# NATURAL RESOURCE ABUNDANCE AND HUMAN CAPITAL ACCUMULATION

JEAN-PHILIPPE STIJNS*
University of California at Berkeley
Department of Economics

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This study examines indicators of human capital accumulation together with data for natural resource abundance and rents in a panel of 102 countries running from 1970 to 1999. Mineral wealth makes a positive and marked difference on human capital accumulation. Matching on observables reveals that cross-country results are not driven by a third factor such as overall economic development. Political stability does seem to affect both human capital accumulation and subsoil wealth, but not enough to overturn my conclusions. Instrumentation reveals that reverse causality running from education to natural resources does not drive the results. Estimation of a panel VAR indicates that, over the three decades, a $1 shock to resource rent generates five cents of extra educational expenditure per year. These results are consistent with Hirschman's conjecture that enclave economies have weaker production leakages but stronger government revenue linkages than other activities. The "wealth channel" identified in this paper implies that caution should be exerted when discouraging countries from exploiting their mineral wealth, especially for countries where human capital is scarce.

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Correspondence: stijns@econ.berkeley.edu; University of California, Department of Economics, 549 Evans Hall #3880, Berkeley CA 94720-3880.

> **"**Mines, as well as land, generally pay a rent to their owner; and this rent, as well as the rent of land, is the effect, and never the cause of the high value of their produce."
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> D. Ricardo, *The Principles of Political Economy and Taxation* (London, 1948), p.46. Written in 1817.

## 1. Introduction

It is widely assumed in the literature that natural resources tend to harm countries which posses or discover them. Such a bold and surprising assumption deserves careful scrutiny if only because of its implications for development policy. At the same time, there is growing debate among academics, development and environment related lobbyists and policy makers regarding whether or not resource abundant countries should be encouraged to exploit their resource base. Resource booms are likely to have a large variety of possibly conflicting effects on different sectors and functions of the economy. In this paper, I restrict my attention to the link between resource abundance and human capital accumulation. Do natural resource abundant countries tend to have higher or lower stocks of human capital? Do resource booms tend to result in increased or decreased levels of educational expenditure? Let me first review the limited literature dealing with these questions:

Thorvaldur Gylfason (2001) claims that public expenditure on education relative to national income, expected years of schooling for girls, and gross secondary enrolment are all shown to be inversely related to the share of natural capital in national wealth across countries. He concludes that natural capital appears to crowd out human capital, thereby slowing down the pace of economic development. His opinion is "nations that are confident that their natural resources are their most important asset may inadvertently – and perhaps even deliberately! – neglect the development of their resources, by devoting inadequate attention and expenditure to education." He goes on to add "Their natural wealth may blind them to the need for educating their children."

Nancy Birdsall, Thomas Pinckney and Richard Sabot (2001) start-out by observing that most governments around the world extol the benefits of education while claiming that investment in education is limited because of a lack of money. As these authors admit, if limits on human capital investment primarily result from binding government constraints, resource abundance should induce additional investment, all else equal. Yet, these authors argue that statistics tell another story: resource-abundant countries, on average, invest *less* in education than other countries.

To the extent that mineral states tend to lavishly spend their mineral revenues on numerous development projects and programs (see for example William Ascher, 1999), it is surprising to read that education is the only exception. It is even more surprising to read that regarding education, the same mineral states actually spend *less* than other states. In this paper, I reach an opposite interpretation of the data. I show that human capital indicators are *positively* associated with resource abundance and mineral rents indicators. In an often-overlooked paper about resource abundance and economic growth, Graham Davis (1995) takes a first interesting pass at this question and finds similar results. I improve upon Davis (1995) by using richer human capital data as well as better resource abundance measures; I attempt to control for other determinants of human capital besides resource abundance; and I account for the common determinants of resource abundance and human capital. Instrument variables are introduced to take care of reverse causality running from human capital accumulation towards mineral wealth. VAR modeling is used to uncover some of the key dynamics among variables of interest, such as the interdependence between education, mineral production and aggregate output.

The theme of this paper lies at the heart of the debate regarding the effect of natural resource abundance on economic growth and development. If something, say an increase in human capital, is usually left as a byproduct of resource booms, resource abundance should provide for more than just a temporary increase in income per capita. Is this increase in human capital itself a temporary phenomenon? The answer to this question hinges upon the type of growth model we think best describes economic development. Yet, if we think that countries are only conditionally converging, the question becomes, is education capable of affecting some of the fundamental determinants of a country's steady state?

Robert Barro (1997, 2001) argues that education permanently increases the efficiency of the labor force by fostering democracy and that human capital facilitates the absorption of superior technologies from leading countries. This channel is supposed to be especially important at the secondary and higher education levels. Similarly, Philippe Aghion, Eve Caroli and Cecilia Garcia-Penasola (1999) assert that education creates better conditions for good governance by improving health and enhancing equality.

Development economists, and most notably Amartya Sen (1999), stress the importance of education, and in particular the importance of educating women in developing countries. The marginal social returns of education for growth are considered sizeable at the human capital levels that characterize developing economies. Given the high degree of inequality prevailing in these countries, education is often considered a better *indicator* of the *median* level of development. Along the same lines, education can also be considered a better *predictor* of long-term improvement prospects for the *median* level of income.

Importantly, in this paper I show that resource abundance is associated with higher *female* human capital accumulation across countries. I reach a similar conclusion is reached regarding "health capital." Matching techniques are used to allow resource abundance to be endogenous to a country's state of social and economic development, which is thought to affect human capital accumulation. However, matching does not substantially alter the conclusions. I also consider other factors that can drive both human capital and mineral wealth.

In panel regressions, a $1 boom in resource rents per capita is associated with an additional 3-5¢ spent on education per capita. The cross-country effect is much higher, 12-14¢ per dollar. I suspect this difference has to do with the higher inter-temporal uncertainty of resource rents relative to the uncertainty regarding the geographical distribution of subsoil wealth. Furthermore, across countries inter-temporal effects add up over time as VAR results indicate. In a VAR model, the effect of a shock to resource rents turns out to be three times more important than that of a residual GNP increases. Over the course of three decades, a $1 shock to resource rents ends up generating close to 5¢ of extra educational expenditure per year.

Why would we think natural resource abundant countries should tend to spend more on education than otherwise similar countries? There is an elementary "aggregate wealth effect" at work. Many researchers seem to assume that riches tend to spoil nations just as riches tend to spoil a rich person's children. Indeed, rich kids may often spend their parental wealth on expensive drinks on exotic islands, rather than learning invaluable lessons about life while working hard as seasonal gardeners. But the irony of this analogy is that empirically, the very same rich children end up, on average, highly educated and economically better off than their poorer children of their generation. The political leaders of resource rich developing nations may spoil part of their country's mineral revenues on "expensive shopping trips in

Paris," but all else equal, they will also tend to spend part of these revenues on education. Few dictatorships can afford to completely disregard the aspirations of their population, if only out of fear of coups or under foreign pressure from rich democracies or international organizations.

Albert Hirschman (1961) noted very early on that one would expect very few "production linkages" from mineral production. This view has lead to the coining of the term "enclave economy." Yet, in a less famous paper, Hirschman (1977) also pointed out there is presumably a trade-off between production and government revenue linkages. The idea is that an activity like manufacturing, which is highly interlinked with the rest of the economy, has a strong political lever with which it can avoid taxation. Conversely, enclave economies are by definition economically isolated and are often run by foreigners. Hence, mineral extraction activities represent fewer votes, have less political leverage, and are very often the object of heavy corporate income and export taxation. Additionally, as Helen Hugues (1975) points out, "Following Ricardian logic [see introductory quote], the supply of mineral is inelastic in the short-run, so that with a given demand the resource rent can be siphoned off without affecting the amount of mineral that will be mined." Obviously, the ability of a government to extract resource rents in these conditions will depend crucially on its relative bargaining power vis-à-vis international mining corporation. One would imagine that the more geographically concentrated a resource is, the higher this bargaining power. A good example of this is the weakening oligopoly power of OPEC following the discovery of oil in an increasing number of non-OPEC countries.

Any increase in production activity will generate additional government revenues and a share of these revenues is generally spent on education. But, if Hirschman's conjecture is correct, increases in resource extraction activities should generate more educational spending than other activities. On the other hand, strong production linkages in the manufacturing sector may over time compensate for the weaker government revenue linkages. Hence, this is essentially an empirical question. VAR estimation results indicate that government revenue effects more than make up for the lower production linkages as well as depletion and price variation effects associated with mineral activities, at least over the three decade period under consideration. This is remarkable given the implications of the Raúl Prebsich (1950) - Hans Singer (1950) hypothesis, *i.e.* the long-term downward trend in commodity prices, which is actually observed over the three decades under consideration here.

Yesterday's resource abundance translates itself into current higher human capital stocks. In this sense, resource abundance is more than a temporary windfall and can have a permanent effect on a country's income per capita as opposed to the counterfactual case where the country had never experienced resource abundance. This effect should be all the more important to development if human capital is key to the adoption of foreign technologies or the advance of a national research sector. This effect will matter all the more where education is key to the mitigation of income inequality and the advancement of democracy. For the former, secondary and tertiary education are expected to be key, whereas for the latter, primary and secondary education are expected to matter most. I show them to all be positively associated with resource abundance in this paper.

This is obviously decisive in terms of development strategy formulation: the wealth effect implies that resource rich countries should not be discouraged from exploiting their natural resource base, especially where human capital is in short supply. Of course, there are most likely other important "channels" of operation running from resource abundance to development — not to mention environmental concerns. These have to be systematically investigated, and should also be considered for the formulation of development policies. I conclude by stressing the importance for future research of detailed analyses of these other channels.

This paper is organized as follows. Section 2 presents the cross-country data used in this paper and reports non-parametric results. This section also reports the results of matching analysis with the aim of accounting for the expected determinants of natural resource abundance. Section 3 presents the panel of data used in the rest of the paper and moves onto panel regression analysis. Section 4 sets up a VAR and examines impulse responses from a one-dollar shock to resource rents. Section 5 reports the conclusions. The reasons why different conclusions are reached than in the existing literature are discussed in this last section.

## 2. Cross-Country Non-Parametric Analysis

Cross-country data for resource endowments come from the World Bank (1997). Their "subsoil wealth" variable will be used. Subsoil wealth covers metals, minerals, oil, coal and gas. Figure 1 shows the distribution of subsoil wealth across the sample of countries covered by the World Bank. The skewness of country data for subsoil wealth stands out very clearly. The geographical distribution of subsoil wealth appears to be quite independent of the level of development achieved by countries. There are highly developed resource rich countries like Norway, Australia, Canada, and the United States. There are resource-rich developing countries as well, such as Venezuela, Trinidad and Tobago, Chile, Mexico, and Malaysia.

Many human capital accumulation indicators have been analyzed for this research. They all tell a very similar story regarding the association between subsoil wealth and human capital accumulation, with a degree of statistical significance basically varying with the quality of the data series and their coverage. For the purposes of presentation, I select six human capital summary statistics: average years of primary, secondary, tertiary and total education for women, and illiteracy rates for women and life expectancy at birth. These indicators have been selected to get at distributional issues regarding education. Also, using indicators for women increases variation at the margin as compared to, say, the average years of primary education for males given that primary education for males is universal in many countries.

It is often argued in the development literature that it is human capital stocks that matter for development rather than crude measures of enrollment. I have used the two sets of data that are available. The first data set comes from Vikram Nehru, Eric Swanson, and Ashutosh Dubey (1995). The second and more recent data set comes from Robert Barro and Jong-Wha Lee (2000). Results reported in this paper correspond to this newer data set, but similar conclusions are reached with the Nehru-Swanson-Dubey dataset. Barro and Lee (2000) provide improved measures of educational attainment for a broad group of countries. They extend Barro and Lee's (1993) previous estimates of educational attainment for the population over age 15 and over age 25 up to 1995 and provide projections for 2000. Results corresponding to their projections for year 2000 for age 25 up are reported here. The idea is that introducing a five-year window between resource and human capital observation helps mitigate — but by no means rule out — risks of reverse causality.

Results are reported for females since one would expect the female educational attainment variable to better capture the median level of human capital accumulation, and its impact on development as mentioned above. Similarly, illiteracy rates tell us more about the median skill levels than other average indicators, especially in the case of women. The development literature also considers that health indicators are human capital indicators especially in the case of poorer citizens of poorer nations, where workers' efficiency often depends critically on their health conditions. One would also expect life expectancy at birth to be more informative regarding the median level of human capital accumulation than standard indicators and so results concerning life expectancy at birth are reported. These data come from the World Bank (2001) and have been averaged over 1995-1999 to increase coverage given the fact that all countries do not always report these statistics yearly.

Table 1 serves three purposes. First, it reports Spearman rank correlation coefficients between subsoil wealth and these key indicators of human capital accumulation. The main advantage of working with rank correlations rather than linear correlations is twofold. First, rank correlations do not impose a linear structure on the data. Second, they are insensitive to monotonic transformations of the series themselves. Since available human capital statistics are only imperfect indicators of the underlying concept of human capital, this property is particularly attractive. Developing countries being of particular concern in this paper, these correlation coefficients have also been calculated for the subset of developing countries. Additionally, there is the concern that rich countries may drive the observed correlations and that there are no implications for developing countries.

Average years of education for females at the primary, secondary and tertiary level are all positively correlated with subsoil wealth. The same is true of total years of education for females, as well as life expectancy at birth. Illiteracy rates for females are negatively correlated with subsoil wealth. All indicators are more strongly correlated within the subset of developing countries than within the whole sample. One plausible explanation for this is that subsoil wealth and the corresponding government revenues matter more for human capital accumulation at lower levels of income and in countries where general tax collection is politically and logistically more difficult. The importance of taxing and reinvesting subsoil wealth extraction revenues may fall short of some collective "cognitive threshold" when these revenues represent a small share of aggregate income. All rank correlation coefficients are statistically different from zero at a significance level well below 1%.

The rest of Table 1 is meant to answer the following two important questions. First, do observations made using Spearman rank correlations carry over when one compares different quartiles? In other words, is a subset of countries, say the countries exceptionally endowed in mineral wealth, driving the conclusions? Second, do mineral endowments reflect to some degree the state of technological and economic development of a country? If so, the fact that human capital indicators are positively associated with subsoil wealth could merely indicate that something common is driving both mineral endowments and educational investment.

To address the first question, Table 1 reports for each subsoil wealth quartile average values of the four summary human capital indicators. These averages are reported for all countries and for the subset of developing countries. It is clear from these figures that Spearman correlations are not driven by a set of countries corresponding to a specific subsoil wealth quartile. Average years of schooling for females and life expectancy at birth all increase from one quartile to the next. Female illiteracy rates decrease as we move up the subsoil wealth distribution quartile by quartile. Furthermore, this holds true if we consider the full sample as well as if we focus on the subset of developing countries.

In regard to the second question, Paul David and Gavin Wright (1997) hint that strong “positive feedbacks,” even in the exploitation of depletable resources, were responsible for the explosive growth of the US “minerals economy.” Yet, they challenge the premise that resource abundance simply reflects a country’s geological endowment of mineral deposits. They argue, in the century following 1850 that the US exploited its natural resource potential to a far greater extent than other countries, and did so across virtually the entire range of industrial minerals. N atural resource abundance was an endogenous, “socially constructed” condition that was not geologically pre-ordained. Davis (1995) mentions this potential limitation to his results but does not try to control for it.

However appropriate this bi-directional causality story may be regarding the US in the 19$^{th}$ century, in today’s world, multinational mineral extraction companies deploy state-of-the-art exploration technology even in the least developed corners of the world. It is thus open to question how we should see today’s mineral endowment, and to what extend this is driving the previous section’s results. This type of question naturally suggests the use of a kernel-based matching approach.

This technique is used to draw causal inferences about the relative effects of economic “treatments”, such as different social programs or macroeconomic policies and regimes. The data available to compare many such treatments are not based on the results of carefully conducted randomized experiments, but rather are collected while observing programs, policies or regimes as they operate.

Typically, such data are relatively inexpensive to obtain, and often are the only data available. There is a potential need to control for naturally occurring systematic differences in background characteristics between the treatment group and the control group, systematic differences that would not occur in the context of a randomized experiment.

Hidehiko Ichimura and Petra Todd (1998), James Heckman, Hidehiko Ichimura, Jeffrey Smith and Petra Todd (1998), as well as Richard Blundell and Monica Costa-Dias (2000) evaluate this technique in the context of economics. One important advantage of matching techniques is that they are non-parametric and allow the researcher to check the sensibility of regression results to the particular parameterization that has been adopted. In the macroeconomics literature, Torsten Persson, Guido Tabellini and Francesco Trebbi (2001) have applied this technique to study the effect of electoral systems on corruption.

Consider two groups of countries: those in the top quartile for subsoil wealth, and countries in another quartile, say the second (or third or fourth) quartile. Define as "treated" the countries in the top quartile for subsoil wealth. The set of second (or third or fourth) quartile countries is not subject to treatment and will make up the control group. I would like to estimate the average effect subsoil wealth treatment has on treated countries in terms of human capital accumulation. The problem is that the human capital a country not in the top subsoil wealth quartile would have, if it hypothetically had such a mineral endowment cannot be observed.

How can the information in the control group be exploited, allowing for the fact that, in this non-experimental setting, mineral endowments may not be random? Suppose "selection" is affected by an observable variable, for example GNP per capita as a proxy for technology and development, which could also have an independent effect on human capital accumulation. To exploit the control group, I will use the central identifying assumption of *conditional independence*, also known as the *selection on observables* assumption (Rosenbaum and Rubin, 1983, Rubin, 1974, 1977). This assumption asserts that, conditional on GNP per capita, human capital accumulation and mineral endowments are independent. In other words, once we have controlled for GNP per capita, no omitted or unobserved variable influences both membership in a particular subsoil wealth quartile and the human capital outcome. The impact of using observables other than GNP will also be investigated.

A non-parametric test of our central hypothesis can be obtained by combining observations in our treated and control group with similar values of their observable (say GNP per capita). Each treated country will be associated with the following statistics: $\hat{H}_i^T$, the weighted human capital outcomes of its neighbors in the treated group, and $\hat{H}_i^C$, the weighted human capital outcomes of its neighbors in the control group. The average $\left(\hat{H}_i^T - \hat{H}_i^C\right)$ will be the estimate of the treatment effect. The technical term for this approach is kernel-based matching. The weights given to each country's human capital outcome are in Gaussian proportion to the closeness of observables (*e.g.* GNP per capita) within the bandwidth, set here to two standard deviations of the observable.

Dividing the sample into four quartiles allows me to investigate the outcome of three different treatments: *What would be the human capital outcome of countries in the second, third, and bottom quartile for subsoil wealth had they found themselves in the top quartile for subsoil wealth?* Five different sets of observables are used in turns to match countries.

First, GNP per capita is used as a proxy for the overall technological development of a country to answer concerns raised by David and Wright (1997) as well as Davis (1995). Second, I select on political instability given that it may be driving both resource exploitation and exploration as well as human capital accumulation. Third, I select on legal origin is made because, for example, England both managed to colonize very valuable countries and choose for social institutions conducive to human capital accumulation. Fourth, I select on religions since, for example, Muslim countries happen to often be oil-rich countries and also have a culture conducive to literacy (thanks to the Koranic tradition). Note that legal origins and religions are measured as sets of dummy variables; in this case the Mahalanobis distance constructed from the variables, via Rubin's (1980) formula, is used. Fifth, and finally, propensity score matching is done. The propensity score is the probability of belonging to the treated group (top quartile for subsoil wealth) estimated using a probit model with, in this case, all the above four set of observables used as regressors, *i.e.* GNP per capita, political instability, legal origin and religion variables.

The bottom of Table 1 shows the effect of the three above-mentioned treatments, conditioned on the observables. The results are not fundamentally affected by kernel-based matching, indicating that neither the level of development of a country (as proxied by GNP per capita), nor political instability, nor legal origins nor religions are driving the results. Also, the results show that the larger the jump in the subsoil wealth quartile the larger the effect on the human capital outcomes. This reassuring conclusion is not generally affected by kernel-matching either. This is noteworthy given how unforgiving a cross-section of countries can be expected to be in these respects.

Interestingly, the results are actually strengthened by GNP matching. This implies that at equivalent GNP per capita, countries abundant in subsoil wealth do better at human capital accumulation than resource-poor countries. This is hardly compatible with a reverse-causality story where overall economic and technological development is driving both resource abundance and human capital accumulation. This is all the more remarkable since resource abundance is known to be associated with higher GNP per capita *everything else being equal* (Gallup and Sachs, 1998.) Kernel-based matching does not take into account the fact that causality can run from subsoil wealth to GNP per capita. The effect that matching on GNP captures is *beyond* the increased educational spending due to increased income per capita that stems from mineral extraction and production. This is consistent with Hirschman's (1977) proposition that enclave activities have stronger tax revenue linkages than other activities. In other words, these results indicate that when considering two countries with similar GNP per capita (including mineral extraction revenues!), mineral endowments make a substantial difference for human capital accumulation.

Matching on religion or legal origins generally *strengthens* the results. This implies that subsoil wealth tends to lay in countries whose religious traditions and legal origins are *less* favorable to education. On the other hand, matching on political instability somewhat weakens the results. This implies that a climate of political stability is favorable to both human capital accumulation and resource extraction. Overall, however, this effect is not strong enough to overturn my basic conclusions. The same is true in the case of propensity score matching where the probability of belonging to a particular quartile of subsoil wealth per capita is regressed in a probit regression on GNP, political instability, religions and legal origins. Propensity score matching does weaken somewhat the results but certainly not enough to overturn my original observations.

What about the empirical relevance of these effects? If unmatched results are used, moving from the bottom to the top quartile implies an increase in life expectancy of nearly 12 years of life at birth, nearly 4 additional years of education for females, and a 32% reduction in female illiteracy. If the propensity score matching results are used, which are the most comprehensive matching estimates I have, moving from the bottom to the top quartile implies an increase in life expectancy of nearly 8½ years of life at birth, 2½ additional years of education for females, and a 23% reduction in female illiteracy.

In either case, these are substantial differences relative to the values these indicators reach on average, especially in developing countries. However, an important concern is that of reverse causality running from human capital accumulation to resource abundance. Section 3 moves on to panel regression analysis. I will tackle endogeneity issues by using instrument variables that can be safely assumed to be exogenous to both resource extraction and aggregate output.

## 3. Panel Data Regression Analysis

This section reports results from panel regression analysis. I am moving here to a year-to-year setup as opposed to the cross-country setup of Section 2. In such a year-to-year setup, I want to use educational expenditure per capita as the dependent variable, and resource rents as the main independent variable. Basically, I am moving from a stock to a flow analysis. Hamilton and Clemens (1999) provide a blueprint for the calculation of what the World Bank calls genuine savings rates. I use their educational expenditure data, *i.e.* the share of educational expenditure in national expenditure, and their calculated series for resource rents. These data cover a panel of 102 countries from 1970 to 1999, and the series are divided by population data to obtain educational expenditure per capita and resource rents per capita, respectively.

The list of data sources for the resource rental estimates are given in Hamilton and Clemens (1999). Their basic approach to calculating resource rents for non-renewable resources is to subtract country- or region-specific average costs of extraction from the world price for the resource in question, all expressed in current US dollars. For minerals the levels of total resource rents are calculated as:

Rent = World price - mining cost - milling and beneficiation costs

- smelting costs - transport to port - 'normal' return to capital.

For crude oil, unit rents are calculated as the world price less lifting costs. Natural gas, though its international trade has soared in recent years, does not have a single world price. A world price was estimated by averaging free-on-board prices from several points of export worldwide, following which the unit rents were calculated as for oil. In addition to timber, coal, oil and natural gas, the minerals covered include zinc, iron ore, phosphate rock, bauxite, copper, tin, lead, nickel, gold, and silver. Data problems led to the exclusion of diamonds from their estimates. Note that rents cover neither extraction costs nor normal profits. I am thus *under*estimating the contribution of the resource extraction sector to education.

I want to make sure that the correlations and differences in means observed in Section 2 are not due to the omission of other important determinants of human capital accumulation. A number of control variables will thus be introduced. Ideally one would like to control for the economic, demographic, political and ethnic characteristics of the countries used as observational units. First, I construct another variable from the original Hamilton (2000) data; non-resource, non-education GNP, referred to hereafter as the "rest of GNP per capita" or "residual GNP per capita", is calculated by subtracting resource rents per capita and educational expenditure per capita from GNP per capita. The rest of GNP per capita is introduced as the summary (proxy) economic variable. Indeed, the richer a country the more I expect it to achieve higher educational enrolment rates, especially since education is in part a consumption good. Other economic characteristics relevant to the determination of enrollment rates are also likely to be substantially correlated with residual GNP per capita.

On the demographic side, the age dependency ratio is included as a way to control for the demands put on the educational system (and the corresponding government budget) by the population age structure. This variable comes from the World Bank (2001). Years for which age-dependency data was not available have been linearly extrapolated. On the political side, the Freedom House's Political Freedom index is introduced. I have multiplied this index by (–1) so that, more intuitively, the higher this index, the more democratic a country is. This political freedom index is available for a wide panel of countries from 1972 to 1999. Finally, ethnic fractionalization is introduced to capture the difficulties in implementing wealth-sharing programs such as public education when a society is ethnically heterogeneous. Dependent variables are all lagged by one period since educational budgets are usually set one fiscal year in advance. This also helps mitigate possible reverse causality running from educational spending to resource rents since, arguably, all dependent variables are pre-determined.

Table 2 reports results from regressing educational expenditure per capita on resource rents per capita, the rest of GNP per capita, political freedom, the age dependency ratio, and ethnic fractionalization. DFBETA statistics have been computed for each panel regressions following the exclusion of all observations of each country. The only country that modifies the coefficient relative to resource rents per capita (and is hence likely to affect unduly the conclusions of this paper) is Saudi Arabia, the exclusion of which weakens the resource rents coefficient. Hence Saudi Arabia has been excluded from our sample as an outlier. Table 2.A presents between, population-average, random and fixed effects. Table 2.B tackles more specifically the issue of heteroskedasticity.

In Table 2.A, both standard panel data results and IV results are presented. Instrument variables are used to instrument for resource rents per capita, residual GNP per capita, and political freedom. Instrumental variables include the age dependency ratio and ethnic fractionalization. Pre-determined (i.e. twice lagged) values of the instrumented variables are also used. Beside these, four types of instruments are introduced: geographical data, a set of legal origins dummies, a set of religion dummies (measured in 1980, *i.e.* the middle of my sample), land per capita, and a series for the world price of the minerals involved in Hamilton's resource rent variable.

Geographic variables consist of the mean distance to the nearest coastline or sea-navigable river (in km) and the share of land area in geographical tropics (in percent). The series for the world price of coal, copper, gold, iron, lead, nickel, oil, phosphate, silver, timber, tin and zinc come from the International Financial Statistics (IFS) CD-Rom from the IMF. Note that geographic variables, religious and legal origin dummies do not vary with time. Hence, they can only explain cross-country variations in resource rents or residual GNP. Conversely, the series for world mineral prices do not vary by country, and hence, can only account for inter-temporal variations in rents and the rest of GNP.

Geographic instruments are introduced because Gallup, Sachs and Warner (1999) find them to be important, non-conventional determinants of income per capita. The list of scholars who have emphasized the importance of geographic factors includes, inter alias, Nicolo Machiavelli, Charles de Montesquieu, and Alfred Marshall. All of these authors viewed climate as a key determinant to work effort, productivity, and ultimately, the success of nations. In a recent influential book, Jared Diamond (1997) has argued for the importance of the geographic determinants of the Neolithic revolution, and linked modern prosperity to the timing of the emergence of settled agriculture.

Mineral prices are mainly introduced to instrument for resource booms. It is assumed that commodity price changes are reasonably exogenous to any specific country. At the very least, mineral prices are certainly more exogenous than resource rents themselves which result from production decisions that can hardly be considered exogenous to a country's human capital accumulation decisions. Land per capita is introduced under the premise that the vaster the land (in per capita term) the more likely resources will be discovered on average.

Religious dummies are introduced without strong priors because they are reasonably exogenous to the variables of interest. They are also what some authors, starting with Max Weber in his *Protestant Ethic and the Spirit of Capitalism*, first published in 1904, have identified as the exogenous and long-term determinants of the economic development of nations

Legal origin dummies are introduced following what Daron Acemoglu, Simon Johnson and James A. Robinson (2001) refer to as the "institutions hypothesis". This relates differences in economic performance to the institutional organization of society. This view dates back at least to Adam Smith, who stressed the role of "peace, easy taxes, and a tolerable administration of justice" in generating prosperity. Brad De Long and Andrei Schleifer (1993) compare urban growth under princely rulers, whom they characterize as despots with short time horizons, with free regimes. More recently, Edward L. Glaeser and Andrei Schleifer (2001) argue that despite considerable legal evolution, the legal origins of countries (which they explain historically) have persisted for centuries and may explain many differences between common and civil law traditions with respect to both the structure of legal systems and the observed social and economic outcomes.

Table 2.A provides four sets of estimates: between, population-average, fixed, and random effects. Standard panel regressions are estimated using 2233 observations while instrumented regressions use 2117 observations. Overall $R^2$ is around 90%. IV regressions' $R^2$'s are very similar to those of the non-instrumented regressions.

Ethnic fractionalization is intuitively associated with lower educational spending, even though this effect is only marginally significant in the case of the population average model. The coefficient on the age dependency ratio is inconsistent and insignificant in most cases. A higher age-dependency ratio often implies more educational needs, more political leverage for the youth, and hence more expenditure per capita. However, a relatively smaller active population contributes to the total educational expenditure. If the age dependency ratio is high because there is a lot of elderly to care for, this should reduce the budget available for education. The data do not allow me to tell which effect dominates, or alternatively, these opposing forces seem to counter-balance each other in the data.

Similarly, the sign of the coefficient on political freedom is inconsistent. It is positive in the only case where it is significant, IV random effects. This sign inconsistency and the lack of significance could be due to the fact that besides democratic pressures for increased education an opposite effect may be at play; authoritarian regimes sometimes have, for better and for worse, an easier time committing resources to costly long-term objectives than democracies. An example of is seen when comparing the relative effectiveness of birth control plans in authoritarian China and democratic India. The “great leap forward” policies applied painfully to a generation of South Koreans also serves as example. Russia is not in my sample but the Soviets’ ability to commit resources to education is one of the stylized fact of the Russian post WWII economic policies.

The coefficient on the rest of GNP is consistently highly significant and ranges between 5% and 6%. Instrumentation does not affect the magnitude or significance of this coefficient. A $1 increase in the rest of GNP per capita is associated with an additional 5¢ spent on education per capita. The cross-country effect is higher, 6¢ per dollar. The coefficient on resource rents ranges between 3% and 14% and is also consistently significant. Instrumentation tends to increase both the magnitude and the significance of this coefficient over time but to decrease them across countries. A $1 increase in the resource rents per capita is associated with about 4¢ extra cents spent on education per capita. The cross-country effect is much higher, about 13¢ per dollar.

What can of inferences can be drawn regarding the relative strength of the effect of resource rents *versus* the rest of GNP? Table 2.A reports the result of an F-test for the null hypothesis of equal coefficients on resource rents and the rest of GNP. This hypothesis cannot be rejected in all regressions. In other words, with the data at hand and the specifications used here, the hypothesis that the effect on educational spending of an additional $1 of rents or residual GNP do not differ statistically cannot be confidently rejected.

On the other hand, the cross-country effect of a difference in rents is quantitatively much higher than the effect of the rest of GNP, about twice as strong. This difference is consistent with the non-parametric results from Section 2 where, cross-sectionally it is found that resource abundant countries to have substantially higher human capital indicators. It is also consistent with Hirschman's (1977) hypothesis, according to which enclave activities have stronger government revenue linkages than other activities. I conjecture that the strength of cross-country effects of resource rents relative to their inter-temporal effects may be due either to long lags or to the greater uncertainty of resource rents across time rather than across countries. Additionally, in a cross-section the inter-temporal effects are summed up over the course of history. Section 4 presents results from the estimation of a VAR model. These help us better understand some of the interesting dynamics of the panel under consideration.

Table 2.B addresses the issue of the sensitivity of coefficients to different types of heteroskedastic error structure. The baseline model used here is OLS. Overall $R^2$ is also around 90%. With OLS variants the effect of resource rents per capita on educational expenditure per capita is similar to the between effect estimated in Table 2.A. A \$1 difference in the rest of GNP per capita is associated with around an additional 5¢ spent on education per capita. A \$1 difference in the resource rents per capita is associated with around 11¢ extra cents spent on education per capita. To test for the impact on the signif icance on the coefficient for resource rents of heteroskedasticity, 5 variations on the OLS error structure are introduced in turn.

First, the Huber/White/sandwich estimator of variance is used in place of the traditional calculation. The resource rent coefficient remains highly significant. Second, panel corrected standard error (PCSE) are produced. When computing these standard errors and the variance -covariance estimates, the disturbances are, by default, assumed to be heteroskedastic and contemporaneously correlated across panels. The resource rent coefficient remains highly significant. Third, clustered OLS estimates are reported. Observations are clustered by country, which is equivalent to assuming random time effects and thus allowing observations to be correlated across time periods. Clustered standard errors are the mirror image of Table 2.A's random effects. The resource rent coefficient remains significant, albeit less so than in baseline OLS. Finally, OLS results weighted by population size (WLS) are reported, since aggregate variables are averages whose variance is assumed to be proportional to the size of the population from which they have been estimated. WLS actually strengthens the coefficient of resource rents as compared with standard OLS while keeping its very high significance. It is certainly not small countries that are driving the magnitude of the coefficient on resource rents per capita.

The *p*-value corresponding to an *F*-test of the null hypothesis of equality of coefficients on resource rents and residual GNP is also reported in Table 2.B. The hypothesis is confidently rejected in the case of standard OLS and WLS. This hypothesis cannot be rejected in all other cases. Quantitatively, the effect of resource rents is nevertheless more than twice as high as that of residual GNP. In OLS regressions, political freedom has a consistently and perhaps more intuitive positive effect on educational spending. The same is true of the age dependency ratio, most likely implying that a larger student population results in higher educational spending per capita. The coefficient on ethnic fractionalization is negative and usually significant, except in the case of WLS where, counter-intuitively, it is significantly positive.

## 4. Vector Autoregressive Regression Analysis

The single equation set-up of Section 3 potentially hides some interesting dynamics of the variables. A VAR allows me to capture these inter-dependencies between education, resource rents and residual GNP without imposing a prior on the direction of the effect. The vector of education per capita, resource rents per capita and residual GNP per capita is regressed upon itself, and a vector of exogenous controls made up of the political freedom index and the age dependency ratio. Ethnic fractionalization is dropped to save some degrees of freedom given its marginal significance in most regressions presented in Section 3. The results of estimating this 3-equation system are presented in Table 3.

In the equation with rents per capita as dependent variable (third column of coefficients), 2545 observations are used and an 87% centered $R^2$ is reached. The joint hypothesis that all variables have a zero coefficient can be rejected with a *p*-value well below 1%. Yet, the only individually significant variable is the lagged value of resource rents themselves. This coefficient is lower than one, indicating that over time resource rents tend to dissipate. This coefficient is probably picking up both a depletion effect and the downward trend in mineral prices over the three decades in consideration, akin to the Prebsich-Singer hypothesis.

In the equation with the rest of GNP per capita as the dependent variable, the second column of coefficients, a 99% centered $R^2$ is reached. Here, the only insignificant variable is education per capita. The lagged value of the rest of GNP comes up with a coefficient above unity, perhaps as a result of what I would call, following Hirschman (1961), strong intertemporal "production linkage effects". Interestingly, rents per capita are positively and significantly associated with residual GNP. A $1 increase in resource rents is associated with a 5¢ increase in the rest of GNP. This obviously contradicts the presumption of the "Dutch disease" literature. Note however, that the small size of this effect is consistent with the Hirschman view of weak production linkages between enclave activities and the rest of the economy.

The effect of political freedom is intuitive. Democracy is strongly and significantly associated with higher residual income per capita. The age dependency ratio takes an intuitively coherent and statistically significant toll on income per capita. Educational expenditure per capita is estimated to have a negative, *albeit insignificant*, effect on the rest of GNP. This is perhaps not so surprising as human capital accumulation can only be expected to have a significant direct and indirect impact on GNP per capita over a horizon probably much longer than a year. In the short-run education may even crowd out other economic activities, if only because it will divert youth away from directly productive activities.

Robert Barro (1991) finds that growth and schooling are highly correlated across countries, with each additional year of 1960 enrollment associated with about .6% per year faster growth in per capita GDP from 1960 to 1990. Jess Benhabib and Mark Spiegel (1994), Robert Barro and Xavier Sala-i-Martin (1995), Sala-i-Martin(1997), and Barro (2001) confirm schooling to be positively correlated with the growth rate of per capita GDP across countries.

These conclusions do not, however, constitute a consensus. In their calibration exercise, Mark Bils and Peter Klenow (2000) find that the impact of schooling on growth explains less than one -third of the empirical cross-country relationship. According to them, the reverse channel from expected growth to schooling, in contrast, is capable of explaining the empirical relationship. They conclude that the evidence favors a dominant role for the reverse channel from growth to schooling. Similarly, Edward Wolff (2000) finds that econometric results showing a positive and significant effect of formal education on productivity growth among OECD countries are spotty at best. I conjecture that unless the potentially complicated and lagged channels of operation between education and income are appropriately modeled, it will be difficult to pin down their magnitude, direction and significance. Unfortunately, three decades is too short a panel horizon to unravel the long-term effects of education on GNP in a VAR.

In the equation with educational expenditure per capita as the dependent variable, first column of coefficients, educational expenditure is strongly autocorrelated. One possible explanation for this is that the appropriation of factors of production by the education sector, such as teaching labor, schooling equipment and structures introduces strong "hysteresis" into educational expenditure, especially in the case of publicly provided education. Alternatively or complementarily, education can create its own market: as a child starts a schooling program, there will be strong incentives for her to stay in this program until graduation. Additionally, tertiary education is only accessible to high-school graduates and high schools are only accessible upon completion of elementary schooling.

Political freedom is intuitively associated with significantly higher educational spending. The age dependency ratio is here associated positively and significantly with educational spending. Residual GNP per capita and resource rents per capita are both positively associated with educational spending per capita, respectively at a 5% and 10% level of significance. Quantitatively, the effect of resource rents turns out to be three times more important than that of residual GNP.

Figure 2 plots the cumulative response to a $1 shock to rents per capita and residual GNP per capita, respectively. Over 30 years, this $1 shock generates close to 5¢ of extra educational expenditure per year. In comparison, a $1 increase in the rest of GNP per capita generates, over the course of three decades, 3¢ of extra educational expenditure per year. The rest of GNP has increased by more t han 75¢, or two thirds of the initial shock to resource rents. The evolution of GNP per capita can be calculated by summing back together my three endogenous variables. GNP per capita ends up decreasing by 7¢ as compared to the period where the shock occurred. This is in spite of the facts that resource rents have fallen to less than 15¢ over the course of three decades. However, when compared with the counter-factual of no resource rent shock at all, total GNP per capita has actually increased by 93¢.

## 5. Preliminary Conclusions

Do natural resource abundant countries tend to have higher or lower stocks of human capital? Do resource booms tend to result in increased or decreased levels of educational expenditure? My paper's answer to these questions is unequivocal. Resource wealth and its corresponding rents make a positive and significant difference in terms of allowing countries to invest in human capital. This pattern holds across all countries as well as across the subset of developing countries. Moving from the top to the bottom quartile (and vice-versa) implies a change in life expectancy on the order of nearly 12 additional years of life at birth, nearly 4 additional years of education for females, and a 32% reduction in female illiteracy. These are substantial differences relative to the values these indicators reach on average, especially in developing countries.

This paper clearly sides with Davis (1995). One improvement I make in this paper is to control for two types of concern Davis has. The positive association between resource abundance and human capital is not due to missing variables nor is it due to a third factor driving both resource wealth and human capital accumulation. Nor is it due to reverse causality running from education towards resource rents. Matching countries (among others) on the basis of GNP per capita does not alter these conclusions. Cross-country data actually reveal that subsoil wealth improves human capital outcomes beyond the effect running from mineral production to national income.

In panel regressions, instrumentation reveals that reverse causality running from educational expenditure to resource rents does not seem to be driving results. A $1 boom in resource rents per capita is associated with an additional 3-5¢ being spent on education per capita. The cross-country effect is much higher, 12-14¢ per dollar. I suspect this difference has to do with the higher uncertainty of rents across time than across space. Besides, across countries inter-temporal effects add up over time as VAR results indicate.

In a VAR model, the effect of resource rents turns out to be quantitatively three times more important than that of the rest of GNP. This is consistent with Hirschman's (1977) conjecture according to which enclave economies have weaker production linkages with the rest of the economy and yet stronger government revenue linkages than other activities. VAR results reveal that this latter government revenue effect dominates the production linkages effect over the course of the three decades under consideration here. Any increase in production activity will generate additional government revenues and a share of these is generally spent on education. However, increases in resource extraction activities seem to actually generate more educational spending than other activities because they are easily taxable, often foreign-run, enclaves, and all the more if governments have any concern about the temporary nature of mineral revenues, and try to smooth consumption through time.

Over the course of three decades, a $1 shock to resource rent is estimated to generate 5¢ of extra educational expenditure. In comparison, a $1 increase in residual GNP will generate, over the same period, a little less than 3½¢ of extra educational expenditure. Following this $1 shock to resource rent, the rest of GNP ends up increasing by more than 75¢. GNP per capita decreases by 7¢ as compared with the period where the shock occurred. This is in spite of the facts that resource rents have fallen to less than 15¢ over the course of three decades. However, when compared with the counter-factual of no resource rent shock at all, total GNP per capita has actually increased by 93¢. To put it another way, a resource rent shock is "all good". If there are adverse effects to be concerned about, they are not captured by the VAR model estimated here.

To be conservative, let me assume that education has no impact on productivity, but simply tends to equalize the income distribution of a country. A 5% increase in educational expenditure as a result of a 100% jump in resource rent should be welcomed, particularly in a developing country. Shocks of this magnitude, as compared to the pre-existing level of income per capita, have happened in several developing countries during the three decades under consideration. Figure 3 plots the experience of five selected developing countries, which have experienced substantial resource booms. It is clear from the experience of Indonesia, Zambia, Venezuela, Trinidad & Tobago, and Saudi Arabia, that educational spending per capita is tracks resource rents per capita, and the magnitude of the change observed in educational spending must have profoundly affected these countries. They may not necessarily stand out as the most successful examples of economic development but, the counterfactual in terms of what the level of educational investment in these countries would have been, had they have failed to experience a resource boom, needs to be borne in mind.

My observations contrast those of Thorvaldur Gylfason's (2001). My approach differs from his to the extent that I look at subsoil wealth per capita instead of the ratio of natural capital in overall wealth. As the author himself notes in a footnote, if natural capital results in higher physical capital and human capital, using the share of natural capital in the sum of these three types of capital – thus including human capital itself – is misleading. Further, Gylfason uses natural capital, a concept that includes, besides subsoil wealth, agricultural land, pasturelands, forests (timber and non-timber benefits) as well as protected areas. These may not have government taxation linkages comparable to those of subsoil wealth and its corresponding resource rents. My observations also contrast those of Nancy Birdsall, Thomas Pinckney and Richard Sabot (2001). In their case, the problem is that they define a mineral country in an arbitrary way, instead of in the light of actual resource rents and subsoil wealth series as I do. I suspect they unknowingly let their priors influence their classification.

If one explicitly or implicitly defines a mineral country as a country where the share of human to mineral capital is low, one is effectively selecting on failure to invest resource rents. It is certainly not my opinion that resource abundance guarantees human capital accumulation. Yet, on average, and everything else being equal, I show that resource abundant countries invest a non-negligible proportion of their rents in human capital. In terms of development strategy formulation, the wealth effect identified in this paper implies that resource rich countries should not be discouraged from exploiting their natural resource bases, especially when human capital is in short supply.

It goes without saying that one cannot over-emphasize the importance of the quality of governance and political stability to turn "geologic luck" into long-term shared prosperity. Of course, there are most likely other important "channels" of operation running from resource abundance to development, not to mention environmental concerns. These should be systematically investigated, and considered for the formulation of development policies. I conclude by stressing the importance, for future research, of detailed analyses of these other channels.

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## Table 1: Spearman correlations, Indicator Averages and Matching Results

| | Subsoil wealth | Average Years of Education for Females 1ary | 2ary | 3ary | Total | Illiteracy Females | Life Expectancy |
|---|---|---|---|---|---|---|---|
| *Spearman rank correlation* | | *47%* *** | *42%* *** | *46%* *** | *45%* *** | *-43%* *** | *36%* *** |
| **Averages** | Top quartile | 4.79 | 2.59 | 0.55 | 7.93 | 23% | 70.24 |
| **All countries** | 2nd quartile | 3.98 | 1.95 | 0.35 | 6.28 | 28% | 66.52 |
| | 3rd quartile | 3.12 | 1.54 | 0.30 | 4.96 | 29% | 65.92 |
| | Bottom quartile | 2.65 | 1.27 | 0.17 | 4.08 | 55% | 58.46 |
| *Spearman rank correlation* | | *52%* *** | *54%* *** | *50%* *** | *54%* *** | *-47%* *** | *48%* *** |
| **Averages** | Top quartile | 3.93 | 1.89 | 0.31 | 6.13 | 23% | 66.81 |
| **Developing countries** | 2nd quartile | 3.37 | 1.27 | 0.26 | 4.89 | 29% | 61.70 |
| | 3rd quartile | 2.70 | 0.87 | 0.23 | 3.80 | 36% | 61.30 |
| | Bottom quartile | 1.97 | 0.75 | 0.09 | 2.80 | 55% | 53.94 |
| **Difference in averages** | Top vs. 2nd quartile | 0.81 | 0.64 | 0.20 | 1.65 | -5% | 3.72 |
| *No matching* | Top vs. 3rd quartile | 1.67 | 1.05 | 0.25 | 2.97 | -7% | 4.32 |
| | Top vs. Bottom quartile | 2.14 | 1.32 | 0.38 | 3.85 | -32% | 11.78 |
| | Top vs. 2nd quartile | 0.94 | 0.60 | 0.21 | 1.75 | -5% | 3.83 |
| *Matching on GDP* | Top vs. 3rd quartile | 1.82 | 1.22 | 0.26 | 3.31 | -11% | 5.28 |
| | Top vs. Bottom quartile | 2.16 | 1.35 | 0.39 | 3.91 | -32% | 13.01 |
| | Top vs. 2nd quartile | 0.54 | 0.32 | 0.14 | 1.00 | 0% | 0.03 |
| *on Political Instability* | Top vs. 3rd quartile | 1.43 | 0.79 | 0.23 | 2.45 | 6% | 2.63 |
| | Top vs. Bottom quartile | 0.72 | 0.37 | 0.21 | 1.29 | -25% | 4.82 |
| | Top vs. 2nd quartile | 0.48 | 0.75 | 0.24 | 1.47 | -6% | 6.98 |
| *on Legal Origin* | Top vs. 3rd quartile | 1.94 | 1.34 | 0.31 | 3.59 | -12% | 9.18 |
| | Top vs. Bottom quartile | 2.65 | 1.75 | 0.48 | 4.88 | -32% | 15.49 |
| | Top vs. 2nd quartile | 0.50 | -0.13 | 0.18 | 0.55 | -9% | 4.08 |
| *on Religion* | Top vs. 3rd quartile | 2.09 | 1.05 | 0.22 | 3.37 | -11% | 9.53 |
| | Top vs. Bottom quartile | 2.23 | 1.43 | 0.45 | 4.11 | -34% | 15.71 |
| | Top vs. 2nd quartile | 0.37 | 0.15 | 0.10 | 0.62 | -13% | 6.09 |
| *on Propensity Score* | Top vs. 3rd quartile | 0.95 | 0.35 | 0.06 | 1.37 | -7% | 7.15 |
| | Top vs. Bottom quartile | 1.38 | 0.94 | 0.22 | 2.54 | -23% | 8.49 |

# Table 2.A: Panel Data Estimation Results

**Dependent variable: Educational spending per capita**

| Method | Between effects | | Population | Random effects | | Fixed effects | |
|---|---|---|---|---|---|---|---|
| | ***Standard*** | ***IV*** | **Average** | ***Standard*** | ***IV*** | ***Standard*** | ***IV*** |
| **Resource Rents per capita** | 0.14 ** | 0.12 * | 0.04 *** | 0.04 *** | 0.05 *** | 0.03 ** | 0.04 *** |
| **(lagged)** | *0.07* | *0.07* | *0.01* | *0.01* | *0.01* | *0.01* | *0.01* |
| **Rest of GNP per capita** | 0.06 *** | 0.06 *** | 0.05 *** | 0.05 *** | 0.05 *** | 0.05 *** | 0.05 *** |
| **(lagged)** | *0.00* | *0.00* | *0.00* | *0.00* | *0.00* | *0.00* | *0.00* |
| **Political Freedom** | 19.68 | -0.57 | 0.94 | 0.11 | 12.08 ** | -0.71 | 7.68 |
| **(lagged)** | *12.18* | *21.12* | *1.83* | *1.58* | *5.37* | *1.60* | *5.43* |
| **Age Dependency Ratio** | 368.81 ** | 202.31 | -23.30 | -17.54 | 11.65 | -9.04 | 9.55 |
| **(lagged)** | *148.58* | *203.37* | *29.25* | *25.67* | *27.32* | *26.44* | *26.65* |
| **Ethnic Fractionalization** | -0.23 | -0.18 | -0.63 * | -0.71 | -0.32 | (dropped) | (dropped) |
| **(lagged)** | *0.50* | *0.53* | *0.36* | *0.44* | *0.39* | | |
| **constant** | -241.58 ** | -195.37 * | 67.99 ** | 66.41 ** | 64.79 ** | 21.56 | 31.95 |
| | *102.43* | *116.45* | *27.25* | *28.95* | *27.31* | *21.21* | *25.41* |
| **Number of obs** | 2233 | 2117 | 2233 | 2233 | 2117 | 2233 | 2117 |
| **F or Wald chi2** | 178 | 839 | 9467 | 12213 | 12955 | 2872 | 30634 |
| **Prob > F or Wald chi2** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| **R-sq** | 91.73% | 91.00% | -- | 89.64% | 91.00% | 89.81% | 91.18% |
| **Prob > F test that RR = RGNP** | 27.14% | 38.90% | 51.20% | 27.0% | 90.72% | 16.24% | 60.76% |

Note: Standard errors are reported below estimates. One star, two star and three stars indicate statistical significance at alpha=10%, 5% and 1% respectively. Saudi Arabia excluded as outlier according to DFBeta statistics. Inclusion would raise coefficient on resource rents substancially. Instrumented variables: lagged resource rents per capita, rest of GNP, and political freedom. Georgraphical instrument variables: mean distance to the nearest waterway and share of land in tropical area. Other country-fixed instrument variables: legal origin, religion dummies, ethnic fractionalization and age dependency ratio. Time-varying instruments: a trend variable, area per capita, **world price of coal, copper, gold, iron, lead, nickel, oil, phosphate, silver, timber, tin, and zinc.** Pre-determined variables : twice lagged resource rents per capita, rest of GNP percapita, and political freedom.

# Table 2.B: Robust Results

**Dependent variable: Educational spending per capita**

| **Method** | **OLS** | | | | |
|---|---|---|---|---|---|
| | ***Standard*** | ***Robust*** | ***PCSE*** | ***Clustered*** | ***Weight=POP*** |
| **Resource Rents per capita** | 0.11 *** | 0.11 *** | 0.11 *** | 0.11 * | 0.12 *** |
| **(lagged)** | *0.01* | *0.02* | *0.02* | *0.06* | *0.01* |
| **Rest of GNP per capita** | 0.05 *** | 0.05 *** | 0.05 *** | 0.05 *** | 0.05 *** |
| **(lagged)** | *0.00* | *0.00* | *0.00* | *0.00* | *0.00* |
| **Political Freedom** | 10.95 *** | 10.95 *** | 10.95 *** | 10.95 * | 4.81 *** |
| **(lagged)** | *1.73* | *1.82* | *1.50* | *5.54* | *1.10* |
| **Age Dependency Ratio** | 112.27 *** | 112.27 *** | 112.27 *** | 112.27 | 19.56 |
| **(lagged)** | *22.83* | *25.26* | *26.40* | *80.04* | *14.89* |
| **Ethnic Fractionalization** | -0.20 * | -0.20 ** | -0.20 ** | -0.20 | 0.20 *** |
| **(lagged)** | *0.10* | *0.08* | *0.08* | *0.28* | *0.05* |
| **constant** | -50.00 *** | -50.00 ** | -50.00 ** | -50.00 | -25.39 ** |
| | *16.51* | *22.19* | *20.90* | *63.97* | *10.06* |
| **Number of obs** | 2233 | 2233 | 2233 | 2233 | 2233 |
| **F statistics** | 4110 | 1448 | 6324 | 108 | 14248 |
| **Prob > F** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| **R-sq** | 90.22% | 90.22% | 90.22% | 90.22% | 96.97% |
| **Prob that RR = RGNP** | 0.00% | 0.17% | 0.19% | 33.5% | 0.00% |

Note: Standard errors are reported below estimates. One star, two star and three stars indicate statistical significance at alpha= 10%, 5% and 1% respectively. Saudi Arabia excluded as outlier according to DFBeta statistics. Inclusion would raise coefficient on resource rents substancially. Clustered regressions are clustered by country, hence allowing observational unit's errors to be correlated across time without specifying the exact nature of the auto-correlation

# Table 3: VAR Estmation Results

| **Method** | **VAR** | | |
|---|---|---|---|
| ***Dependent variable*** | ***EDUCPC*** | ***RENTSPC*** | ***RGNPPC*** |
| **Education per capita [-1]** | 1.00537 *** | -0.0146 | -0.1616 |
| | 0.00774 | 0.03642 | 0.1355 |
| **Resource Rents per capita [-1]** | 0.00258 * | 0.93576 *** | 0.04526 ** |
| | 0.00158 | 0.00741 | 0.02758 |
| **Rest of GNP per capita [-1]** | 0.00082 ** | 0.00084 | 1.02095 *** |
| | 0.00046 | 0.00218 | 0.00809 |
| **Political Freedom** | 2.07523 *** | -1.3202 | 33.6265 *** |
| | 0.55658 | 2.61889 | 9.74323 |
| **Age Dependency Ratio** | -26.717 *** | -0.1222 | -716.38 *** |
| | 7.24293 | 34.0804 | 126.792 |
| **constant** | 34.7332 *** | 6.72208 | 819.95 |
| | 5.53646 | 26.0509 | 96.9188 |
| **Number of obs** | 2545 | 2545 | 2545 |
| **F** | 36822.3 | 3370.07 | 36557.2 |
| **Prob > F** | 0.00% | 0.00% | 0.00% |
| **R-sq (centered)** | 98.64% | 86.91% | 98.63% |

Note: Standard errors are reported below estimates. One star, two star and three stars indicate statistical significance at alpha=10%, 5% and 1% respectively

**Figure 1**

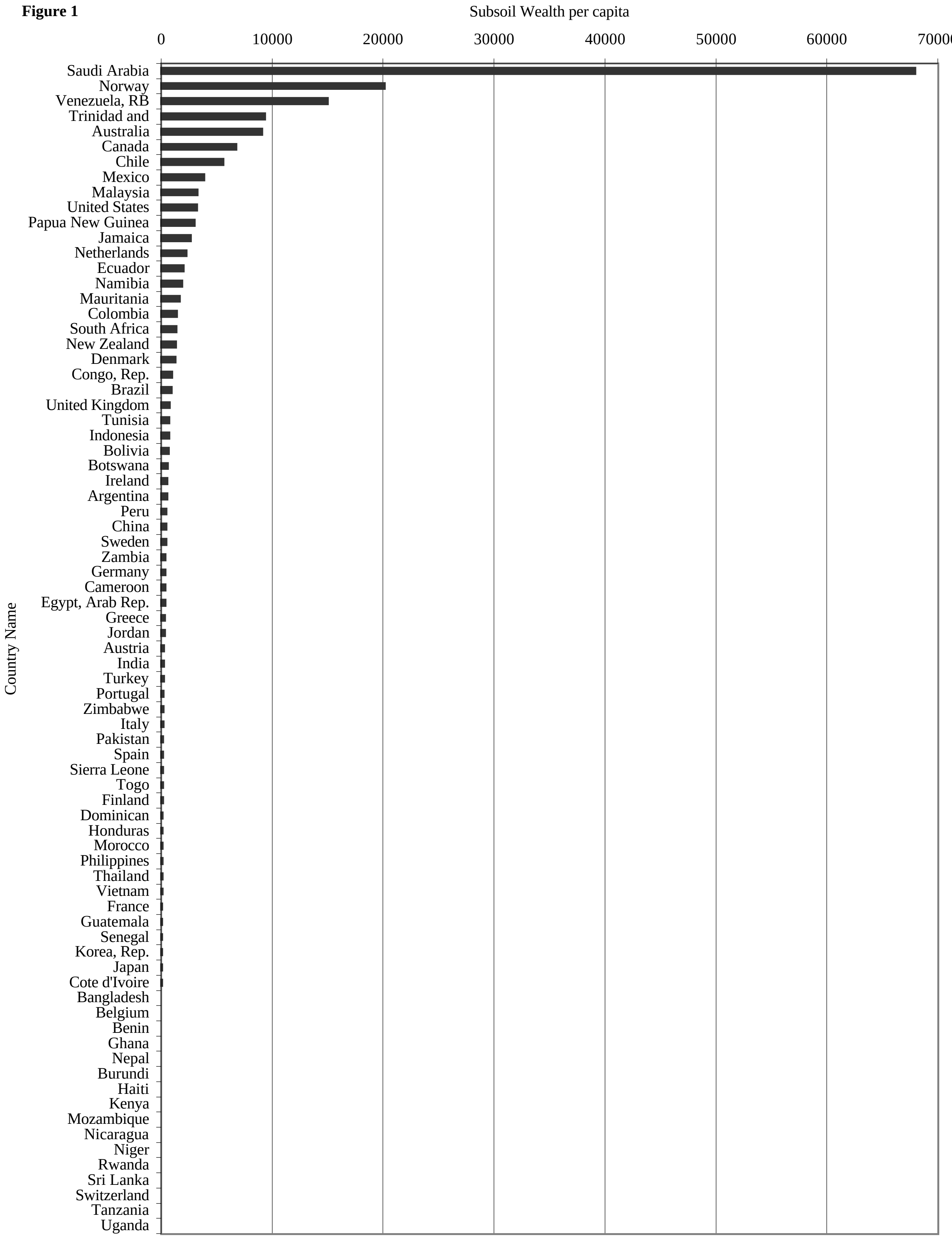

Subsoil Wealth per capita
0
10000
20000
30000
40000
50000
60000
70000
Country Name
Saudi Arabia
Norway
Venezuela, RB
Trinidad and
Australia
Canada
Chile
Mexico
Malaysia
United States
Papua New Guinea
Jamaica
Netherlands
Ecuador
Namibia
Mauritania
Colombia
South Africa
New Zealand
Denmark
Congo, Rep.
Brazil
United Kingdom
Tunisia
Indonesia
Bolivia
Botswana
Ireland
Argentina
Peru
China
Sweden
Zambia
Germany
Cameroon
Egypt, Arab Rep.
Greece
Jordan
Austria
India
Turkey
Portugal
Zimbabwe
Italy
Pakistan
Spain
Sierra Leone
Togo
Finland
Dominican
Honduras
Morocco
Philippines
Thailand
Vietnam
France
Guatemala
Senegal
Korea, Rep.
Japan
Cote d'Ivoire
Bangladesh
Belgium
Benin
Ghana
Nepal
Burundi
Haiti
Kenya
Mozambique
Nicaragua
Niger
Rwanda
Sri Lanka
Switzerland
Tanzania
Uganda

**Figure 2: Response a to 1 unit shock to resource rents**

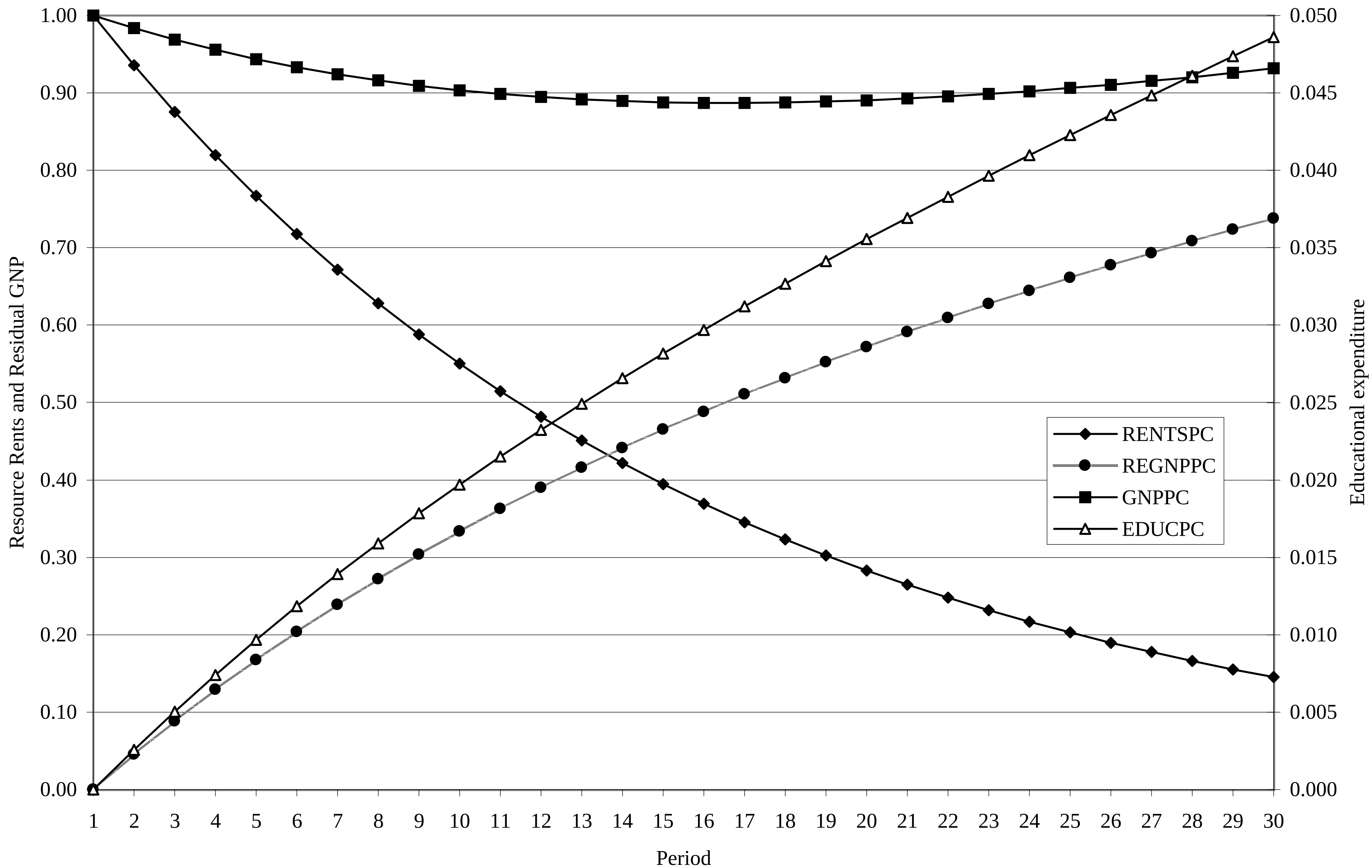
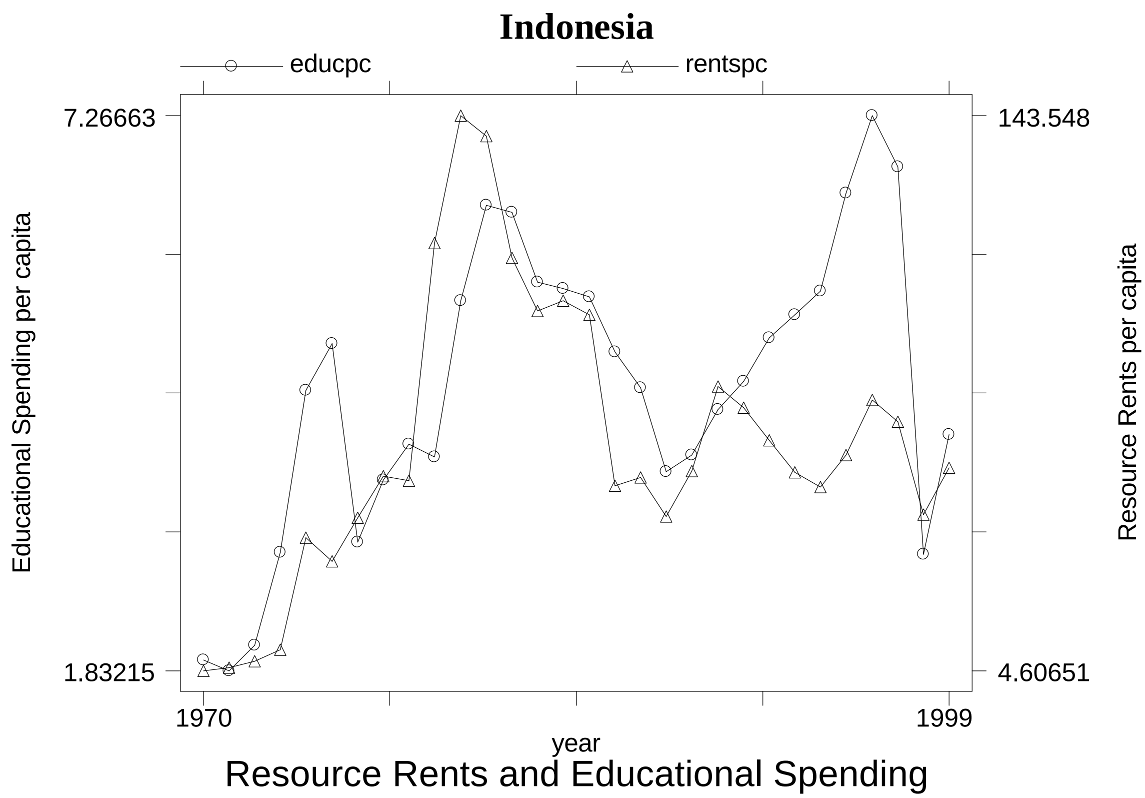
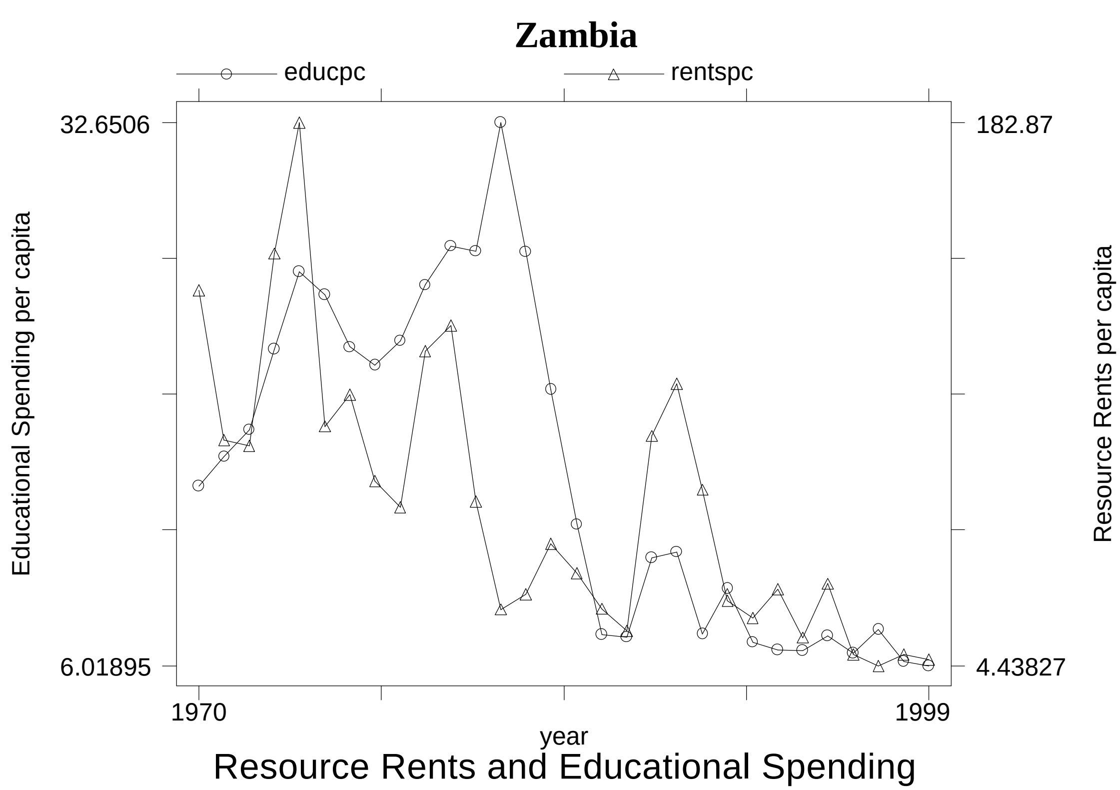
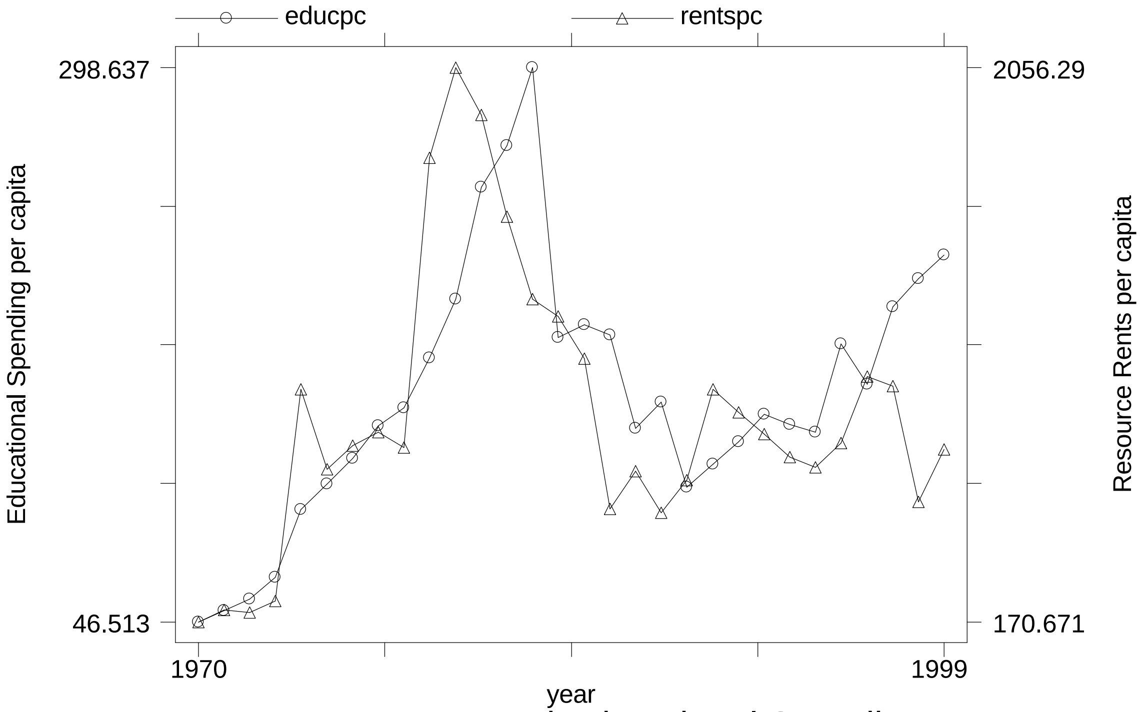


**Figure 3: The experience of a few selected developing countries**



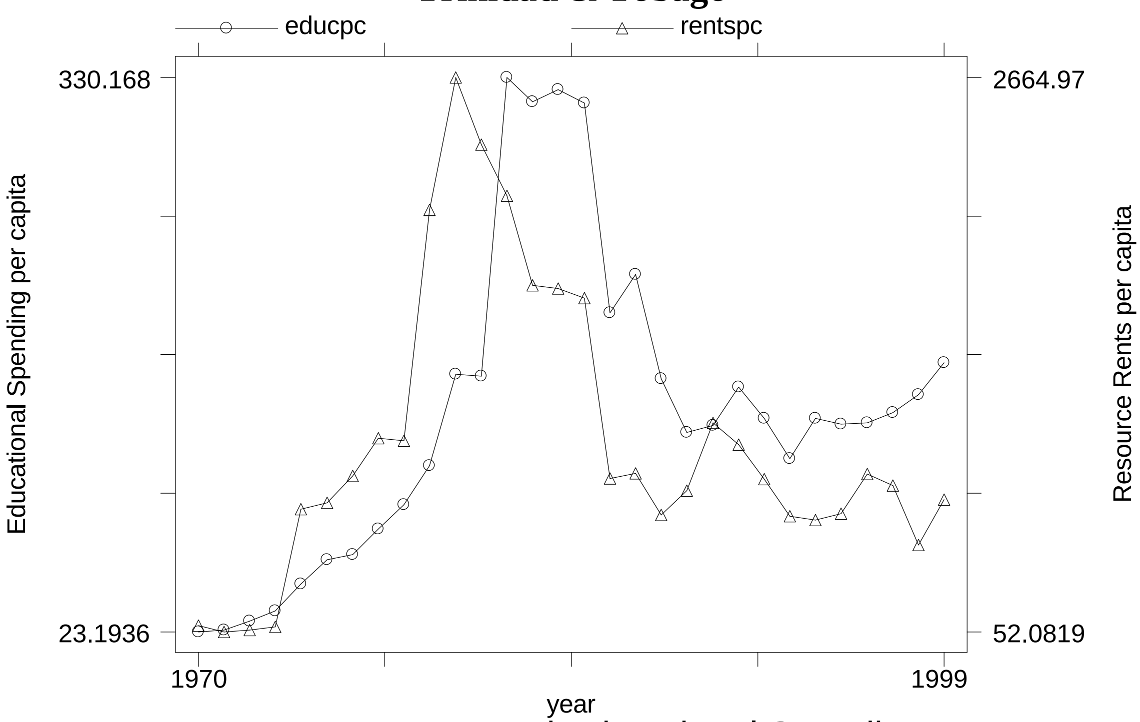



## Venezuela



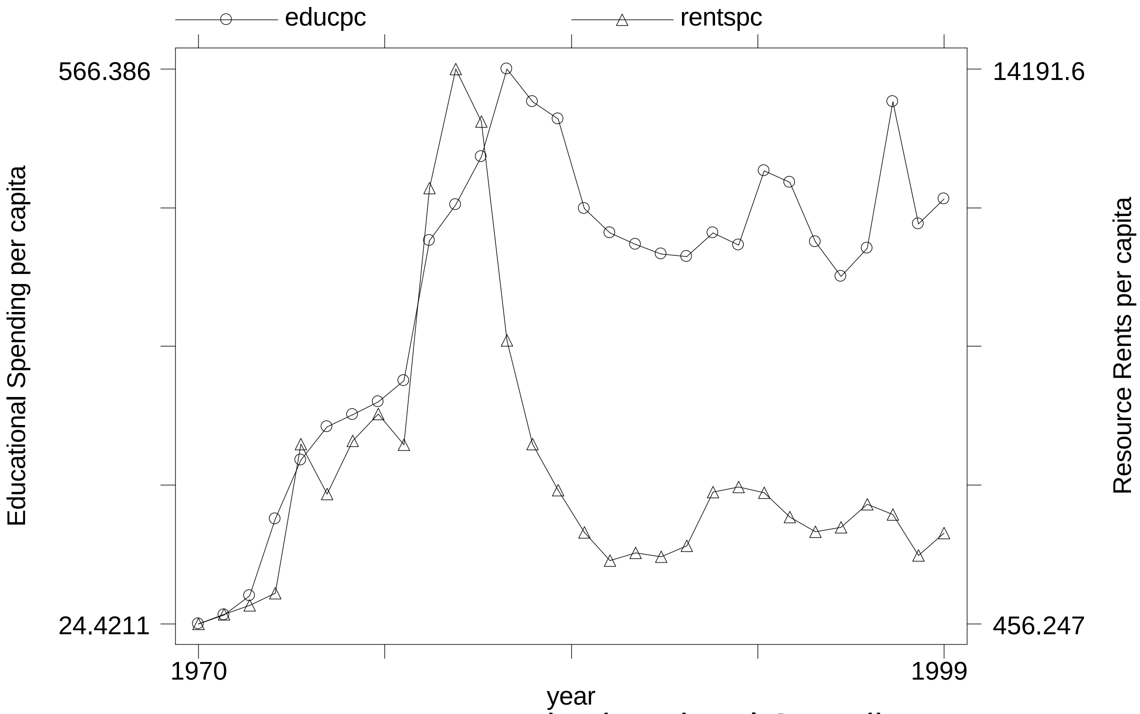

Resource Rents and Educational Spending

## Trinidad & Tobago




Resource Rents and Educational Spending

## Saudi Arabia




Resource Rents and Educational Spending