

Keywords: Natural Resources, Resource Curse; Human Capital; Overlapping Generations; Economic Growth; Macroeconomics

ملخص

نقدم في هذه الورقة آلية بديلة للعنة الموارد الطبيعية. في هذه الآلية، تؤدى إيجارات الموارد الطبيعية، وخاصة عندما تكون موزعة على للأفراد الى تأخر النمو الاقتصادي من خلال التأثير السلبي بتحريف على الحافز للاستثمار في رأس المال البشري. وبتوسيع نموذج OLG لهذا الغرض، تبين لنا أنه في حالة حدوث هذا التأثير وعند مستوى هامشى للتكنولوجيا، تتكون فرصة أن تتقارب البلاد إلى مستوى منخفض ويتم زيادة فخ التوازن بشكل كبير وأن تتلاقى لتوازن الدخل المرتفع على المدى الطويل وهو انخفاض مماثل. لنجد دعما تجريبيا للنموذج في كل من الانحدارات والقطاعات ديناميكية.

1. Introduction

We propose an alternative explanation for the "curse" of natural resources. In this explanation, direct transfers to households, financed from natural resource rents, have the potential to retard economic growth in resource rich countries because of their adverse effect on the *incentive* to invest in human capital. Extending an Over Lapping Generation (OLG) model for this purpose, we show that the windfall rents from natural resources, when transferred to augment citizens' income, distort their incentives *away* from the accumulation of human capital and thus economic growth. This increases the chance that the economy would converge to a low-level equilibrium trap and reduces the chance that it would converge to a high income per capita equilibrium, provided technology level is marginal. Thus, countries with more advanced technologies can escape this low-income equilibrium convergence. Our focus, both theoretically and later in empirically testing our model, is mainly on tertiary education that is more closely tied to economic growth via technological progress.

Intuition suggests that rents from natural resources should accelerate economic growth by expanding the production possibilities frontier and enhancing the accumulation of factors that contribute to growth.[1] However, evidence suggests a more complex picture. For example, the Middle East and North Africa (MENA) region with its wealth in oil and other natural resources, has experienced low or negative long-term growth.[2] Yet other countries as diverse as Botswana, Chile, and Norway which possess vast endowments of natural resources have experienced acceptable rates of economic growth. Explanations for these contradictory phenomena are equally diverse. For example, some explanations focus on the interaction of governance and natural resources.[3] Others focus on the so-called Dutch Disease, where resource booms induce an appreciation of the real exchange rate that impede the production of tradables, retarding diversification and growth.[4] Higher resource rent volatility belongs to yet another set of explanations especially applicable to countries that are highly dependent on resource profits and their government spending is pro-cyclical (Gylfason 2001)[5].

However, because it is well known that economic growth is also highly influenced by human capital investments, the question arises whether natural resources might have an inherently adverse effect on human capital accumulation. Evidence suggests this may indeed be the case. For example, in a cross-country study Behbudiet. et al. (2010) showed that there is an inverse relationship between secondary education and resource abundance in oil producing nations. If we recast this result for the case of *tertiary* education (a form of education more closely tied to R&D and thus to economic growth according to the growth theory), we find that for a sample of countries that include most of the developed and developing resource rich nations, natural resource rents (as a percentage of GDP) and tertiary education (as a percentage of population of tertiary education age) are *negatively* correlated (Figure 1).

In this paper, we seek to explain the adverse outcome of distributed rents by focusing on the effect of natural resources on the *incentive* to accumulate human capital. We argue that natural resource rents result in an *adverse incentive* problem that *retards* the optimal desire to invest

[1] For example, Thorvaldur Gylfason (2007) cited several factors that should be enhanced by natural resource windfalls: increased savings, accelerating the accumulation of physical and human capital; foreign trade and the accumulation of foreign reserves; manufacturing and industrialization to enhance diversification in production and increased economic growth.

[2] Esfahani (2008) showed that economic growth for the oil producing MENA countries between 1970 and 2006 was only 0.7 percent. For the sub-period 1986 to 1995, growth in this region was actually negative at -0.8 percent.

[3] A majority of natural resource-rich economies suffer from poor governance, as indicators of both democracy and corruption in these countries are found to belong to the lowest range. In this explanation, countries with poor institutions become subject to the "curse" (e.g., the Middle Eastern economies) while those with good institutions have a greater chance of escaping the curse (e.g., Norway and Botswana) (Mehlum et al. 2006)

[4] See Corden and Neary (1972) for the original Dutch disease hypothesis in the Netherlands. For its application to resource curse see Sachs and Warner (2001). For a comprehensive survey see (Frankel 2010).

[5] Higher growth volatility in natural resource countries reduces the certainty of investment in physical capital, and lower growth. Philippot (2010) argued that fluctuations in international resource prices create a high level of uncertainty in private and public investments.

in one's human capital, if rents are distributed to append individuals' overall income. This happens as resource rents enter the individual's budget constraint via a lump-sum transfer. To examine this issue, we extend an Overlapping Generations model by Iyigun and Owen (1997) and incorporate natural resource rents into it. The model shows how natural rents, when distributed as lump-sum transfers, reduce the optimum expected returns to human capital in the long run. It is true that transfers may occur with and without natural resources. However, transfers from sources *other* than the windfall rents would have to be financed by tax revenues. As such, their "incentive reducing" effect (as we shall see) will be countered by the income taxes that need to be generated to finance them. It is in this sense that the transfers of the type we model in this paper are closely tied to resource rents, as resource rich (especially resource dependent) countries have significant income transfer programs and simultaneously significantly lower tax rates than non-resource countries[6].

Evidence suggests that resource rich countries do provide this form of income transfers, possibly to placate society or reduce the risk of social and political unrest. For example, the Kuwaiti authorities spent 4.12 billion dinars in 2008 on lump-sum cash transfers to national citizens, which accounted for up to 43% of government aggregate expenditures (El-Katiri et al. 2011). Further evidence of such transfers can be found in the case of Saudi Arabia and United Arab Emirates (IMF 2012). For example, in Saudi Arabia these transfers show up in the form of wage premiums that stem from oil rents. To indicate the extent of such transfers, one can compare the wages of Saudi nationals with those of foreign workers. According to the IMF, on average, non-skilled labor income of Saudi nationals is 4.1 times that of the expatriates. In UAE, Gelb and Decker (2011) argued that the levels of transfers received by the citizens through guaranteed employment and other mechanisms discourage work effort and education aspirations for many individuals. As anecdotal evidence of the link between government transfers and resource rents, the average fiscal revenues from natural resources in 14 Middle Eastern natural resources exporters accounted for 57.2% of total revenues (Gelb and Decker 2011). In fact, as a matter of policy, authors such as Subramanian and Sala-i-Martin (2003) advocated direct resource rents distributions for countries such as Nigeria and Iraq (the latter, before US invasion).

We study how human capital's expected returns depend on resource rents using two types of human capital, entrepreneurship and professional. Our findings indicate that higher levels of distributed rents to society at large reduce the aggregate level of both types of human capital, leading to a more unskilled labor force in the long run. Additionally, the fraction of resource rents transferred merely to human capital generates a misallocation of talent between entrepreneurial and professional capital, changing the income growth dynamics along the growth path. This causes income to enter a low-level equilibrium trap in a multi-equilibria setting in the long run. We do find, however, that if the initial technology is sufficiently advanced, countries can still escape the trap and converge to a high steady-state equilibrium, regardless of the level of resource rents distributed. Our empirics support our theory.

The remainder of the paper is as follows: section 2 conducts an extensive review of the literature on natural resources and economic growth, stressing the literature that is most relevant to our study. Section 3 presents the theoretical model, which specifies the behavior of households when resource revenues are distribution by the government as transfers and it also explains the findings of our model with some concluding remarks. Finally, section 4 will cover a dynamic panel data and a cross section analysis that supports our theoretical findings and presents a conclusion.

[6] According to the 2012 CIA fact-book, the majority of resource rich developing countries have tax rates below ten percent, and some of them go down to zero percent.

2. Overview of the Literature

The economic history of the last two centuries demonstrates conflicting evidence concerning the connection between resource abundance and economic growth (Behbudi, Mamipour, and Karami 2010). The development experience in many of today's industrial economics during the 19th century and the first half of the 20th century saw natural resources as an engine of growth (Stevens 2003)[7]. For example, resource rich nations have sought to utilize the vast revenues from oil to finance investments in industrial and financial sectors. An example from the 19th century can be found for the U.S., Germany, and Britain, which were highly endowed in natural resources and experienced a rapid industrial development during that period. The availability of coal deposits in such countries was the *sine qua non* for the development of the local steel industry (Gylfason, and Zoega 1999). Yet, even for these countries and even in the 19th century, that assumption was not universally borne out. For example, many resource-poor economies outperformed Spain despite its immense reserves of gold and silver brought from the colonies. Continuing into the 20th century, resource-poor nations such as Japan and Switzerland surged ahead of resource-rich countries such as Russia. Japan and Korea in the past century succeeded in becoming world-class steel manufacturers *despite* their virtual dependence on imported iron ore. The past three decades has witnessed the resource-poor economies of East Asia as the world's star performers while many resource-abundant countries including oil producers such as Nigeria, Venezuela, Mexico, and the MENA countries have not performed nearly as well.[8] The question is: while natural resources are no longer a key to economic development in the above-mentioned developed countries, can they actually *hinder* development?

A large body of literature points to the adverse impact of resources on economic growth in developing countries over the past four decades, a relationship now termed "the resource curse"[9]. Figure 2 reconfirms this adverse effect using our own data.

2.1 Natural capital and the Dutch Disease

The Dutch disease hypothesis argues that natural resource abundance influences prices through the overvaluation of the country's currency associated with high inflation, which reduces exports of non-resource tradables and increases production of non-tradable goods (Frankel 2010). Sachs and Warner (2001) claimed that if the traded sector is the engine of growth, then a resource shock retards growth by reallocating factors such as labor and land from the traded (manufacturing) to the non-traded sector. Moreover, higher inflation, stemming from higher government spending via taxes or royalties, contributes to a higher return in the non-traded sector. These crowded-out non-resource exports occur mainly in the manufacturing sector, which results in deindustrialization in the long run. Evidence of this crowding out phenomenon can be observed among the Middle Eastern oil exporters for whom total non-oil exports as a share of the GDP declined over the last five decades. During the same period non-oil producing nations saw a significant increase in their total exports (Gylfason 2004).

2.2 Natural resources and investments

According to this view, the volatility associated with natural resource revenues and the resulting uncertainties have the potential to reduce both public and private investments, impeding economic growth (Gylfason and Zoega 2001; IMF 2012).[10] Consistent with this,

[7]Stevens presented a review of the historical growth experience of the US, the Scandinavian countries, Australia, and Canada. Pointing to the positive role, his analysis logically implies that natural resources should actually boost economic development in the above countries. His main argument is that as natural capital should increase the production possibilities frontier of the endowed economy. Stevens also argued that at the very least, wealth from natural resources should not deter or impede economic performance.

[8]Bravo-Ortega and Gregorio (2007) go further by arguing that natural resources may even be blamed for the slow-down in the development of countries such as Latin America, and now the MENA regions.

[9] See Frankel (2010) for an excellent survey.

[10] Gylfason (2001) has extended this argument to include investments in human capital.

Behbudi, Mamipour and Karami (2010) have shown that resource abundant developing countries have a depressed levels of domestic (public and private) investments, thus growing more slowly than resource-poor economies. Expectations and perceptions may also matter. The IMF, in its 2012 annual report on resource rich economies, argued that natural resource rents may create a false sense of security when the lead to a rapid rise in output. This in turn reduces demand for domestic investments as prudent governments save resource rents abroad in the form of sovereign wealth funds (SWFs). This results in lower rates of domestic consumption and investments in the short and the medium run. Estimates suggest that an increase of 10 percent in the share of natural capital decreases the share of investments in GDP by approximately 2 (Gylfason 2001).

2.3 Natural resources, human capital and growth

We will now turn to human capital, our focus of attention. Numerous studies have confirmed the positive contribution of education to economic growth.[11] Given our focus on tertiary education, it is worthwhile to examine this effect for tertiary education. Figure 3 confirms this positive influence between tertiary education and GDP per-capita growth for 46 resource rich and resource poor nations.

Coupled with the findings from Figure 1, one can deduce the adverse role of natural resources on economic growth via the channel of human capital and, in our specific case, tertiary education. The literature seems to support the adverse role of natural resources in human capital accumulation (Gylfason, 2001; Bravo-Ortega and Gregorio 2000; Stijns 2001). However, the mechanism by which natural resources may suppress human capital accumulation seems unclear. Some implicate government spending: government expenditures on education as a fraction of GDP and school enrollments have both been found to be negatively related to the level of natural resources (Gylfason, Herbertsson and Zoega 1999). Similarly, Birdsall, Pinckney and Sabot (2001) showed that resource-rich countries invest less in training than resource-poor countries[12]. Similar results have been reported for Northern Africa and Latin America.[13]

Others have implicated the lack of diversification in natural resource rich economies (Brunnschweiler 2006). Leamer et al. (1999) argued that the under-accumulation of human capital makes it difficult for resource abundant nations to pursue industrial diversification. Comparative advantage has also been attributed as playing a role. Behbudi, Mamipour and Karami (2010) have argued that countries, endowed with large natural reserves, find it easier to engage chiefly in the production or extraction of such resources because their comparative abundance of these resources requires low levels of initial investments. To the extent that resource-based industries are not particularly human capital intensive (compared with such sectors as manufacturing), exploitation of such resources comes at the expense of human capital development. Gylfason (2001) argues that focusing on natural resources as the main source of national income retards the development of the manufacturing sector, because skilled jobs are scarce and hence returns to human capital are low. Birdsall, Pinckney and Sabot (2001) argue that citizens do not find it necessary to pressure their governments into providing skill intensive sectors. None of these explanations address the role of natural resource abundance in the incentive to accumulate human capital in the first place. This is the task to which we will turn shortly. We will argue, as was stated in the introduction, that this incentive effect has to do with

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[11] A recent study by the World Bank suggests the primacy of human physical or natural capital, in generating income as opposed to (as opposed to what?) (Philippot 2010).

[12] Resource poor countries in Asia showed an average of 60 percent school enrollment in the 1980s, but there was only 38 percent average enrollment in resource abundant countries.

[13] The disparity in human capital accumulation in Africa between resource-rich and resource-poor countries, however, is a more complicated matter due to the existence of civil wars and fragility in such countries. Further, highly skilled workers in most African resource rich countries are generally educated in foreign countries and often belong to the political elites (Birdsall, Pinckney and Sabot 2001). In such countries, resource rents may be concentrated within a small portion of the society.

the nature and abundance of transfer payments in resource rich countries. Before we turn to our explanation and model, however, we must first ask: What does the literature say both about transfers in resource rich countries and their role in human capital accumulation?

2.4 Human capital, natural resources and transfers

Over the past 30 years transfer policies were the most common tool to boost educational investments, especially among Latin American resource-rich countries. Such transfers are of two types; conditional (targeted) and unconditional. Conditional cash transfers focus on households conditional on specific guidelines that shall be fulfilled such as school enrollment. These forms are popular especially in Brazil, Mexico, Venezuela, and Colombia. They have been shown to be effective, mainly on early stages of education (pre-school and primary education), but there is little or no evidence of their effect at the tertiary level. Unconditional cash transfers (UCTs) by contrast are directed to append individuals' income for a wide range of needs in different countries.[14] UCTs have been shown to effectively reduce poverty and boost consumption especially in less developed countries. Here, welfare has improved only when transfers have boosted consumption or primary education (World Bank 2011). But once again, there is a very limited evidence of their effect on human capital accumulation especially on tertiary education. In fact there has been suggestion to the contrary, pointing to the transfers' potential in inducing dependency and undesirable behavior (Heinrich 2011). Heinrich has argued that cash transfers increased society's welfare in the short-run through fulfilling short run consumption needs, but not in the long-run as they do not promote investments in post-secondary human capital accumulation. We pick up the mantle exactly from here. Our focus is then how and why transfers from natural resources influence the decision to accumulate tertiary human capital. Given the link between tertiary education and technological innovation on one hand and technological innovation and economic growth on the other, this is a critical question to ask. This is the question to which we now turn.[15]

3. The Model

In this section, we use an Overlapping Generations model that captures the incentive channel and shows how natural resource rents influence human capital, when and if rents are distributed as income transfers. The model adopts an Overlapping Generations (OLG) framework similar to Iyigun and Owen (1997) with distinct innovations. Into this, we incorporate the role of resource rents and the influence of this on the individual's choice to accumulate more skills. Crucially, we distinguish between resources transferred to society at large, and the fraction targeted to human capital. The inclusion of the resource rents distribution mechanism into an OLG model is an important innovation that allows us to study the effect of the resource curse in a dynamic setting. It shows the consequences of natural resource rents for the incentive of citizens to accumulate human capital and therefore increase economic growth.

There are three periods. In the first period, citizens choose either to invest in human capital or to supply unskilled labor in the labor market. In the second period, if an individual invests in human capital, she will receive an expected income plus a resource based transfer known *ex ante*. Otherwise, she works as an unskilled worker, earning a fixed income "ω" and a resource-based lump-sum transfer (predetermined by the government in the first period) in the first and the second period. In the third period both skilled and unskilled workers consume generated income.

Human capital is of two types: professional and entrepreneurial. The return on professional human capital is certain and depends on the level of technology plus lump-sum resources

[14] UCTs can be thought of as the government's redistribution of "wealth" assuming individuals behave rationally (UK Aid 2011).

[15] There is also a vast literature on the institutional aspects of natural resource curse, some with a link to human capital accumulation. Notable among them are Ross (1999) Birdsall, Pinckney and Sabot (2001), Sala-I-Martin and Subramanian (2003), Collior and Goderis (2007), Collier (2010) and Elbadawi and Soto (2012) Ross (2014) and Mohtadi, Ruediger and Ross (2014). For detailed exposition see Araji (2014).

transfer. However, entrepreneurs' income is uncertain with some probability of success plus a certain lump-sum resources transfer. The role of entrepreneurial human capital in this paper is essential for several reasons. First, economic theory suggests that technological advancements and growth rely on both professional and entrepreneurial capital. Second, anecdotal evidence suggests that in oil rich economies resource booms, rather than leading to the accumulation of professional human capital, have instead led to a large increases in self-employed activities in non-manufacturing (non-tradable) sectors such as commercial and residential projects, wholesale and retail merchandise trade, and restaurants and hotels. For example, in 2001, Saudi Arabia's manufacturing sector was only 9.8 percent of its GDP, while self-employed activities such as restaurants and hotels, transportation, and construction projects accumulated to almost 30 percent of total GDP activities (Saudi's Ministry of Economics 2012). Third, the mechanism by which resource booms lead to increased self-employed activities involves disincentives compared to other alternatives such as the accumulation of professional human capital. This dynamic has its roots in governments' massive direct and indirect transfer programs, especially in oil rich (or more generally resource rich) economies, regardless of the uncertainty of self-employment return. Given this background, we convey this stylized fact by adding a stochastic entrepreneurial return to our utility maximization problem, associated with a resource rent-based lump-sum transfer given by the government for both professional and entrepreneurial capital. We look at the effect of resource wealth on an individual's choice while selecting her profession, and how this will influence the economic growth process in resource-rich countries.

To simplifying things and allow a sharper focus on the role of natural resources in the incentive to invest in human capital, we abstract from other channels such as the Dutch disease, volatility, and political economy. To this end, the paper does *not* model the production of the resource itself but instead its distribution. This is captured by considering the role of natural resources in generating windfall profits but not otherwise contributing to the production process. While a simplification, this consideration allows us to focus on an important and overlooked channel, namely the incentive channel.

3.1 Structure of the model

Consider a perfectly competitive economy made up of homogenous goods. At any time (*t*), production (Y_t) is a highly simplified function of human capital (H_t) and unskilled labor (L_t)

$$Y_t = A_t H_t + \omega L_t \quad (1)$$

Each factor input earns its marginal productivity, which in the case of human capital is associated with the level of technology (A_t). (Later, we will see that (A_t) will itself depend on mean education and entrepreneurship of the previous period).

$$\frac{\partial Y_t}{\partial H_t} = w_t^H = A_t \quad (2)$$

$$\frac{\partial Y_t}{\partial L_t} = w_t^L = \omega \quad (3)$$

Where w_t^H and w_t^L represent the economy wide marginal returns to human capital and labor respectively.

3.1.1 Society

Each individual faces three periods and the size of the society is normalized to one. We will assume a zero population growth and each individual is endowed with a certain level of innate ability(a_i). Innate ability (a_i) is uniformly distributed[16] between 0 and 1. Where $a_i = 0$ represent the lowest percentile, and $a_i = 1$ is the highest percentile of innate ability.

[16] The use of the uniform distribution will show up in Section 3.4.

$$\int_0^1 g(a_i)d(a) = 1 \quad (4)$$

Individuals choose to invest in human capital or work as an unskilled laborers, depending on their innate ability. A higher level of innate ability, e.g., above a certain threshold, will increase the chance that an individual will invest in human capital.

In each period an individual is endowed with one unit of time (*t*). If she chooses to invest in human capital, she will spend (s_i) on schooling and $(1-s_i)$ on entrepreneurship, where $(1-s_i)$ is considered an entrepreneur's set up cost. Choosing to invest in human capital requires agents to allocate their time optimally between schooling (s_i) and entrepreneurship $(1-s_i)$, given a level of resource transfers (see below). Individuals can invest in either type of human capital, or both. The level an individual accumulates of professional human capital (p_{t+1}^i) is an increasing function of (s_i). Similarly, accumulation of entrepreneurial capital (e_{t+1}^i) is an increasing function of $(1-s_i)$.

$$p_{t+1}^i = a_i f(s_i), \quad f'(.) > 0, f''(.) < 0 \quad (5)$$

$$e_{t+1}^i = a_i f(1-s_i) \quad 0 < s_i < 1 \quad (6)$$

The level of technology depends on the economy wide average of both professional and entrepreneurial capital:

$$A_{t+1} = A\,(e_t, p_t) \quad (7)$$

with the following properties on the partial derivatives[17],

$A^e > 0, and\ A^{ee} < 0,$

$A^p > 0, and\ A^{pp} < 0$

$A^{ep} > 0, and\ A^{pe} > 0$

Given the level of technology, individuals' total income, including the resource transfer, will be derived below.

3.2 The role of natural resources

Earlier, we highlighted the role of transfers in the case of Kuwait, Saudi Arabia, and the United Arab Emirates. In our model, we assume that resource rents are distributed to the society at large. Resource rents, denoted by Ω, are generated every period. Individuals enjoy a fraction $\Omega_{\text{net}} = (1-\gamma)\Omega$ of the rents where $\gamma\Omega$ is the fraction that the government keeps.[18] The fraction of total resource rent Ω_{net} is distributed as a lump-sum transfer to all agents.

Agents have perfect foresight on the size and the timing of future transfers. If an individual chooses to invest in human capital (of either type) in period t, she will receive a predetermined transfer $\alpha\Omega_{net}$ in t+1. However, if she chooses *not* to accumulate skills, she will receive $(1-\alpha)\Omega_{net}$ in t and t+1 where $0 \leq \alpha \leq 1$. In our model the size of resource rents distributed Ω_{net} and the fraction distributed to human capital α will have significant but distinct influences on the process of human capital accumulation. With this background in t+1, professional and entrepreneurial human capita incomes, respectively, are given by,

$$\left(y_{t+1}^i\right)^P = w_{t+1}^H p_{t+1}^i + \alpha\Omega_{net} = A_{t+1}p_{t+1}^i + \alpha\Omega_{net} \quad (8.1)$$

$$\left(\mathrm{Y}_{t+1}^{\mathrm{i}}\right)_{Sucess}^{\mathrm{e}} = w_{t+1}^H e_{t+1}^i + \alpha\Omega_{net} = A_{t+1}e_{t+1}^i + \alpha\Omega_{net}, with\ probabilty\ q \quad (8.2)$$

[17] Absence of A_t on the right hand side of (7) means that it is the *stock* of technology that is determined by past professional and entrepreneurial human capital, rather than technological change. This aspect of our paper which follows Iyigun and Owen (1997)'s similar assumption would not affect the modeling of the dynamics.

[18] This fraction is kept by the government either to extract political allegiance or to fund public goods. We do not model either aspect in this paper.

$$\left(Y_{t+1}^{i}\right)^{e}_{Failure} = \alpha\Omega_{net}, with\ probabilty\ (1-q) \quad (8.3)$$

Note that unlike professionals, for the entrepreneurs success is not guaranteed. The subscripts (*Success)* and (*Failure)* represent the two possible states of the entrepreneur's income with the probability (q) for success and $(1-q)$ for failure. Finally, unskilled labor income, (Y^{i}) is fixed in every period and given by

$$Y^{i} = \omega + (1-\alpha)\Omega_{net}, \quad (9)$$

3.3 Households

We assume a simple natural log form of the utility function, U(c) = $ln\ (c)$. Households earning an unskilled labor income will earn a fixed income in periods (t) and $(t+1)$, and consumes all generated income in period $(t+2)$. Given this, unskilled laborers maximize the follow utility:

$$\underset{c_i}{Max}\left[U\left(c_{t+2}^{i}\right) = ln(c_{t}^{i}) + ln(c_{t+1}^{i})\right] \quad (10)$$

Subject to $Y^{i} = [\omega + (1-\alpha)\Omega_{net}]$

While skilled workers maximize the following:

$$\underset{s_i}{Max}\left[E\left[U\left(c_{t+2}^{i}\right)|t\right] = \left[q ln\left(c_{t+2}^{i}\right)_{Sucess} + (1-q) ln\left(c_{t+2}^{i}\right)_{Failure}\right]\right] \quad (11)$$

Subject to: $Y_{t+1}^{i} = \left(Y_{t+1}^{i}\right)^{p} + \left(Y_{t+1}^{i}\right)^{e}$,

Substituting the budget constraint from (11), the expected utility of skilled workers is:

$$E\left[U\left(c_{t+2}^{i}\right)|t\right] = q ln\left[\left(Y_{t+1}^{i}\right)^{p} + \left(Y_{t+1}^{i}\right)^{e}\right]_{Sucess} + (1-q)\ ln\left[\left(Y_{t+1}^{i}\right)^{p}\right]_{Failure} \quad (12)$$

Substituting from (8) through (8.3) in equation (12), the maximization problem is:

$$\underset{s_i}{Max}\ \{EU\left[\left(c_{t+2}^{i}\right)\middle|t\right] = q ln[A_{t+1}(p_{t+1}^{i} + e_{t+1}^{i}) + \alpha\Omega_{net}] + (1-q) ln[A_{t+1}p^{i}{}_{t+1} + \alpha\Omega_{net}]$$
(13)

The first order condition then yields optimal schooling (s_i^{*}) as a solution to the equation[19]:

$$-q[A_{t+1}a_i f(s_i^{*}) + \alpha\Omega_{net}][f'(s_i^{*}) - f'(1-s_i^{*})] = (1-q)\{A_{t+1}a_i[f(s_i^{*}) + f(1-s_i^{*})] + \alpha\Omega_{net}\}f'(s_i^{*}) \quad (14)$$

It is instructive to rearrange (14) in terms of consumption. This yields:

$$\frac{\left(c_{t+2}^{i}\right)_{Sucess}}{\left(c_{t+2}^{i}\right)_{Failure}} = \frac{q}{(1-q)}\frac{f'(1-s_i^{*}) - [f'(s_i^{*})]}{f'(s_i^{*})} \quad (15)$$

Expressed in this form, note that the right hand side of (15) increases with s_i^{*}, indicating that more schooling increases the consumption level of a successful entrepreneur relative to a failed one, a result that is not unexpected.

3.3.1 Human capital investment decision

Suppose there is a threshold innate ability $\tilde{a}_t$, such that any individual that has $a_i > \tilde{a}_t$ will choose to invest in human capital. However, if $a_i < \tilde{a}_t$, she will choose to work as an unskilled laborer. Given any threshold mental ability $(\tilde{a}_t)$, the condition below must hold with equality as individuals' returns equate, and people are indifferent between investing in human capital or work as an unskilled laborer.

[19] The second order condition is satisfied as shown in Appendix A.

$$q ln\{A_{t+1}\tilde{a}_t[f(s_i^*) + f(1 - s_i^*)] + \alpha\Omega_{net}\} + (1 - q) ln\{A_{t+1}\tilde{a}_t f(s_i^*) + \alpha\Omega_{net}\} = ln\, 2\{\omega + (1 - \alpha)\Omega_{net}\} \quad (16)$$

It can be readily seen from (16) that a lower threshold value of innate ability is associated with an increase in the incentive to invest in human capital, as greater fraction of population will have ability level (a_i) exceeding $(\tilde{a}_t)$. From equation (16) one can see that the threshold level of innate ability is influenced by the resource portion transferred to human capital (α), the size of resource rents distributed to the society Ω_{net}, and the level of technology A_{t+1}.

Proposition 1:

The threshold innate ability $(\tilde{a}_t)$ declines as the share of resource rent distributed (α), and professional and entrepreneurial human capital (e_t) and (p_t) increase. However, $(\tilde{a}_t)$ increases with an increase in resource rents distributed, Ω_{net} thus reducing the incentive to invest in both types of human capital.

Proof:

Implicitly differentiating (16) it is simple to show that:

$$\frac{\partial \tilde{a}_t}{\partial e_t} < 0\, , \frac{\partial \tilde{a}_t}{\partial p_t} < 0, \frac{\partial \tilde{a}_t}{\partial \alpha_t} < 0, \frac{\partial \tilde{a}_t}{\partial \Omega_{net}.} > 0, \quad (17)$$

It is interesting to note the critical distinction, in their effect on threshold innate ability $(\tilde{a}_t)$, between the *fraction* of resource rents distributed to skilled workers (α) versus the overall *level* of such rents Ω_{net} distributed to society at large. While the former acts to reduce the required threshold ability, causing greater number of citizens to invest in human capital,[20] the latter behaves in the reverse fashion: An increase in Ω_{net} acts to increase the required threshold ability $(\tilde{a}_t)$ at which skilled and unskilled incomes equalize, thus *reducing* citizen incentives to invest in human capital. As a result of an increase in total transfers Ω_{net}, the average level of human capital $A(e, p)$ will decrease in a future period.

Returning to equation (14), keeping a focus on skilled workers, i.e., only those with $a_i > \tilde{a}_t$, the optimal level of schooling can be expressed as follows,

$$\frac{q}{1-q} = - \frac{\{A_{t+1}a_i[f(s_i^*)+f(1-s_i^*)]+\alpha\Omega_{net}\}}{[A_{t+1}a_i f(s_i^*)+\alpha\Omega_{net}]} * \frac{f'(s_i^*)}{[f'(s_i^*)-f'(1-s_i^*)]} \quad (18)$$

We see that optimum schooling (s_i^*) depends on innate ability, on the combined effect of resource rents and the fraction transferred to human capital $\alpha\Omega_{net}$, and on technology A_{t+1}. The left hand side of equation (18) shows the odds ratio of success to failure at entrepreneurship, while the right hand side yields the ratio of returns in the two states.

Proposition 2:

Part A: For ∀ (q), $(0 < q \leq 1)$, and an innate threshold ability such that $\tilde{a}_t < a_i < 1$, the optimal amount of schooling (s^*) holds if $s_i > \frac{1}{2}$. Part B: The optimal level of schooling (s^*) declines as the level of total resource rents distributed Ω_{net} increases. Similarly (s^*) declines with the resource rents fraction distributed to human capita (α). However, (s^*) increases in the average level of technology A_{t+1}.

Proof:

Part A of *proposition 2* holds because any value of $s_i^* < \frac{1}{2}$ will lead the right hand side of equation (18) to be negative, where $[f'(s_i^*) - f'(1 - s_i^*)] > 0$ due to the diminishing marginal

[20] The fraction distributed to human capital (α) decreases the threshold innate ability in many ways. One could assume that (α) can increase accessibility to schooling, universities, and other training programs. Further, in this model we assume no human capital investment cost.

return of schooling. Having an $s_i^* > \frac{1}{2}$ can be explained intuitively: Given that individuals are risk averse, and entrepreneurial capital is uncertain, people choose to invest in entrepreneurial capital only when the expected return is significantly high. To prove part B of *proposition 2*, implicit differentiation of (18) yields:

$$\frac{\partial s*}{\partial p_t} > 0 , \frac{\partial s*}{\partial e_t} > 0, \frac{\partial s*}{\partial \Omega_{t_{net}}} < 0, \frac{\partial s*}{\partial \alpha} < 0 \qquad (19)$$

(See Appendix A for additional proof).

To explain these result, higher $\alpha\Omega_{net}$ means that agents will opt for *less* optimum schooling while increasing their investments in entrepreneurship over time. This behavior is consistent with our utility function which has a decreasing absolute risk aversion (D.A.R.A.). Any increase in resource rents distributed allows agents to enjoy higher consumption, where a D.A.R.A. means that they become less risk averse increasing their risk appetite to invest in uncertain projects.

3.4 Dynamics

Suppose the threshold innate ability exceeds the maximum possible level of ability in society, $\tilde{a}_t > 1$. Then no one will invest in human capital. This can be seen from the set μ below and is depicted by the shaded areas in figures (4) and (5) later in this section.

$$\mu \equiv \Big\{\{e_t, p_t, \Omega_{net})|[q\ln A_{t+1} a_i\big(f(s_i) + f(1-s_i)\big) + \alpha\Omega_{net}] + [(1-q)\ln(A_{t+1}a_i f(s_i) + \alpha\Omega_{net}] \le \ln[2(\omega + (1-\alpha)\Omega]\}\Big\} \qquad \text{given } \tilde{a}_t > 1 , \qquad (20)$$

However, when $\tilde{a}_t \le a_i \le 1$, the dynamics are given by the following pair of equations.

$$e_{t+1} = \begin{cases} \int_{\tilde{a}_t}^{1}(1-\tilde{a})f(1-s_i^*)da_i & \text{if } 1>\tilde{a}_t>0 \\ f(1-s_i^*) & \text{if } \tilde{a}_t<0 \end{cases} \qquad (21)$$

$$p_{t+1} = \begin{cases} \int_{\tilde{a}_t}^{1}(1-\tilde{a})f(s_i^*)da_i & \text{if } 1>\tilde{a}_t>0 \\ f(s_i^*) & \text{if } \tilde{a}_t<0 \end{cases} \qquad (22)$$

Since s_t^* and $\tilde{a}_t$ are functions of $A_{t+1}(e_t, p_t)$ and $\alpha\Omega_{net}$, respectively, it follows that,

$$e_{t+1} = \Sigma((e_t, p_t), \alpha\Omega_{net}), \text{ and } P_{t+1} = B((e_t, p_t), \alpha\Omega_{net}) \qquad (24)$$

Consideration of both the non-skill constraint (equation 20) and the dynamics of e and p for the skilled (equation 24) imply the following proposition.

Proposition 3:

For any (q), such that $0 < q \le 1$, there exists a non-trivial stable steady state equilibrium in the space of $e_t - p_t$ provide that the initial technology is sufficiently advanced.

Proof:

Proposition 3 can be illustrated graphically by showing that at a given level of $\bar{e}$ *and* $\bar{p}$, and $A\ (\bar{e}, \bar{p})$, there exists $e_{t+1} = p_{t+1} = \bar{e} = \bar{p}$. This observation is obvious from equation (18). To illustrate this point suppose $q = 1$ and $s_t^* = \frac{1}{2}$, then $e_{t+1} = p_{t+1}$. Therefore for any $\bar{e}_t = \bar{p}_t$ both curves will cross exactly on the 45° line. This stable equilibrium is represented by point (y) in Figure 4 (See Appendix A for full proof).

The above graph stipulates that only a sufficiently high average level of initial professional and entrepreneurial human capital will lead to a high non-trivial steady state (*y*), where the $\dot{P} = 0$ and $\dot{E} = 0$ loci intersect. Point (*x*) is not a stable steady state because for any initial level of technology (A_3) outside $\dot{E} = 0$ and $\dot{P} = 0$, the long-run income will converge back to the shaded area. Countries with a low initial technology such as A_3 will experience deskilling as the average level of e_t and p_t is decreasing overtime. However, for countries with a sufficiently advanced initial technology (such as points $\mathrm{A_0, A_1, A_2,}$ and $\mathrm{A_4}$), incomes will converge to a stable steady state level represented by point (*y)* in the long run.

It is against this background that we can study the role of a positive resource shock.

Proposition 4:

A positive shock to resource transfers at large, $\Delta\Omega_{net}$ and/or the fraction transferred to human capital $\Delta\alpha$ makes it more likely that the economy will converge to a low-level equilibrium trap.

Proof:

As illustrated in figure 5, increases in either Ω_{net} or α have two effects; they cause the shift in the two loci, $\dot{P} = 0$ and $\dot{E} = 0$; they also cause a shift in the non-skilled constraint represented by the gray area. The first type of shift is critical to establishing the results. To establish this, recall from equation (19) that $\frac{\partial s^*}{\partial \Omega_{net}} < 0$ and $\frac{\partial s*}{\partial \alpha} < 0$. This negative effect shifts the $\dot{E}$ *and* $\dot{P}$ loci in different directions, causing a change in the location of the steady state. This can be shown by dividing equation (21) to (22) to obtain $\mathrm{p_t} = \frac{\mathrm{f}(s_t^*)}{\mathrm{f}(1-s_t^*)} e_t$. More specifically, professional human capital locus $\dot{P} = 0$ will shift down to $\dot{\mathrm{P}}' = 0$ while the locus for entrepreneurial human capital $\dot{E} = 0$ will shift right to $\dot{\mathrm{E}}' = 0$. But because of the concavity structure of $f(.)$, *a decrease in s_t will marginally decrease $f(s_t)$ to a greater extent than it will increase $f(1 - s_t)$*. As a result the region of "good" equilibrium shown by its tips at x and y will shrink.

As for the case of the shift in the non-skill constraint, unlike Iyigun and Owen (1997) where the size of this region, if it exists, depends only on the level of technology, here the size of the region is also affected by Ω_{net} and α as can be seen from the non-skill constraint (inequality 20). Here, we note that an increase in Ω_{net} raises both the left and the right hand side of this inequality while an increase in α always increases the left hand side and reduces the right hand side. It follows that the effect of the latter (i.e. α) is to shrink the set $\mu = (e_t, p_t)$ and thus the size of the gray area, while the effect of Ω_{net} is ambiguous.[21] Either way, as the arrows on two loci, $\dot{P} = 0$ and $\dot{E} = 0$ indicate, the process will always approach the low-income equilibrium trap. The difference will be that if α increases the approach toward this "bad" equilibrium will be slower, but if Ω_{net} increases it may either accelerate or slow down the approach to low-income equilibrium (see the previous note).

Let us now see how technology interacts with resources. Suppose that $\mathrm{A_0}$ and $\mathrm{A_2}$ initially represent two countries' technologies before any windfall resource rent distributions in figure 5; thus the relevant loci, $\dot{P} = 0$ and $\dot{E} = 0$, are those denoted by solid lines. It is obvious that the two economies belong to the region of convergence to the *good* equilibrium. Now consider a resource windfall transfer. The relevant loci are now $\dot{P}' = 0$ $\dot{E}' = 0$. As a result, the two economies will now converge towards the low income equilibrium. The contrast with country

[21] This depends on which side of inequality (20) increases more with an increase in Ω_{net}. Taking the derivative of both sides in Ω_{net} and comparing, a threshold level of $\overline{\Omega}_{net}$ is found by setting the two derivatives equal. Then, the set $\mu = (e_t, p_t)$ will expand if $\Omega_{net} >$ $\overline{\Omega}_{net}$ and contract if $\Omega_{net} < \overline{\Omega}_{net}$. The threshold $\overline{\Omega}_{net}$ is, $\overline{\Omega}_{net} = \dfrac{1-\alpha-2\alpha\omega}{2\alpha(1-\alpha)}$.

whose technology is given by A_1 is instructive. This country's technology is sufficiently advanced that the presence or absence of windfall resource transfers will not deter its march towards the "good" or high-income equilibrium. In short, countries will advanced technology will be able to escape the curse, while those with marginal technology will not.

There are some theoretical caveats. For example, a country with technology that is highly entrepreneurial-capital-intensive but professional-capital-poor (A_5) may actually benefit from windfall resource transfers and experience a switch from convergence to a bad equilibrium to one to a good equilibrium. Such possibilities are unlikely to exist in reality probably because a "minimum scale" of either type of capital needs to exist for a technology to succeed.[22]

Figure 5 describes the effect of distributed natural resource rents on human capital accumulation after a positive shock. The figure demonstrates that due to their higher level of overall technology, only higher income countries escape the resource curse if resources are distributed as lump sum transfers. However, resource shocks have more influence on lower-income countries, as those countries will eventually converge back to a low or unskilled labor economy being caught in a development trap.

4. Empirical Analysis

While studies that focus on the impact of either human capital or natural resources on economic growth abound, few if any have considered the interaction of the two, as our model requires us to do (see below)[23]. Two factors distinguish our empirics. First, given the model, our hypothesis is ***not*** that natural resources might have a positive or negative effect on human capital accumulation, nor that transfer have a positive or negative effect on human capital accumulation; rather that the ***interaction*** of lump-sum transfer and resources have a deleterious impact on the incentive to accumulate human capital. This says that, in countries that have high level of natural resource rents per labor, government transfers have a negative effect on human capital accumulation. This relates to the term $\alpha\Omega_{\text{net}}$ in the theoretical model discussed earlier. This unique aspect, especially derived from the model, has not been examined before. Second, we focus on ***tertiary*** education in our analysis, while most studies focus on secondary education as a measure for human capital. For us this is crucial, because it is *this* measure that is pertinent to the notion of specialization and skills, so crucial to technological innovation and the process of economic growth. It so happens that the role of tertiary education in growth has received less attention, thus an added contribution of our work. Our empirical approach entails both a dynamic panel and a cross sectional model.

4.1 Dynamic Panel

A dynamic estimator is used to analyze panel data that have inherent dynamic characteristics. It is clear from the economic growth literature that the *initial* level of education is considered as a base for higher growth. From our hypothesis above, our benchmark equation is as follows[24],

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[22] The level of technology $A(e, p)$ is a function of the average level of both types of human capital. This explains why a minimum level of both types of human capital is needed.

[23] On the curse, i.e., the effect of natural resources on growth, the best recent source is Frankel's (2010) survey, though as is well known, this line of inquiry began with Sachs and Warner (1995, 1997, 1999, 2001). On the relation between human capital and growth, Barro and Sala-i-Martin (1995) and Barro (2001) are among the better known earlier studies. Two studies that come close to our thinking are Gylfason (2001) who suggested that "natural capital" intensity may crowd out human capital as well as social, physical and financial capital and Bravo-Ortega and De Gregorio (2005) who studied the interaction between human capital and natural resources, but with a different goal in mind: to show that the resource curse may be offset by human capital. Using a panel data model, they showing that high levels of human capital may outweigh the negative effects of the natural resource abundance on growth. However, the issue of the endogeneity of human capital itself as a consequence of resource windfall-which is our take-was not in their purview.

[24] See Appendix B for variables specifications.

$$TertiaryEdu_{it} = \alpha + \beta_0 TertiaryEdu_{it-1} + \beta_1 ResourceRents\ per\ labor_{it} + \beta_2 Gov.Transfers_{it} + \beta_3 (Gov.Transfers * Resource\ rents\ per\ labor)_{it} + \beta_4 X_{it} + u_i + \psi_t + \epsilon_{it}$$

We use the Arellano-Bover and Blundell-Bond estimator for the above model due to the following reasons: First, the regressors might be endogenous as some of the control variables might have a relation that is going in both directions. Second, the lagged dependent variable $TertiaryEdu_{it-1}$ is correlated with the first difference of the error term. Arellano-Bover and Blundell-Bond estimation starts through transforming regressors to eliminate the country specific intercept u_i, and then allows for the use instruments for regressors that might be endogenous. Further, Arellano-Bover and Blundell-Bond estimation instruments the lag of the dependent variable $TertiaryEdu_{it-1}$ by $TertiaryEdu_{it-2}$ to avoid auto-correlation. In this model, we assume a sequential moment restriction to insure that our independent variables are sequentially exogenous, conditional on the unobserved effect.

$$E(\epsilon_{it} | X_{it}, X_{it-1}, \dots . X_{i1}, u_i) = 0$$

The above assumption insures that using the first difference, as an instrumental variable is sequentially exogenous.

Here, *"Tertiary Edu" and its lagged value "$TertiaryEdu_{it-1}$"* are defined as the tertiary education enrollment as a percentage of total population of tertiary education age. Five years average data was calculated from the World Bank Development Indicators including both genders from 1980 to 2009. *Resource Rents per labor* is the measure of resource profits generated per unit of labor. According to the World Bank Development Indicators, the natural resource rents variable is the sum of oil rents, natural gas rents, coal rents, mineral rents, and forest rents, net of cost. *Gov. Transfers* represent government transfers as a percentage of total government expenses. We examine the effect of government transfers on tertiary education where such transfers stem from resource rents in resource rich countries as taxes in many resource rich nations are minimal. To capture this effect, we construct an interaction variable, $Gov.Transfers * Resource\ rents\ per\ labor$ that represents the combined effect of natural resources and government transfers on tertiary education. We consider this variable as a proxy of the $\alpha\Omega_{net}$ innovation in our theoretical model. Finally, X_{it} is a set of other control variables including education expenditures as a percentage of total expenses, GDP per capita, foreign direct investments as a percentage of the GDP, tax revenues percentage of total revenues, time dummies, and terms of trade as a percentage of the GDP.

4.1.1 Model estimation

Table 1 presents our results for the dynamic panel data regressions. First, our data covers 44 countries. The constraint in the country coverage is due the limitation in government transfers data. For robustness we stratified two data sets from our original sample based on different country characteristics such as the level of resource dependence, or regions (e.g., the Middle East-North Africa or MENA region). Looking at government transfers and resource rents per labor in all three regressions, each variable *alone* has a negligible effect on tertiary education. But the key variable, the ***combined*** effect of transfers and natural resource rents per labor, is negative and significant at less than 5% significance level. Further this negative effect is persistent in resource dependent and MENA region countries. From regression (1), if the product of resource rents per labor and government transfers increases by $10,000 (represented in constant dollars), the percentage of tertiary education enrollment will decrease by 3.06 units[25]. If we investigate only resource rich dependent countries, one can see that the combined effect of resource rents per labor and government transfers has also a negative and significant effect on tertiary education. From regression (2), a $10,000 increase in the product of resource rents per labor and government transfers will decrease the enrollment percentage of tertiary

[25] *(Government transfers*resource rents per labor*) is expressed by 1/10000 of a unit.

education by 2.12 units. Considering the MENA region, an increase in *(government transfers*resource rents per labor)* by $10,000 is associated with a decrease in the enrollment percentage of tertiary education by 2.88 points. One interesting observation is that the initial level of tertiary education has a significant effect on the path of tertiary education only in regression (1) and (2). However, in the MENA region countries the initial level of tertiary education is not significant.

Additional observations are as follows: Regression (1) suggests that public spending on education has a positive and significant effect on tertiary education. A one unit increase in public spending as a percentage of total government expenditures will increase the percentage of tertiary education enrollment by 2.6 percentage points. However, from regressions (2) and (3), the effect of public spending on tertiary education is negligible. These results are expected as most resource rich dependent countries, and MENA countries have relatively inefficient government spending associated with a high level of rent seeking activities and corruption[26].

In sum this dynamic panel data model provides support for our model as to how resource rent transfers lower the incentive to invest in schooling. The adverse role of resources *via lump sum transfers* is brought home further, when we note that either variable *alone* exhibits an insignificant effect.

4.1.2 Robustness checks

We also tested if results are robust to different model specifications such as different natural resource rents variable specification, different types of education, and different time periods. For example, we used resource rents per GDP instead of resource rents per labor. Further, we used secondary education instead of tertiary education.

The combined effect of resource rents per GDP and government transfers has a negative and statistically significant effect on tertiary education while an insignificant effect on secondary education. Additionally, using secondary education as a dependent variable, we found that the combined effect of government transfers and resource rents per labor on secondary education is positive and *not* statistically significant. However, employing a dynamic panel data model with annual data of tertiary education, our results coincide with table 1: The combined effect of resource rents per labor and government transfers on tertiary education remains negative and statistically significant. The fact that the interaction term holds for territory and not secondary education and it does so regardless of model variations points to the robustness of the findings and strengthens the validity of the proposed mechanism.

4.2 Cross-sectional estimation

We now examine the same combined effect of resource rents and government transfers on human capital *in* a cross section regression by averaging out over the entire period, 1980-2009. Our benchmark equation is as follows:

$$TertiaryEdu_i = \alpha + \beta_1 Resource\ rents\ per\ labor_i + \beta_2 Gov.transfers_i + \beta_3(Gov.Transfers * Resource\ rents\ per\ labor)_i + \beta_4 X_i + \epsilon_i$$

We have also added additional controls such as the stock of technology and savings that might influence tertiary education enrollment in the longer run. To see the effect of technological progress, we use the Technological Output Index.[27] This index measures the innovation at the country level. Technology output is measured as a weighted average of knowledge creation,

[26] Besides Norway, and according to the International Country Risk Guide, countries such as Saudi Arabia has a corruption level of 2.5 out of 5, Kuwait 2.3 out of 5, Iran 1.75 out of 5, and Venezuela 2.8 out of 5. These numbers are based on averages of 25 years of data for each country.

[27] Technology output was taken from the Global Innovation Index.. INSEAD, Cornell University, and the World Intellectual Property Organization created the index through a joint effort.

knowledge impact, and knowledge diffusion. We also added democracy and corruption to control for the institutional performance in our studied countries. [28]

4.2.1 Models estimation

Results are reported in Table 2. Here, the negative interaction effects of resource rents per labor and government transfers on tertiary education are consistent with the results from panel regressions, pointing to further robustness of mechanism we have proposed. In addition, we also find that resource rents per labor alone have a negative and significant effect on tertiary education as well. This latter result coincides with the natural resource curse literature as natural resources have a long-term negative effect on social capital investments such as tertiary education. A one dollar increase in resource rents per labor will *significantly* decreases the percentage of tertiary education enrollment by .124 units. This ties well with the negative effect of an increase in Ω_{net} in our model.

As before, the combined effect of resource rents and government transfers has a negative and significant effect on tertiary education among 44 countries. For countries with a high level of resource rents per labor, an increase in government transfers by $10,000 constant dollars reduces the percentage of tertiary education enrollment by 1.179 units. One interesting observation is that the initial level of tertiary education can significantly influence tertiary education enrollment in the short run (Table 1) and the long run (Table 2). From Table 2, an increase of 1 percent enrollment in tertiary education in the 1980's level of tertiary education, will improve tertiary education by 0.609 percent between countries. Considering the combined effect of technological output and resource rents shows that any improvement in technological output index will significantly increase tertiary education.

5. Conclusion

We have argued theoretically, and demonstrated empirically, that rents distributed from natural capital distort individual decisions to acquire skills. Using an overlapping generations framework for this purpose we find that when countries are rich in natural resources and poor in technology, lump sum transfers from windfall resource rents have an adverse effect human capital investments. In such economies a positive resource shock actually increases the likelihood of convergence to a poor (low income) equilibrium trap in the long run. It does so by reducing human capital investments are thus long-run growth. When technology is sufficiently advanced, however, the trap can be avoided and convergence to a high-income equilibrium remains possible.

Our empirics support the theoretical findings explained above. Both the dynamic panel data and cross section models show that government transfers stemming from natural resource rents will negatively influence investments in tertiary education. Specifically, in both dynamic panel regressions and cross sectional regressions, we find that the interaction of government transfers and resource rents per labor is associated with *less* human capital investments in tertiary education, a key indicator of a country's technological capacity. Additionally, cross sectional regression show that resource rents per person *alone* exerts a significant negative effect on tertiary education. This significant effect ties well with the resource curse literature.

The policy implications arising from these findings are starkly different from those offered by others. For example, Sala-I-Martin and Subramanian (2003) suggest that Nigeria should distribute its oil earnings on an equal per capita basis, and Birdsall and Subramanian (2004) make the same proposal for Iraq. However, our research indicates that government policies that

[28] In this cross sectional analysis we tried different regressions, including a regression with the same number of variables as our dynamic panel regressions reported in Table 1. However results are not robust due to the high degree of endogeneity. The reported regression in Table 2 includes additional control variables so to reduce the endogeneity issue and increase the robustness of our results. (Please see Table 4 in Appendix A)

depend on distributing generated rents as income transfers, will discourage investments in human capital in the long run and hamper growth.

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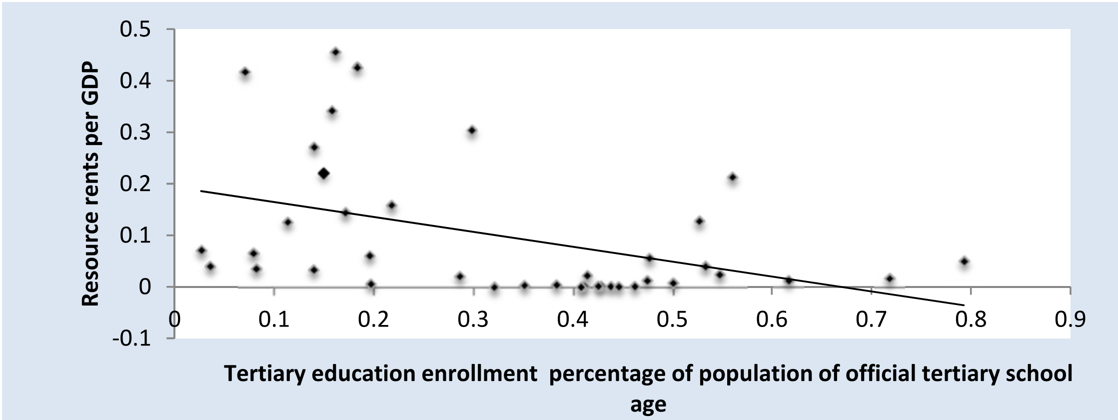
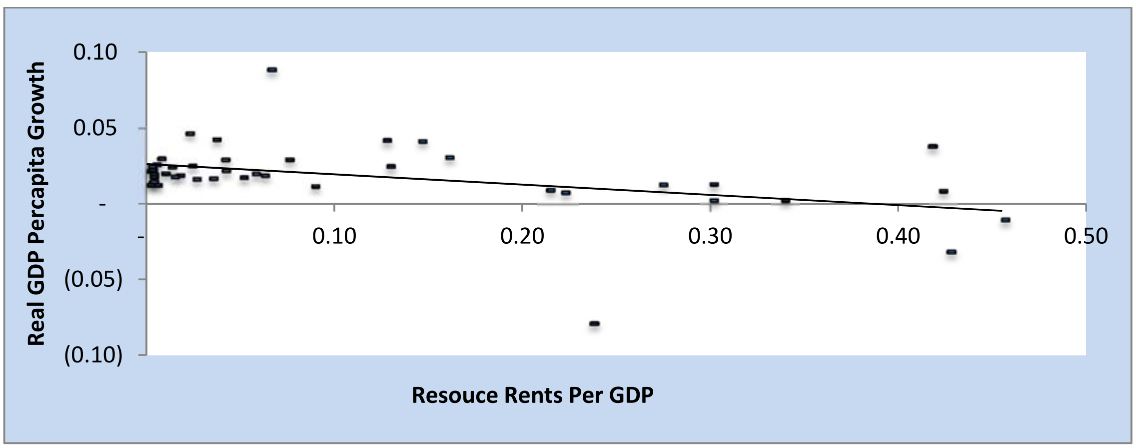
Figure 1: Natural Resources Percentage of GDP and Tertiary Education



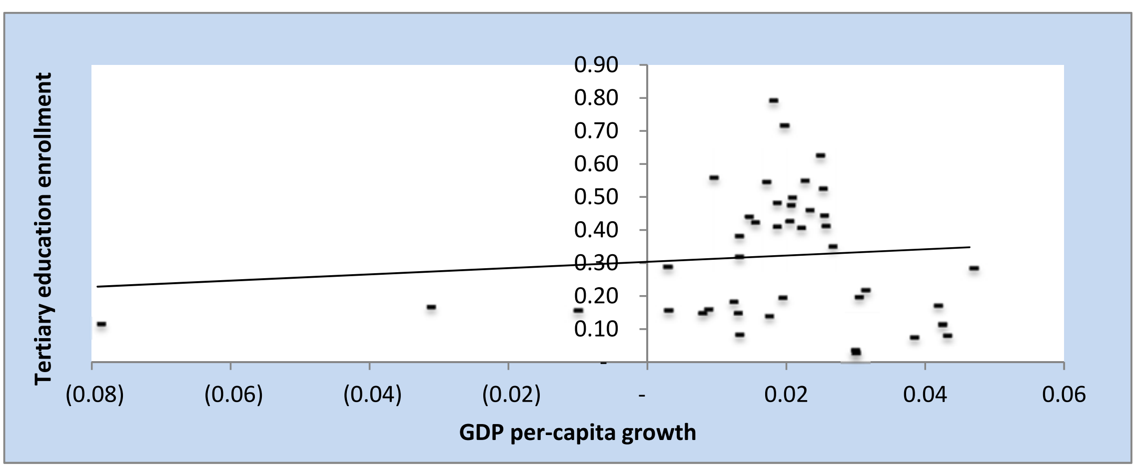
Source: Authors, using WDI data.

Figure 2: Natural Resources and Economic Growth



Source: Authors, using WDI data

Figure 3: TERTIARY EDUCATION and Real GDP Per-capita Growth between 1980 and 2009



Source: Authors, using WDI data

Figure 4: Graphical Interpretation of the Model's Dynamic

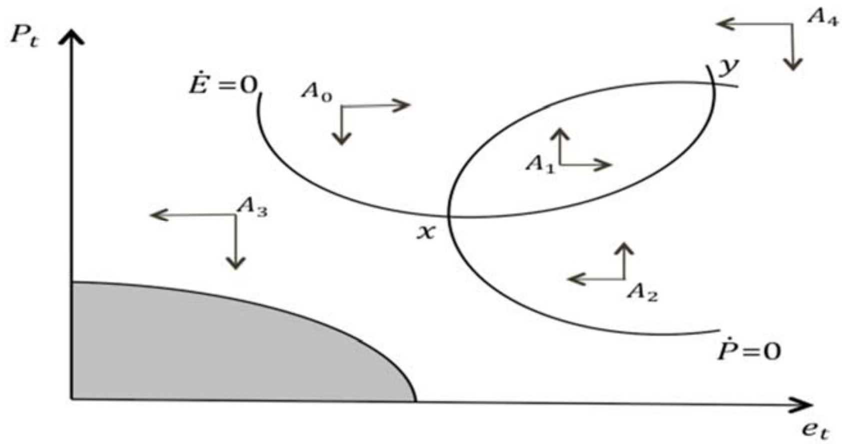


Figure 5: The Effect of Natural Resources on Schooling and Entrepreneurship after a Resource Shock

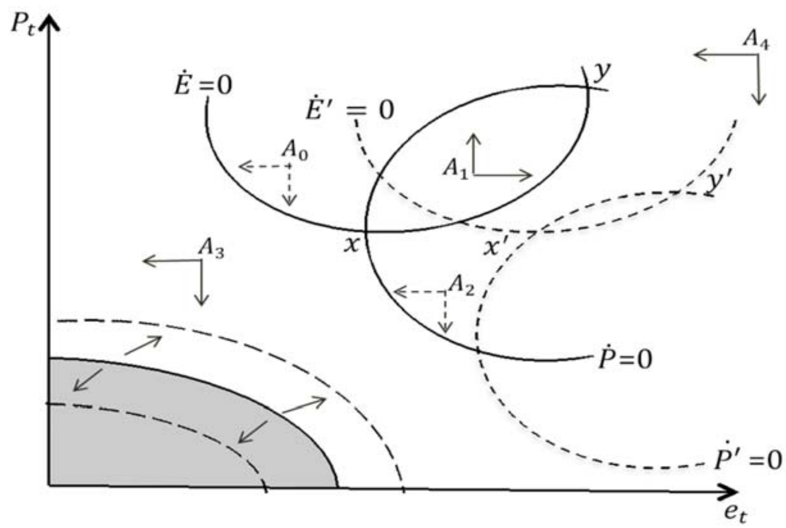


Table 1: Dynamic Panel Data to Study the Combined Effect of Transfers and Resource Rents on Human Capital

	All Countries (1)	Resource Dependent Countries (2)	MENA Region (3)
Lag of tertiary education	1.159	1.243	0.021
	(12.92)**	(9.39)**	-(0.08)
Lag log gdp-per capita	-0.093	-0.196	0.172
	-(0.51)	-(1.79)	-(1.19)
Lag FDI	0.012	0.007	-0.003
	-(1.47)	-(1.17)	-(0.74)
Resource rents per labor	0.506	0.304	0.202
	-(1.05)	-(0.08)	-(0.06)
Gov. transfers	0.106	0.054	-0.042
	-(1.46)	-(0.46)	-(0.26)
Gov. transfers* resource rents per labor	-3.063	-2.127	-2.887
	-(2.39)*	-(2.52)*	-(3.14)**
Education expenditures	2.627	1.755	-1.292
	(3.11)**	-(1.65)	-(1.26)
Tax revenues per gdp	0.042	0.24	0.651
	-(0.25)	-(1.07)	(2.60)**
Terms of trade	-0.002	0.018	0.019
	-(0.05)	-(0.30)	-(0.41)
Democracy	-0.017	-0.03	-0.013
	-(1.13)	-(1.58)	-(0.90)
Time dummies added	Yes	Yes	Yes
Constant	0.1	-0.104	-0.075
	-(0.62)	-(0.68)	-(0.53)
N	220	60	56

Notes: The numbers in parentheses are t statistics. Variables were taken from the World Bank Indicators. Note that the significance level is: *p<0.05; **p<0.01. Model (1) includes our overall sample including resource rich and resource poor countries. Model (2) represents countries with resource rents higher than 20% of total GDP. Model (3) represents resource countries in the MENA region.

Table 2: Cross Section Model to Study the Combined Effect of Resource Rents and Government Transfers on Tertiary Education

	Robust standard errors
Initial tertiary education	0.609
	(2.06)*
Resource rents per labor	-0.124
	-(2.05)*
Gov. transfers	0.22
	(2.19)*
Gov. transfers* resource rents per labor	-1.791
	-(2.17)*
Education expenditures	-0.739
	-(1.04)
Tax revenues per gdp	-0.036
	-(0.21)
Terms of trade	0.03
	-(0.59)
Democracy	0.016
	(0.99)
Log gdp per capita	0.028
	-(1.38)
Savings	-0.204
	-(1.23)
Corruption	0.047
	(1.74)
Technology output	-0.003
	-(2.49)*
Technology output* resource rents per labor	0.008
	(2.63)*
Constant	-0.186
	-(1.50)
R^2	0.82
N	44

Notes: The numbers in parentheses are t statistics. Variables were taken from the World Bank Development Indicators. Note that the significance level is: *p<0.05; **p<0.01

Appendix A

I. Proposition 1:

Using the implicit function theorem and equation (11) one can prove the following: $\frac{\partial \tilde{a}_t}{\partial p_t} < 0, \frac{\partial \tilde{a}_t}{\partial e_t} < 0 \frac{\partial \tilde{a}_t}{\partial \alpha_t} < 0 \ \frac{\partial \tilde{a}_t}{\partial \Omega_{net}} > 0$

let,

$$F(e_t, p_t, \alpha_t) = F(\{qln\{[A_{t+1}\tilde{a}_t[f(s_i) + f(1 - s_i)] + \alpha\Omega_{net}\} + (1 - q)ln\{A_{t+1}\tilde{a}_t f(s_i) + \alpha\Omega_{net}\} - \ln\{\omega \ + 2(1 - \alpha)\Omega_{net}\}\} = 0),$$

then, $\frac{\partial \tilde{a}_t}{\partial p_t} = -\frac{F_{p_t}}{F_{\tilde{a}_t}} < 0$, $\frac{\partial \tilde{a}_t}{\partial e_t} = -\frac{F_{e_t}}{F_{\tilde{a}_t}} < 0$, $\frac{\partial \tilde{a}_t}{\partial \alpha_t} = -\frac{F_{\alpha_t}}{F_{\tilde{a}_t}} < 0$

, $\frac{\partial \tilde{a}_t}{\partial \Omega_{net}} = -\frac{F_{\Omega_{net}}}{F_{\tilde{a}_t}} > 0$

II. Proposition 2:

$$\underset{s_i}{Max} \left[E[U(c^i_{t+2})|t] = [qln(c^i_{t+2})_{Sucess} + (1 - q)ln(c^i_{t+2})_{Failure}]\right]$$

Subject to: $Y^i_{t+1} = (Y^i_{t+1})^p + (Y^i_{t+1})^e$

The first order condition (F.S.O) with respect to (s_i):

$$\partial \frac{E[U(c^i_{t+2})|t}{\partial s_i} = \frac{qA_{t+1}\, a_i[f'(s_i) - f'(1 - s_i)]}{\{A_{t+1}a_i[f(s_i) + f(1 - s_i)] + \alpha\Omega_{net}\}} + \frac{(1 - q)A_{t+1}a_i f'(s_i)}{[A_{t+1}a_i f(s_i) + \alpha\Omega_{net}]}$$

This can be written as:

$$\frac{\partial E[U(c^i_{t+2})|t}{\partial s_i} = \frac{qA_{t+1}\, a_i[f'(s_i) - f'(1 - s_i)]}{(c^i_{t+2})_{Sucess}} + \frac{(1 - q)A_{t+1}a_i f'(s_i)}{(c^i_{t+2})_{Failure}}$$

taking the second order condition (S.O.C) with respect to (s_i) :

$$\frac{\partial^2 E[U(c^i_{t+2})|t}{\partial^2 s_i} = \frac{qA_{t+1}\, a_i[f''(s_i) + f''(1 - s_i)].(c^i_{t+2})_{Sucess} - qA^2_{t+1}a^2_i[f'(s_i) - f'(1 - s_i)]^2}{(c^i_{t+2})^2_{sucess}} + \frac{(1 - q)A_{t+1}a_i f''(s_i)\,(c^i_{t+2})_{Failure} - (1 - q)A^2_{t+1}a^2_i[f'(s_i)]^2}{(c^i_{t+2})^2_{Failure}} < 0$$

To prove the following condition: $\frac{\partial s*}{\partial p_t} > 0$, And $\frac{\partial s*}{\partial e_t} > 0, \frac{\partial s*}{\partial \Omega_{t_{net}}} < 0, \frac{\partial s*}{\partial a_i} > 0$ we also use the implicit function theorem and equation (12).

Let,

$G(s_i, e_t, p_t, \Omega_{net}) = G\{\frac{q}{1-q} + \{\frac{\{A_{t+1}a_i[f(s^*_i)+f(1-s^*_i)]+\alpha\Omega_{net}\}}{[A_{t+1}a_i f(s^*_i)+\alpha\Omega_{net}]} * \frac{f'(s^*_i)}{[f'(s^*_i)-f'(1-s^*_i)]}\} = 0\}$ then,

$\frac{\partial s^*}{\partial p_t} = -\frac{G_{p_t}}{G_{s^*_t}} > 0$, $\frac{\partial s^*}{\partial e_t} = -\frac{G_{e_t}}{G_{s^*_t}} > 0$, $\frac{\partial s^*}{\partial \Omega_{net}} = -\frac{G_{\Omega_{net}}}{G_{s^*_t}} < 0$

III. Proposition 3:

Assume the following: $\dot{E} = 0, \dot{P} = 0$ will not intersect with the shaded area i.e. :

$$\mu = \{(e_t, p_t, \Omega_{net}) | q ln[A_{t+1}\tilde{a}_t[f(s_i) + f(1 - s_i)] + \alpha\Omega_{net} + (1 - q) ln\{A_{t+1}\tilde{a}_t f(s_i) + \alpha\Omega_{net}\} - \ln\{\omega + 2(1 - \alpha)\Omega_{net} > 0\}$$

1- From $\dot{P} = 0 = \mathrm{p_{t+1}} - p_t = 0, and\ \dot{E} = 0 = \mathrm{e_{t+1}} - e_t = 0$, equation (15) and (16) and given $0 \leq \tilde{a}_t \leq 1$, one can prove the following:

$\frac{\partial p_t}{\partial e_t} | \dot{E} = -\frac{\Sigma_e - 1}{\Sigma_p}$, and $\frac{\partial p_t}{\partial e_t} | \dot{E}$ will be negative if $\Sigma_e > 1$, and positive otherwise.

$\frac{\partial p_t}{\partial e_t} | \dot{P} = -\frac{B_e}{B_p - 1}$, and $\frac{\partial p_t}{\partial e_t} | \dot{P}$ will be negative when $B_p > 1$, and positive otherwise.

The slope of $\dot{E} = 0$ and $\dot{P} = 0$ will have the following characteristics:

A-For a given small value of “e” $\frac{\partial p_t}{\partial e_t} | \dot{E} < 0$, however as “$e$” goes to ∞, $\frac{\partial p_t}{\partial e_t} | \dot{E} > 0$

B- For a given small value of “p” $\frac{\partial p_t}{\partial e_t} | \dot{P} < 0$, however as “$p$” goes to ∞, $\frac{\partial p_t}{\partial e_t} | \dot{P} > 0$

C- Given that $s_t, and\ \tilde{a}_t$ are continuous on $e_t and\ p_t$, there exist a value $p', and\ e'$ such that $\frac{\partial p_t}{\partial e_t} | \dot{P} = 0$

D- Given that $s_t, and \tilde{a}_t$ are continuous on $e_t and p_t$, there exist a value $p', and\ e'$ such that $\frac{\partial p_t}{\partial e_t} | \dot{E} = 0$.

Points A, B, C, D justify the shape of $\dot{E} = 0$ and $P \doteq 0$ loci in the space of e_t and p_t.

2- we will show that there exist a non-trivial steady state to exist for a given value of e_t and p_t.

Assume a value of q=1, then equation (12) will hold only if, $\mathrm{f}'(\mathrm{s}^*) = \mathrm{f}'(1 - \mathrm{s}^*) = \mathrm{f}'\left(\frac{1}{2}\right)$. Then, $e_{t+1} = p_{t+1} = (1 - \tilde{a}) f(\frac{1}{2})$. Given this, for any value of e and p, $(\mathrm{e}^*, \mathrm{p}^*)$, such that $\mathrm{e}^* = \mathrm{p}^*$on $\dot{P} = 0$, and a value of e and p, $(\bar{\mathrm{e}}, \bar{\mathrm{p}})$, such that $(\bar{\mathrm{e}} = \bar{\mathrm{p}})$ on $\dot{E} = 0$, then $\bar{\mathrm{e}} = \bar{\mathrm{p}} = \mathrm{e}^* = \mathrm{p}^*$and there exist a steady state exactly on the intersection of $\dot{P} = 0\ and\ \dot{E} = 0\ loci$. Further both $\dot{P} = 0, and\ \dot{E} = 0$ must intersect exactly at a 45° straight line.

Appendix B:

Table 3: Cross Section Model to Study The Combined Effect of Resource Rents and Government Transfers on Tertiary Education

	(1)	(2)	(3)
Initial tertiary education	0.489	0.508	0.609
	(1.42)	(1.47)	(2.02)
Resource rents per labor	-0.046	-0.14	-0.124
	-(1.49)	-(2.11)*	-(2.05)*
Gov. transfers	0.11	0.279	0.22
	(1.18)	(2.57)*	(2.19)*
Gov. transfers* resource rents per labor	0.64	-1.816	-1.791
	(0.80)	-(1.59)	-(2.17)*
Education expenditures	0.599	0.154	-0.739
	-(0.62)	-(0.16)	-(1.04)
Tax revenues per gdp	0.025	0.013	-0.036
	-(0.12)	-(0.07)	-(0.21)
Terms of trade	-0.03	0.023	0.03
	-(0.60)	-(0.41)	-(0.59)
Democracy	0.02	0.023	0.016
	(1.21)	(1.39)	(0.99)
FDI	0.006	-0.015	
	-(0.43)	-(0.71)	
Log gdp per capita	0.053	0.042	0.028
	(2.24)*	-(1.80)	-(1.38)
Savings		-0.37	-0.204
		-(1.49)	-(1.23)
Corruption			0.047
			(1.74)
Technology output		-0.002	-0.003
		-(1.85)	-(2.49)*
Technology output* resource rents per labor		0.008	0.008
		(2.23)*	(2.63)*
Constant	-0.352	-0.21	-0.186
	(2.28)*	-(1.35)	-(1.50)
R^2	0.77	0.8	0.82
N	44	44	44

Notes: The numbers in parentheses are t statistics. Variables were taken from the World Bank Development Indicators. Note that the significance level is: *p<0.05; **p<0.01

Table 4: Variables Explanation and Sources

Variable Name:	Explanation:	Source:
Per-Capita Income	Gross Domestic Product Per-capita Growth	World Bank
Resource rents per labor	Resource Rents per unit of labor force	World Bank
Savings	Total Savings as a Percentage of GDP	World Bank
Education Spending	Government Expenditures on Education Per Capita	World Bank
Trade	Terms of Trade As a percentage of GDP	World Bank
Manu-Per-GDP	Manufacturing Products as a Percentage of GDP	World Bank
Government Transfers	Government transfers and subsidies of total expenses	World Bank
Democracy	Democracy level going from 0(Nondemocratic) to 6 (Democratic)	ICRG
Technological Output Index	Innovation and production of high tech products	Global Innovation Index
Corruption.	Corruption level going from 0(corrupt) to 5 (not corrupt)	ICRG