NATURAL RESOURCE ABUNDANCE AND HUMAN CAPITAL ACCUMULATION

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VERY PREMILIMINARY AND INCOMPLETE DRAFT

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This study examines indicators of human capital accumulation in parallel with data for natural resource abundance and rents in a large panel of countries running from 1970 to 1999. Mineral wealth is shown to make a positive and marked difference in terms human capital accumulation. Cross-country data actually reveal that mineral wealth improves human capital outcome beyond the effect running from mineral production to national income. Reverse causality is not driving the results, and instrumentation actually strengthens the results. The estimation of a panel VAR indicates that, over three decades, a one-dollar shock to resource rent generates close to five cents of extra educational expenditure per year. In comparison, a one-dollar shock to the rest of GNP will generate, over the same period, a little less than three and a half cents of extra educational expenditure per year. Results are consistent with Hirschman's conjecture that enclave economies have stronger government revenue linkages than other activities. The "wealth channel" identified in this paper implies that caution should be exerted about discouraging countries to exploit their mineral wealth, especially where human capital is scarce.

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1 Introduction

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? These questions are the focus of this paper. There are currently three contributions to these questions:

First, Thorvaldur Gylfason (2001) marshals 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. This author concludes that natural capital appears to crowd out human capital, thereby slowing down the pace of economic development. The opinion of this author is that "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 adding "Their natural wealth may blind them to the need for educating their children."

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

To the extent mineral states tend to spend lavishly their mineral revenues on numerous development projects and programs (see for example William Ascher, 1999), it is surprising to read that education would be the only – quite unfortunate! – exception. It is even more surprising to read that regarding education, the same mineral states would actually spend *less* than other states! In this paper, an opposite interpretation of the data is reached: Human capital indicators are shown to be *positively* associated with resource abundance and 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. This paper improves upon Davis (1995) in that it uses richer human capital data, that attempt is made at controlling for other determinants of human capital besides resource abundance, and that the common determinants of resource abundance and human capital are accounted for. Instrument variables and VAR modeling are also introduced to take care of endogeneity among national income and mineral wealth.

This question lies at the heart of the debate regarding the effect of natural resource abundance on economic growth and development. If something, say human capital, usually remains of resource booms, resource abundance would provide for more than just a temporary increase in income per capita. Is this increase in human capital bound to remain itself a temporary phenomenon? The answer to this question hangs 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 levels. Similarly, Philippe Aghion, Eve Caroli and Cecilia Garcia-Penasola (1999) contend 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 of educating women in developing countries. The marginal social returns of education for growth are considered sizeable at the human capital levels characterizing developing economies. Also, 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 improvement prospects for the *median* level of income.

Importantly, this paper shows that resource abundance is associated across countries with higher *female* human capital accumulation as well. Also, similar observations are made regarding "health capital" indicators. Matching techniques are used to allow resource abundance to be endogenous to a country's state of social and economic development. This does not alter the conclusions.

In instrument variable panel regressions, every $1 increase in the rest of GNP per capita is associated with around an additional 5¢ to 6¢ being spent on education per capita. The cross-country effect is much higher, around 15¢ per dollar. I suspect this difference has to do with the high inter-temporal variability (and corresponding uncertainty) of resource rents relative to that of the subsoil wealth geographical distribution. Besides, across countries inter-temporal effects add up over time. More formal tests of these conjectures are called for. In a VAR model, the effect of resource rents turns out to be three times more important than that of the rest of GNP. Over the course of three decades, a $1 shock to resource rent generates again close to 5¢ of extra educational expenditure per year. In comparison, a $1 innovation in residual GNP will generate, over the same period, a little less than 3.5¢ of extra educational expen diture.

Why would we think natural resource abundant countries 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 they would 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 things about life working hard as seasonal gardeners. But the irony of this analogy is that empirically, the very same children end up, on average, highly educated and economically better off than their poorer cohort members. The political leaders of resource rich developing nations may spoil part of their country's mineral revenues on "expensive shopping trips in Paris," but *ceteris paribus*, 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 international pressure from rich democracies or international organizations.

Albert Hirschman (1961) noted very early on that one would expect that very little "production linkages" from mineral production, which lead to the cornering 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, is going to have a strong political lever to avoid taxation. On the other hand, enclave economies are by definition economically isolated and are often run by foreigners. Hence, they represent fewer votes, have less political leverage, and are very often the object of heavy corporate income and export taxation.

Any increase in production activity will generate additional government revenues and a share of these is generally spent on education. But increases in resource extraction activities actually seem to generate more educational spending than other activities. 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.

As a result, yesterday's resource abundance translates itself into currently higher human capital stocks. In this sense, resource abundance can be 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 this country had never experienced resource abundance. This effect should be all the more important when human capital is key to the adoption of foreign technologies or the development of a national research sector. Also, this effect will matter all the more where education is key to the mitigation of income inequality and the advancement of democracy.

This is obviously crucial in terms of development strategy formulation: this wealth effect implies that resource rich countries should not be discouraged from exploiting their natural resource basis, 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 — and 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 $1 shock to resource rents versus a $1 innovation in the rest of GNP. Section 5 exposes my 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 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. But 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: educational spending educators (as a share of GDP, and per student at different schooling levels), enrollment rates (at different schooling levels and separately for each gender), illiteracy rates (adults and youth), health indicators (life expectancy and child mortality rates at different ages), and average years of education (at different schooling levels and separately for each gender). 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, four human capital summary statistics have been selected: gross spending on education as a percentage of expenditure, total average years of education for the overall population and for women, and life expectancy at birth.

Hamilton (2000) provides 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. To increase the broadness and accuracy of the coverage of these series, they have been averaged from the seventies to the nineties whenever data is available. This approach has the advantage of making this flow variable more comparable to the other stock-like statistics presented here, *i.e.* the total average years of education and life expectancy at birth, since these are the outcome of ongoing public and private expenditure rather than of a annual policy. Other statistics and approaches concerning educational expenditure would lead to similar conclusions, however.

It is often argued in the development literature that it is human capital stocks that matter for development rather than crude measures of enrollment. Two sets of data are available and have been used. 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 development literature also considers that health indicators belong to human capital indicators especially in the context of poorer nations where workers' efficiency often depends critically on their health condition. Results concerning life expectancy at birth are also 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 every year.

Table 1 shows Spearman rank correlation coefficients between subsoil wealth and these key indicators of educational spending and 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, obviously. Second, they are insensitive to monotonous 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.

The rate of educational expenditure, life expectancy at birth and total average years of education for the population as a whole *and for females* are all positively correlated with subsoil wealth. Educational spending is slightly less correlated with subsoil wealth in the subset of developing countries (39%) than in the general sample (41%). However, life expectancy at birth and total average years of education for the population as a whole *and for females* are clearly more strongly correlated with subsoil wealth in the subset of developing countries (61% and 58%) than in the set of all countries (50% and 49%). 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. All these rank correlation coefficients are statistically different from zero at a significance level well below 1%.

The aim of Table 2 is twofold. First, are the associations found in Table 1 still present 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, are mineral endowments reflecting 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 than something common is driving both mineral endowments and educational investment.

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, 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. Natural 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 19th 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.

The aim of this technique is to draw causal inferences about the relative effects of "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, however, and often are the only data available. There is 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. As the prior in this paper is that subsoil wealth treatment causes more human capital accumulation, one would like to estimate the average effect treatment on the treated.

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, a central identifying assumption is needed, *conditional independence* also known as the *selection on observables* assumption (Rosenbaum and Rubin, 1983, Rubin, 1974, 1977). This assumption asserts that, conditional on gross national product per capita, human capital accumulation and mineral endowments are independent. In other words, no omitted or unobserved variable influences both membership in a particular subsoil wealth quartile and the human capital outcome, once we have controlled for gross national product per capita. The impact of using other observables 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). To each treated country will be associated the following statistics: $\hat{H}_i^T$, the weighted human capital outcomes of his neighbors in the treated group, and $\hat{H}_i^C$, the weighted human capital outcomes of his 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 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 in the observable.

Dividing the sample in four quartiles allows to investigate the outcome of three different treatments: *What would be the human capital outcome of countries in the second / third / 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, we will do selection on political instability on the ground that it may be driving both resource exploitation and exploration as well as human capital accumulation.

Third, selection on legal origin is made on the ground that, for example, England managed to colonize very valuable countries and also had a culture conductive to human capital accumulation. Fourth, selection on religions is done on the ground that, for example, Muslim countries happen to often be oil-rich countries and also have a culture conductive to literacy (thanks to the Koranic tradition.) Note that legal origins and religions are measured as a set 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) using a prob it 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 dummy variables.

Table 2 first 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 correlations presented in Table 1 were not driven by a set of countries corresponding to a specific subsoil wealth quartile. Educational savings rates, total average years of schooling for the population and for females and life expectancy at birth all increase from one quartile to the next. Furthermore, this holds if we consider the full sample as well as if we focus on the subset of developing countries.

The rest of Table 2 shows the effect of the three above-mentioned treatments. First, no attempt is made to account for the fact that both subsoil wealth and human capital may both be driven by common factors. Thereafter, kernel-based estimates of treatment effects accounting for this possibility are reported. 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 results. Also, results show that the larger the jump in subsoil wealth quartile the larger the effect on human capital outcomes. This property of the results is not affected by kernel-matching either.

What about the empirical relevance of these effects? They are economically quite significant. For example, moving from the bottom to the top quartile implies an increase in life expectancy on the order of 11 years of life at birth, of more than 3 years of education for the whole population as well as for females, and more than an additional 1% of expenditure spent on education. These are substantial differences relative to the values these indicators reach on average. The only exception is that propensity score matching between the first and the second quartile reverse the effect on educational expenditure to a slightly negative number (-.05% of expenditure). Sections 3 and 4 deal extensively with educational expenditure as dependent variable. This reversal of sign is most likely spurious.

Note that kernel-based matching does not take account of the fact that causality can run from subsoil wealth to GNP per capita as well. The effect Table 2 is capturing is that *beyond* increased educational spending due to increased income per capita stemming from mineral extraction and production. These effects are consistent with Hirshman's (1977) hypothesis according to which enclave activities have stronger tax revenue linkages than other activities. In other words, these results indicate that taking two countries with similar GNP per capita (including mineral extraction revenues!), mineral endowments make a substantial difference for human capital accumulation. Section 3 moves onto panel regression analysis and will tackle this endogeneity issue by using instrument variables that can be safely assume to be exogenous to both resource rents and the rest of GNP.

3 Panel Data Regression Analysis

This section reports results from panel regression analysis. We 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, as well as political characteristics of the countries used as observational units.

As mentioned in the previous section, Hamilton (2000) provides a blueprint for the calculation of what the World Bank calls genuine savings rates. In this section, in addition of their educational expenditure data, *i.e.* the share of educational expenditure in national expenditure, their calculated series for resource rents is used. These data cover a p anel of 102 countries from 1970 to 1999. They are divided by population data to obtain resource rents per capita.

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. We are thus *under*estimating the contribution of the resource extraction sector to education.

Another variable is constructed from the original Hamilton (2000) data. These panel data cover 102 countries from 1970-1999. First 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 we expect it to afford itself higher educational enrolment rates, especially since education is in part a (normal if not superior) consumption good. Also, other economic characteristics relevant to the determination of enrollment rates are 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. We 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.

Table 3 reports results from regressing educational expenditure per capita on resource rents per capita, the rest of GNP per capita, political freedom and the age dependency ratio. Both standard panel data results and IV results are presented. Instrument variables are used for resource rents per capita and the rest of GNP per capita. Instrumental variables include political freedom and the age dependency ratio. 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 our sample), and series for the world price of the minerals involved in our resource rent variable.

Geographical variables consist of the mean distance to 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 geographical variables, religious and legal origin dummies are not time variable. Hence, they can only explain cross-country variations in resource rents or residual GNP. Conversely, series for world mineral prices are not country variable, and hence, they can only account for inter-temporal variations in rents and the rest of GNP.

Geographical 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 alia, Nicolo Machiavelli, Charles de

Montesquieu, and Alfred Marshall. All of these authors viewed climate as a key determinant of 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 state of economic development.

Religious dummies are introduced agnostically because they are reasonably exogenous to our variables of interest and are what some of the literature had identified as the exogenous and long-term determinants of the economic development of nations starting with Max Weber's *Protestant Ethic and the Spirit of Capitalism*, first published in 1904.

Legal origin dummies are introduced following what Daron Acemoglu, Simon Johnson and James A. Robinson (2001) refer to as the "institutions hypothesis," which relates differences in economic performance to the 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) compared urban growth under princely rulers whom they characterize as despots with short time horizons with free regimes and endorsed this institutions hypothesis. 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 3 provides four sets of estimates: country fixed and random effects, time fixed and random effects. Standard panel regressions are estimated using 2555 observations while instrumented regressions use 2416 observations. Overall R^2 is around 90%. IV regressions' R^2's are very similar to those of non-instrumented regressions. To help chose among these specifications, the *p*-value of Hausman tests for error measurement and random effects are reported wherever applicable. We disregard non-instrumented results if the Hausman test rejects significantly the null hypothesis of no-measurement errors. Similarly, we disregard random effects if the Hausman test significantly rejects the null hypothesis of no correlation between the error term and the regressors. The specifications that survive these two tests are IV country fixed and random effects, and IV time fixed effects. These three specifications have been accordingly highlighted with shades in Table 3.

The coefficient on the age dependency ratio is always positive. Higher age-dependency ratio often implies more educational needs and hence more expenditure per capita. But, any given educational budget has to be spread upon more students. Similarly 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. This second effect should drag down the coefficient on the age dependency ratio, but empirically it appears to be dominated by the "needs" effect.

The coefficient on political freedom is, quite surprisingly, negative in most regressions. More *authoritarian* governments tend to spend more per capita on education, when we control for income per capita and the age dependency ratio. Country fixed effects results indicate that *every thing else being equal* democratization is associated with a reduction in educational expenditure. The exception is the case of non-instrumented time fixed and random effects where the coefficient indicates that, across countries (as opposed to across time in the country fixed effects regressions), democratic regimes tend to spend more on education and more democratic regimes. Reassuringly, these are the regressions where the coefficient on political freedom is significant at a *p*-value below 1%. However, this observation is reversed when one instruments for resource rents and the rest of GNP.

The coefficient on the rest of GNP is consistently highly significant and ranges between 5% and 7%. Instrumentation tends to increase both the magnitude and the significance of this coefficient. Every $1 increase in the rest of GNP per capita is associated with around an additional 6¢ spent on education per capita. The cross-country effect is higher, around 7¢ per dollar. The coefficient on resource rents ranges between 2% and 16% and is also consistently very significant. Instrumentation tends to increase both the magnitude and the significance of this coefficient too. Every $1 increase in the resource rents per capita is associated with around 5¢-6¢ extra cents spent on education per capita. The cross-country effect is much higher, around 15¢ 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 3 also reports the result of an F-test for the null hypothesis of equal coefficients on resource rents and the rest of GNP. This hypothesis is always confidently rejected for non-instrumented regressions but these fail the Hausman test for measurement errors. In the case of instrumented regressions, it cannot be rejected in the case of country-fixed effects. In other words, with the data at hand and the specifications used here, the hypothesis that the intertemporal effects of an additional dollar of rents or of residual GNP do not differ statistically cannot be confidently rejected.

On the other hand, the cross-country effect of a difference in rents is significantly higher than the effect of the rest of GNP. This difference is consistent with the non-parametric results from Section 2 where, cross-sectionally it was found that resource abundant countries to have clearly higher human capital indicators and 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 variability (and uncertainty) of resource rents across time than geographically. Additionally, in a cross-section the inter-temporal effects are in effects summed up over the course of history. This naturally begs for further research. I plan to investigate the dynamic aspects of this panel more carefully as well as the effect of higher moments of resource price fluctuations.

4 Vector Autoregressive Regression Analysis

The single equation set-up of Section 3 hides the interesting time-series dynamics of the variables of interest. An important source of endogeneity in these specifications stems from the mutual dependency between resource rents and the rest of GNP. A vector autoregression fortunately allows capturing these inter-dependencies in an agnostic way. 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. The results of estimating this 3-equation system are presented in Table 4.

In the equation with rents per capita as dependent variable (third column of coefficients), 2545 observations are and a 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. In the future, I plan to model explicitly the effect of mineral prices in this equation.

In the equation with the rest of GNP per capita as dependent variable (second column of coefficients), a 99% centered R^2 is reached. Here, the only insignificant variable is education per capita. The lagged value rest of GNP comes up with a coefficient above unity, perhaps as a result of what we would call, following Hirschman (1961), strong "intertemporal production linkage effects." Interestingly, rents per capita are positively and significantly associated with residual GNP. Every $1 increase in resource rents is associated with a 5¢ increase in the rest of GNP. This obviously runs against the presumption of the "Dutch disease" literature. Note however, that the small size of this effect is consistent with the Hirschmanian view of weak production linkages between enclave activities with 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 consistent 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 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 are, however, far from constituting 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. In the future, I plan to devote attention to investigating whether a more sophisticated modeling of the time series relationships between the series used in this paper, can shed light on this empirical question.

In the equation with educational expenditure per capita as dependent variable (first column of coefficients), educational expenditure is strongly autocorrelated. One possible explanation for this is that the appropriation of production factors by the education sector, such as teaching labor, schooling equipment and structures introduces strong "hysteresis" in educational expenditure, especially in the case of publicly provided education. Alternatively or complementarily, education can create its own market: as a child starts on with 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 only accessible after completion of elementary schooling.

Here, political freedom is intuitively associated with significantly higher educational spending. Contrary to single equation estimates from Section 2, the age dependency ratio is here associated positively and significantly with educational spending. The "needs" effect is here dominated by the "spreading" effect. In other words, a large dependent population relative to the active entails fewer dollars spent on education per capita.

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 and 3 plot the cumulative response to a $1 shock to rents per capita and residual GNP per capita, respectively. In Figure 2, we can see that over 30 years, this $1 shock is seen to generate close to 5¢ of extra educational expenditure per year. Interestingly, this estimate is very close to we had in Table 2 with non-instrumented time fixed effect regressions. Indeed, there are instrument variables in the VAR estimation yet, and it would be expected that over the course of three decades, a cross-country effect is actually estimated.

The rest of GNP has increased by more than 75¢, or two third of the initial shock to resource rents. The evolution of GNP per capita can be calculated by summing back together our three endogenous variables. GNP per capita ends up decreasing by around 7¢ as compared with the period where the shock occurred. This is spite of the facts that resource rents have crunched to less than 15¢ over the course of three decades. However, whence compared with the counter-factual of no resource rent shock at all, total GNP per capita has actually increased by 93¢.

In Figure 3, we can see that over 30 years, a $1 innovation in residual GNP will generate close to 3.5¢ of extra educational expenditure (to be compared with 5¢ for resource rents). This estimate is below what we had in Table 2 with non-instrumented time fixed effect regressions. The rest of GNP has increased by an additional 75¢, or three quarters beyond the initial $1 shock to the rest of GNP. Total GNP per capita ends up increasing by around 80 cents as compared with the period where the shock occurred. Whence compared with the counter-factual of no residual GNP innovation, total GNP per capita has actually increased by $1.8.

5 Preliminary Conclusions

To the questions “Do natural resource abundant countries tend to have higher or lower stocks of human capital? Do resource booms tend to engender to increased or decreased levels of educational expenditure?” this paper’s answer is unequivocal. Resource wealth and the corresponding rents seem to 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 an additional 11 years of life at birth, more than 3 years of education on average for the whole population *as well as for females*, and more than an additional 1% of expenditure spent on education. 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 this paper makes is to control for two types of concern this author has. This positive association is not due to missing variables nor is it due to a third factor driving both resource wealth and human capital accumulation, nor apparently to endogeneity or inter-dependence between income and 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 outcome beyond the effect running from mineral production to national income.

Reverse causality running for example from development as proxied by GNP per capita towards subsoil wealth or resource rents does not seem to be driving results. In instrument variable panel regressions, every $1 increase in the rest of GNP per capita is associated with around an extra 5¢ to 6¢ spent on education per capita. The cross-country effect is much higher, around 15¢ per dollar. I suspect this difference has to do with the high temporal variability of rents relative to that of subsoil wealth geographical distribution. More formal tests of this conjecture are called for.

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 stronger government revenue linkages than other activities. Any increase in production activity will generate additional government revenues and a share of these is generally spent on education. But, 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 innovation in residual GNP will generate, over the same period, a little less than 3.5¢ of extra educational expenditure. Following this $1 shock to resource rent, the rest of GNP ends up increasing by more than 75¢s. GNP per capita decreases by around 7¢s as compared with the period where the shock occurred. This is in spite of the f acts that resource rents have crunched to less than 15¢ over the course of three decades. However, whence compared with the counter-factual of no resource rent shock at all, total GNP per capita has actually increased by 93¢.

Obviously, given that an increase in residual GNP per capita is self-sustainable whereas a resource rent shock statistically tends to deplete itself, over the long-run, if there was a choice to be made between a shock in resource rents or a residual GNP innovation, one would argue that a residual GNP innovation will, in the end, indubitably make a country better off. However, in practice and almost by definition, innovations may not lie in the realm of policy making. Further, there is nothing in this model that prevents resource boom to compound itself with an innovation in residual GNP. To put it an other way, here a resource rent shock is “all good.” If there are adversarial effects to be concerned about, they are not captured by the VAR model estimated here.

To be conservative, 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 as a 100% jump in resource rent is to 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, for example in Gabon, Nigeria, Saudi Arabia, Trinidad & Tobago, and Venezuela. These countries may not stand out necessarily as the most successful examples of economic development, but the counterfactual in terms of what would have been the level of educational investment in these countries, would they have failed to experience a resource boom, needs to be born in mind.

These observations come in contrast to Thorvaldur Gylfason’s (2001) findings. My approach differs from his to the extent I look at subsoil wealth per capita instead of the ratio of natural capital in overall wealth. As the author notes himself 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, this author 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 the corresponding resource rents.) My observations also come in contrast with those of Nancy Birdsall, Thomas Pinckney and Richard Sabot (2001). In their case, the problem is that they define a mineral country in a arbitrary way, instead of in the light of actual resource rents and subsoil wealth series as done in this paper. I suspect they unknowingly let their priors influence their classification. In the future, I plan to contrast my results with those of the existing literature more formally.

In terms of development strategy formulation, the wealth effect identified in this paper implies that resource rich countries should not be discouraged to exploit their natural resource basis, 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 — and these have to be systematically investigated, and in due turn should be 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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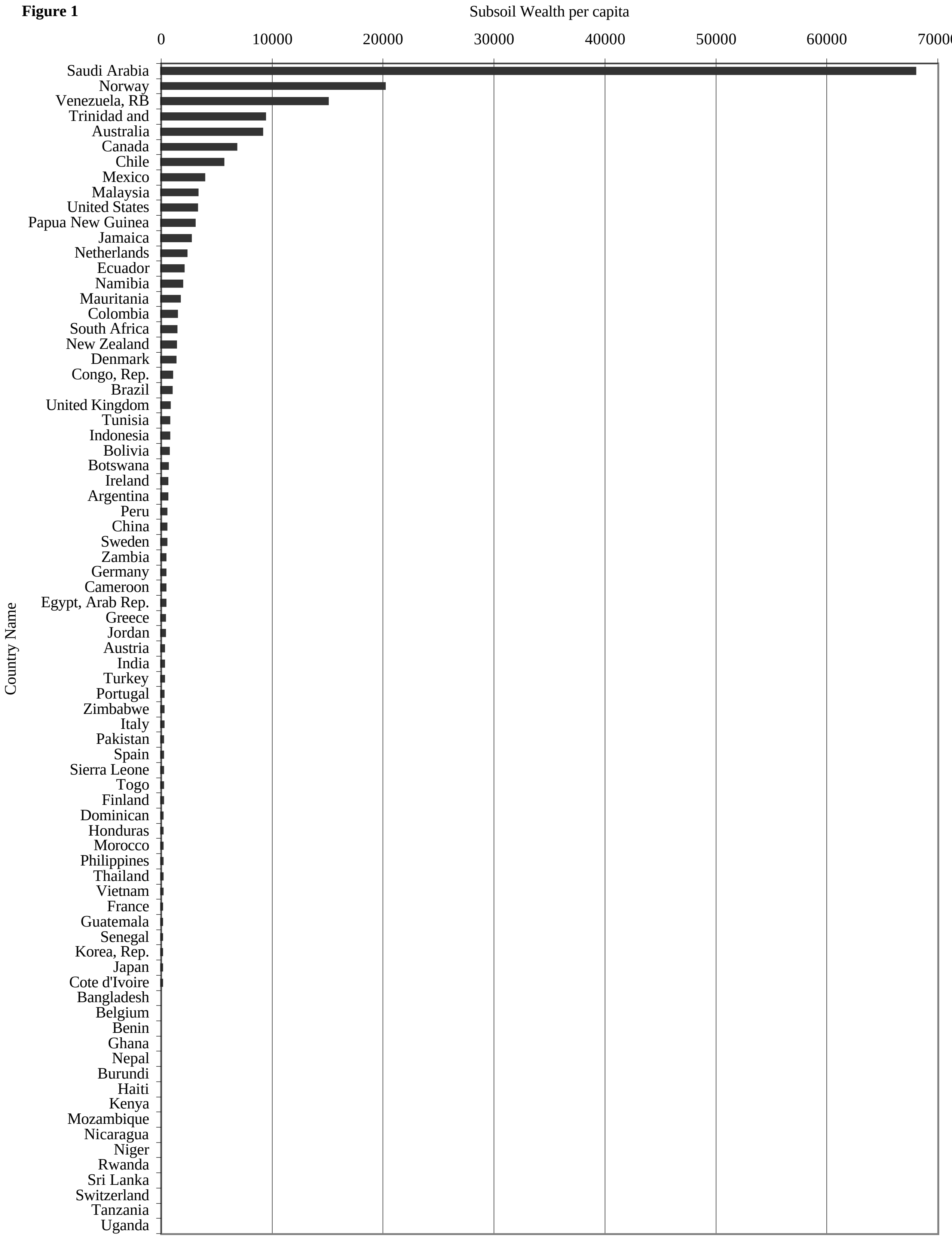
Figure 1



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

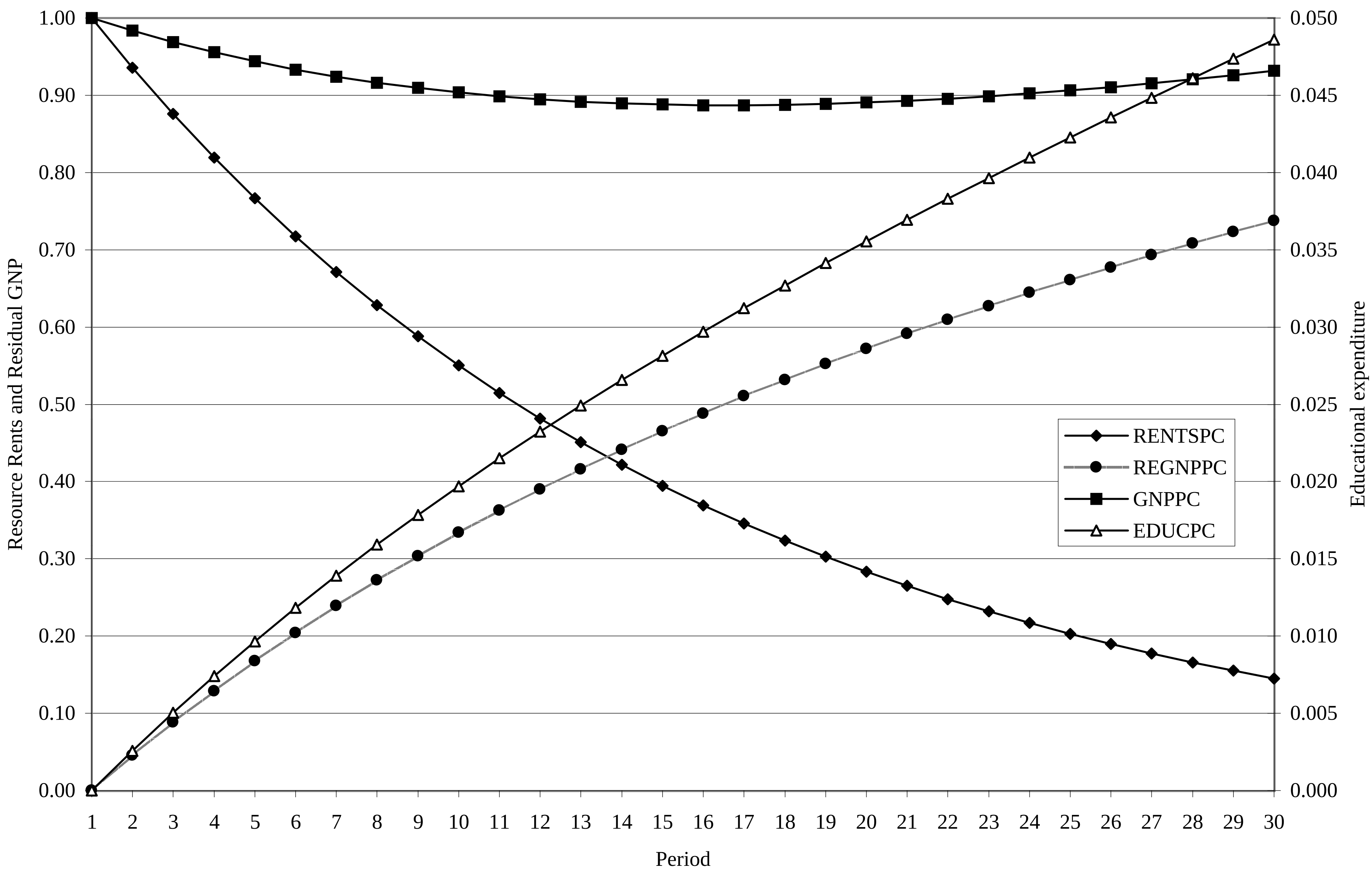


Figure 3: Response a to 1 unit shock to the rest of GNP

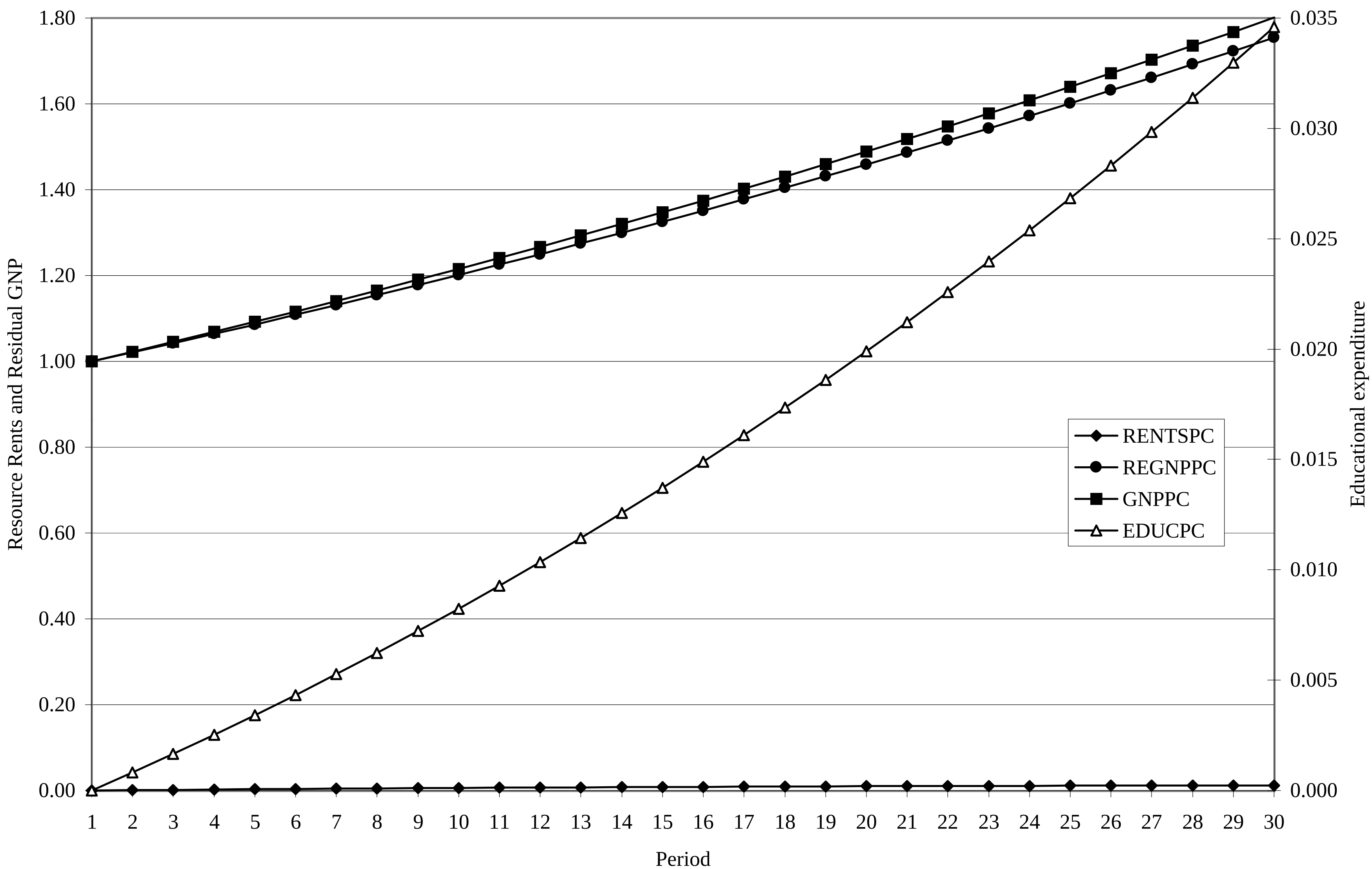


Table 1: Spearman Correlation Coefficients / Prob > |R| under Ho: Rho=0

	Educational savings (% expend.)	Total Years of Education		Life expectancy
		Overall	Female	
All	40.58% ***	50.48% ***	49.17% ***	36.26% ***
countries	0.0003	0.0001	0.0001	0.0012
Developing	38.59% ***	60.52% ***	58.37% ***	48.19% ***
countries	0.0033	0.0001	0.0001	0.0002

Note: One star, two star and three stars indicate statistical significance at alpha=10%, 5% and 1% respectively.

Table 2: Indicator Averages and Matching Results

	Subsoil wealth	Educational savings (% expend.)	Total Years of Education Overall	Total Years of Education Female	Life expectancy
Averages	Top quartile	4.67	8.10	7.93	70.24
All countries	2nd quartile	3.97	6.83	6.28	66.52
	3rd quartile	3.42	5.52	4.96	65.92
	Bottom quartile	3.28	4.61	4.08	58.46
Averages	Top quartile	4.30	6.27	6.13	66.81
Developing countries	2nd quartile	3.49	5.51	4.89	61.70
	3rd quartile	3.07	4.47	3.80	61.30
	Bottom quartile	2.97	3.36	2.80	53.94
Difference in averages for all countries	Top vs. 2nd quartile	0.70	1.27	1.65	3.72
No matching	Top vs. 3rd quartile	1.25	2.58	2.97	4.32
	Top vs. Bottom quartile	1.39	3.49	3.85	11.78
	Top vs. 2nd quartile	0.91	1.41	1.75	3.83
Matching on GDP	Top vs. 3rd quartile	1.41	2.98	3.31	5.28
	Top vs. Bottom quartile	1.52	3.56	3.91	13.01
	Top vs. 2nd quartile	1.11	0.84	1.00	0.03
Matching on Political Instability	Top vs. 3rd quartile	0.96	2.38	2.45	2.63
	Top vs. Bottom quartile	1.19	1.05	1.29	4.82
	Top vs. 2nd quartile	0.62	1.29	1.47	6.98
Matching on Legal Origin	Top vs. 3rd quartile	1.44	3.12	3.59	9.18
	Top vs. Bottom quartile	1.55	3.40	4.88	15.49
	Top vs. 2nd quartile	0.68	0.32	0.55	4.08
Matching on Religion	Top vs. 3rd quartile	0.38	2.97	3.37	9.53
	Top vs. Bottom quartile	0.76	3.68	4.11	15.71
	Top vs. 2nd quartile	-0.05	0.52	0.62	6.09
Matching on Propensity Score	Top vs. 3rd quartile	0.47	1.28	1.37	7.15
	Top vs. Bottom quartile	0.79	2.47	2.54	8.49

Table 3: Panel Data Estmation Results

Dependent variable: Educational spending per capita

Method	**Country Fixed Effects**		**Country Random Effects**		**Time Fixed Effects**		**Time Random Effects**	
	Standard	***IV***	***Standard***	***IV***	***Standard***	***IV***	***Standard***	***IV***
Resource Rents per capita	0.02 ***	0.05 ***	0.02 **	0.06 ***	0.05 ***	0.16 ***	0.05 ***	0.14 ***
	0.00	*0.02*	*0.00*	*0.02*	*0.00*	*0.02*	*0.00*	*0.01*
Rest of GNP per capita	0.05 ***	0.06 ***	0.05 **	0.06 ***	0.05 ***	0.07 ***	0.05 ***	0.07 ***
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
Political Freedom	-1.46	-2.92 **	-0.79	-2.95 **	8.47 ***	-4.29 *	8.40 ***	-3.68 *
	1.40	*1.39*	*1.38*	*1.40*	*1.49*	*2.20*	*1.48*	*2.06*
Age Dependency Ratio	20.29	40.56 *	16.76	48.54 **	125.40 ***	364.95 ***	123.73 ***	339.80 ***
	22.15	*23.97*	*21.38*	*24.14*	*19.52*	*34.00*	*19.38*	*31.89*
constant	-17.813	-56.579 ***	-10.2475	-64.499 **	-79.84 ***	-385.129 ***	-79.0501 ***	-355.365 ***
	17.84	*22.09*	*20.69*	*25.77*	*15.05*	*32.06*	*14.95*	*29.65*
Number of obs	2555	2416	2555	2416	2555	2416	2555	2416
F or Wald chi2	3994.63	26864.8	16830.04	4361.94	5327.94	13361.38	23544.9	
Prob > F or Wald chi2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
R-sq	89.87%	91.32%	89.90%	91.25%	90.23%	88.58%	90.23%	89.04%
Hausman for random effects			0.00%	100.00%			87.32%	5.79%
Prob > F test that RR = RGNP	0.00%	81.00%	0.00%	77.33%	5.7%	0.00%	4.25%	0.00%
Hausman for no measurement errors	9.36%		51.12%		0.00%		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

Table 4: 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