Resource-Abundance and Economic Growth in the U.S.

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Summary

It is a common assumption that regions within the same country converge to approximately the same steady-state income levels. The so-called absolute convergence hypothesis focuses on initial income levels to account for the variability in income growth among regions. Empirical data seem to support the absolute convergence hypothesis for U.S. states, but the data also show that natural resource-abundance is a significant negative determinant of growth. We find that natural resource abundance decreases investment, schooling, openness, and R&D expenditure and increases corruption, and we show that these effects can fully explain the negative effect of natural resource abundance on growth.

Keywords: Natural resources, Growth, Transmission channels

JEL Classification: C21, O13, O51, Q33

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"Do we value this land and are we prepared to protect it, or are we going to desecrate it, diminish it, change it forever for a small amount of oil?"
Senator Joseph Lieberman speaking for Alaska, International Herald Tribune, March 21 2003.

1. INTRODUCTION

Historic experience across countries provides support to the hypothesis that resource-scarce economies often outperform resource-abundant countries in terms of economic growth. A number of recent studies has described and analyzed the resource-curse hypothesis (Gylfason 2000, 2001a, Leite and Weidmann 1999, Papyrakis and Gerlagh 2004, Rodriquez and Sachs 1999, Sachs and Warner 1995, 1997, 1999a). The conclusion is widely accepted: natural riches tend to frustrate rather than promote economic growth. Countries such as Japan, South Korea and Switzerland have experienced remarkably high rates of economic growth despite their lack of natural resources. On the contrary, countries, such as Mexico, Nigeria, Venezuela and the so-called Oil States in the Gulf became examples of development failures despite their extensive reserves of natural wealth.[3]

[3] We notice that there is much confusion about the exact meaning of the concept resource-abundance. The meaning may easily differ between sciences, if not even in different areas of economics (for an extensive analysis of the confusion regarding precise terminologies of natural resources see Laroui and Van der Zwaan 2002). For natural scientists or environmental economists, resource abundance typically refers to the amount of potentially exploitable natural resources. For economists that study the Dutch Disease, resource-abundance typically refers to the amount of already exploited natural resources and reserves proven to be economically exploitable. The proportion of potential resources that, in the end, becomes economically exploitable depends on many economic, political and technological factors. To provide an example, Foster and Rosenzweig (2003) show that there is a strong positive correlation between economic growth and (potential) resource-wealth (forest cover) for a sample of 23 closed developing economies. Sachs and Warner (1995), in contrast, find a negative strong correlation between economic growth and (already exploited) resource-wealth (the share of primary exports in GDP) for their cross-sectional analysis of 95 countries. To use Patten's own words (1889), in economics we often "really need new words more than we do new thoughts". In this paper, we focus on the already exploited natural resources.

The negative correlation between economic growth and resource-abundance, albeit a solid fact, still is a conceptual puzzle. Many development economists accentuated the role of natural resources in economic development (e.g., Nurkse 1953, Rostow 1960 and Watkins 1963). Indeed, there is no obvious reason why natural resources should frustrate economic growth *per se*. Plentiful fertile land, rich fishing banks, diamond mines and vast oil reserves should drive economic growth rather than restrain it. As Sachs and Warner (2001) suggest, the slow-down of economic growth must be an indirect effect of natural wealth. Extensive natural wealth reduces economic growth mainly through crowding-out growth-promoting activities. Economies that maintain growth-promoting activities may be less vulnerable to the natural resource curse. There are a few successful examples of countries that benefited or still benefit from their extensive natural wealth. Norway, for instance, converts its rich oil reserves mostly in foreign securities and, thus, protects its economy from abrupt income increases (Gylfason 2001a). Diamond-rich Botswana experienced high income-growth during the last three decades, but it also had one of the highest ratios of government expenditure on education to GDP (Gylfason 2001b).

In the literature several indirect transmission channels have been identified and investigated through which resource-abundance leads to lower economic growth. A rapid increase in income levels due to natural resource discoveries may lead to sloth and reduced awareness of the need for sound economic management, social equity and institutional quality (Sachs and Warner 1995, Gylfason 2000, 2001a). It may also create a false sense of security and weaken the perceived need for investments, a high-skilled labor force and growth-promoting strategies. Also, manufacturing industries are often harmed by an appreciation of the local currency and a change in the composition of exports in favor of resource-intensive goods. Consequently, natural resource abundant economies usually experience a drop in manufacturing and other non-primary exports, while these are usually characterized by valuable technology spillovers and learning-by-doing (Sachs *et al.* 1995, 1999a, Gillis *et al.* 1996, Gylfason 2000, 2001b). Natural resources may crowd-out entrepreneurial activity and innovation by encouraging potential innovators to work in the resource sector (through a wage premium) and it thus directs funds away from the R&D sector into the primary sector (Sachs and Warner 2001).

In this paper, we contribute to this strand of the literature studying the natural resource curse and its transmission channels on a U.S.-state level. To our knowledge, this is the first empirical analysis performed at a regional level focusing on the negative relationship between economic growth and resource-abundance and the indirect mechanisms through which this occurs. A merit of our analysis is that whereas countries often differ in dimensions – such as language, the quality of institutions and cultural characteristics – that are difficult to control for in growth regressions, these differences are likely to be smaller across regions within a country (Barro and Sala-i-Martin 1995). The U.S. are a relatively homogeneous country, compared to cross-country analyses, and therefore, a regional U.S. analysis may provide more precise estimates of the effect of resource wealth on growth and the indirect channels through which this takes place.

Figure 1 depicts the negative correlation between resource-abundance and economic growth over the period 1986-2001 for the 49 states, for which data were available for all the variables of our analysis (all U.S. states excluding the District of Columbia and Delaware). The correlation is significant at the 1% level. Data are compiled from the Bureau of Economic Analysis of the U.S. Ministry of Commerce.

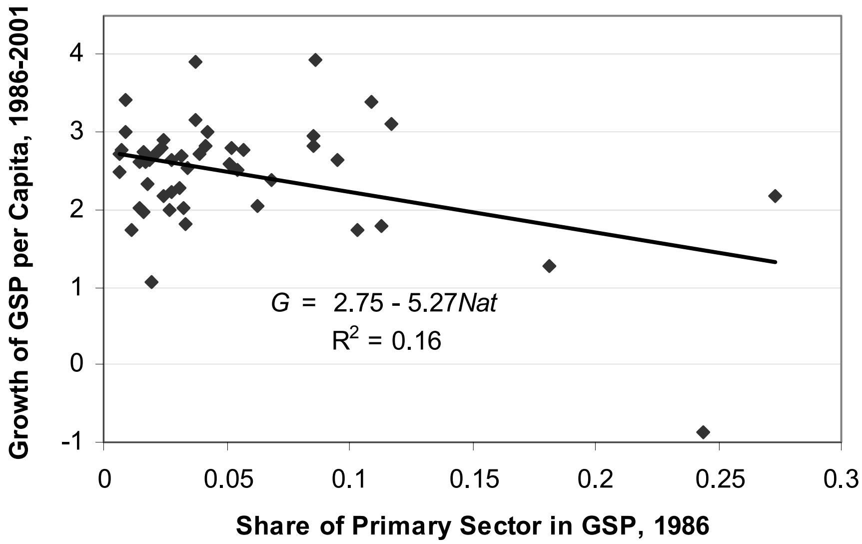

FIGURE 1. *Resource-Abundance and economic growth*

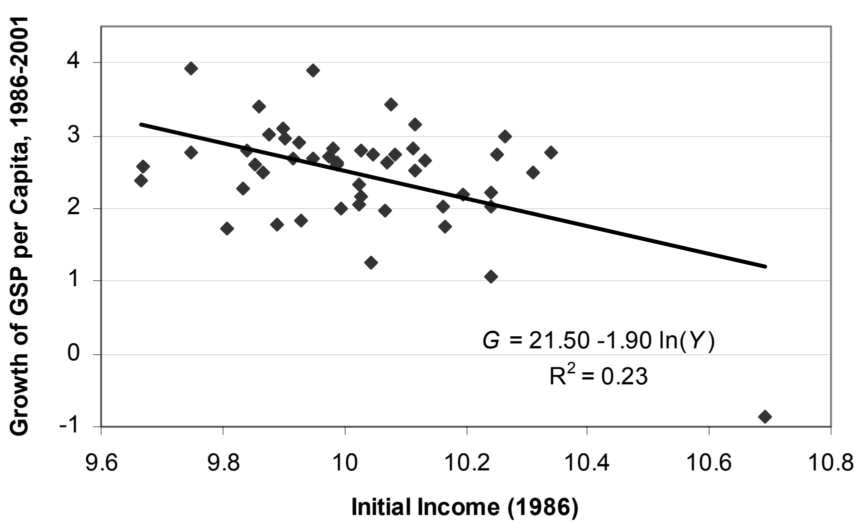

FIGURE 2. Absolute Convergence

Our analysis also contributes to growth theory in a wider perspective, as it estimates the conditional convergence hypothesis for different regions (the U.S. states) within a country. Most of the empirical analyses on regional data sets (e.g. Barro and Sala-i-Martin (1992a, 1992b, 1995), Barro *et al.* (1991) and Johnson (2000)) focus on the absolute convergence hypothesis. In these studies, an implicit assumption is that different regions within the same country are characterized by the same fundamental economic features (tastes, technologies, institutions etc.) and therefore that they all must converge to the same steady-state. Then, changes in growth are fully driven by initial income differences. Figure 2 depicts the negative correlation between economic growth and initial income for our sample of 49 U.S. states, as previously. At a second stage, Barro and Sala-i-Martin (1992) include education and immigration as regressors in their analysis, only to show that the convergence rate they calculate remains stable. We believe that more can be said about the role of these independent variables. Finding the coefficients significant implies that regions converge to different steady-state levels, or stated differently, that regions with the same initial income level but different education and immigration level will experience different growth rates. Johnson and Takeyama (2001) claim, for instance, that the set of U.S. states with a higher density of capital stock experienced stronger convergence since 1950. Though differences in human capital, investment rates, resource-abundance, openness and institutions across regions are likely to be smaller than those across countries, in our analysis we find them to be non-negligible but significant in explaining economic growth.

Our analysis on the resource curse transmission channels follows the methodology set out by Mo (2000, 2001), who investigates the transmission channels through which income inequality and corruption affect growth. Through cross-state regressions (for the United States), we investigate the effect of natural resources on investment, schooling, openness, innovation (R&D) and institutional quality, and we estimate the share of each transmission channel in the overall negative effect of resource-abundance on growth.

The next section is devoted to the empirical evidence on resource-abundance and economic growth for the U.S. We verify our main proposition that natural resource abundance impedes economic development at a regional level. Section 3 focuses on other growth determinants (investment, schooling, openness, innovation and corruption) and the existence of conditional convergence. Section 4 studies empirically the transmission channels and compares their relative weight in the overall negative impact of natural resources on economic growth. Section 5 analyzes the differing growth experience of eight particular U.S. states and attributes their above(below)-average growth performance to their resource endowments and other specific characteristics of their economies. Section 6 summarizes our main results and offers concluding remarks.

2. NATURAL RESOURCE ABUNDANCE AND GROWTH

To identify the dependence of growth on natural resource abundance we estimate cross-state growth regressions for the U.S. states in the tradition of Kormendi and Meguire (1985), Grier and Tullock (1989), Barro (1991) and Sachs and Warner (1995, 1997). We include initial income per capita in our regressions to check for the conditional convergence hypothesis that predicts higher growth in response to lower starting income per capita keeping the other explanatory variables constant. Thus, per capita economic growth from period t_0=1986 to t_T=2000, denoted by $G^i=(1/T)\ln(Y_T^i/Y_0^i)$, depends on initial per capita income Y_0^i, on natural resource abundance, R^i (the sign of dependence is the subject of our analysis) and on a vector of other explanatory variables Z^i:

$$G^i = \alpha_0 + \alpha_1 \ln(Y_0^i) + \alpha_2 R^i + \alpha_3 Z^i + \varepsilon^i, \tag{1}$$

where i corresponds to each single U.S. state.[4]

We keep in mind that, ultimately, it is not economic growth that determines welfare, but the income level, and thus, it is of interest to assess the long-term income effects of a change in a state's resource income R^i, as described by growth equation(1). To estimate the long-term income effect, we

[4] Appendix 1 lists all variables and data sources.

compare two scenarios. In the first scenario, labelled k, the current value of resource abundance R and other regional characteristics Z persist. The other scenario, labelled j, assumes a permanent change in characteristics from R^k to R^j and from Z^k to Z^j. We denote the change in the levels of R^i or Z^i by $\Delta R = R^j - R^k$, and $\Delta Z = Z^j - Z^k$, respectively. As we show in Appendix 2, a permanent difference in R or Z has a long-term effect on expected income given by:

$$E(\Delta \ln(Y_\infty)) = -(\alpha_2/\alpha_1)\Delta R - (\alpha_3/\alpha_1)\Delta Z, \qquad (2)$$

where $\Delta \ln(Y_\infty) = \ln(Y_\infty)^j - \ln(Y_\infty)^k$ is the long-term log-income effect.

Taking exponentials we can rewrite equation (2) and calculate the relative long-term income effect as:

$$\Delta Y_\infty / Y_\infty = \exp[-(\alpha_2/\alpha_1)\Delta R - (\alpha_3/\alpha_1)\Delta Z] - 1 \qquad (3)$$

For small values of $(\alpha_2/\alpha_1)\Delta R$ and $(\alpha_3/\alpha_1)\Delta Z$, we can use the approximation

$$\Delta Y_\infty / Y_\infty \approx -(\alpha_2/\alpha_1)\Delta R - (\alpha_3/\alpha_1)\Delta Z. \qquad (4)$$

The ratio $-(\alpha_2/\alpha_1)$ captures the long-term income effect of changes in resource endowments. Similarly, the ratio $-(\alpha_3/\alpha_1)$ captures the long-term impact of changes in other explanatory variables. Assuming conditional convergence, i.e. $\alpha_1 < 0$, four different situations may arise. A ratio $-(\alpha_2/\alpha_1)=1$ indicates that an immediate one percent increase in current income based on natural resource exploitation (ΔR=0.01) also raises the long-term income level by one percent ($\Delta Y_\infty / Y_\infty$=0.01). An income increase brought about by increased resource abundance is permanent. If $-(\alpha_2/\alpha_1)>1$ resource abundance is so beneficial to growth that a one percent increase in current resource income raises long-term income by more than one per cent. If, on the other hand, $-(\alpha_2/\alpha_1)<1$, a one per cent increase in resource income results in less than one per cent raise in long-term income. The economy benefits from the resource expansion but the permanent income effect falls short of the temporary resource income effect. Finally, when $\alpha_2<0$ and $\alpha_1<0$, increased resource rents lead to a short-lived increase in income since growth is affected negatively to the extent that, in the long term, permanent income falls short of income without the natural resource. The latter case represents a situation known as the 'curse of natural resources'.

We now estimate growth equation (1) using OLS, gradually increasing the set of variables Z^i.[5] As a starting point, we estimate growth dependent only on initial income per capita in 1986 ($Ln\,Y_{86}$). Data on income levels are provided by the Bureau of Economic Analysis of the U.S. Ministry of Commerce, and we use the real Gross State Product (GSP) database, which is the state equivalent to GDP. As a second step we include natural-resource abundance, for which we take the share of the primary sector's production (agriculture, forestry, fishing and mining) in GSP in 1986 (*Nat*) as a proxy (values in the range of 0 to 1). The results are listed in column entry (1) and (2) of Table 1. Our findings support the hypothesis that poorer regions tend to grow faster than richer regions (a result that still holds when conditioning on any other characteristics of the regions).[6] The second column

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[5] We focus our analysis on the 49 states (all U.S. states excluding the District of Columbia and Delaware), for which data are available for all variables of interest. Since there is a lack of data on R&D expenditures for the District of Columbia and Delaware, we exclude these states from the first regressions in order to avoid a sample bias when comparing coefficients. To check qualitatively our results, we include Table 7 in Appendix 3 that repeats the (first five) regressions of Table 1 for the whole sample of 51 states.

[6] For our final sample of 49 regions, we find an estimated convergence rate of 0.022 per year. Our data for the initial sample of 51 regions supported a smaller convergence rate, but this is mainly due to the District of Columbia that has a GSP per capita twice as high as the average level of the sample. When we include three regional dummy variables in the analysis (south, midwest and west) as in Barro and Sala-i-Martin (1992), we find a convergence rate of 0.028. Both results are close to the absolute convergence rate estimated in Barro and Sala-i-Martin (1992). We do not use these geographical variables in our empirical analysis since most of the time they are insignificant and unstable in

reveals that there is a highly significant and negative relationship between economic growth and natural resources. It is apparent that regions within the U.S. differ substantially in economic features that are important for economic growth, apart from initial income levels. A one-percentage point increase in income from the primary sector's production relative to total income decreases growth by 0.047% per year. An increase in income from natural resources of one standard deviation (0.06) decreases the growth rate by about 0.28% per year. This is an effect of substantial magnitude. As a comparison, we observe that a one standard deviation increase in initial income decreases growth by 0.34% per year. When the negative effect of natural resources on growth persists, the long-term effect of an increase in natural resource income of one per cent amounts to 4.77/1.77=3 per cent (see equation (4)). A persistent one standard deviation increase in natural resource income leads to a decrease in long-term income by about 16 per cent. The numbers illustrate the argument that whereas in the short term natural resources may increase wealth, in the long term the economy can fall back more than it gained. This is consistent with Alaska's experience. It has vast oil reserves and fishing banks, but it is the only region in the U.S. with a negative rate of income growth over the last two decades.

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sign when included in Table 1. In the final regression of Table 1, where we account for all the explanatory variables captured in the vector Z^i, we estimate, though, a much higher rate of conditional convergence (close to 0.033). In that respect, our results contradict Barro and Sala-i-Martin' analysis, which predicts a common rate of absolute and conditional convergence. Furthermore, as expected, the estimated convergence rate for our cross-state analysis is larger than the ones estimated at a cross-sectional level for different countries (e.g. Barro (1991) and Barro and Sala-i-Martin (1992)). At a cross-country level, the absolute convergence rate is usually close to zero and the conditional convergence rate close to 0.018. This implies that within a country, it is relative easy for poorer regions to catch up.

3. Conditional convergence

We now turn to the possible crowding-out effects of natural resources (Sachs and Warner 2001). Let us assume that the vector Z^i in growth equation captures a set of growth-promoting activities. If resource abundance (R^i) crowds-out the activities captured by Z^i, then natural resources will indirectly harm economic growth (G^i). In other words, a negative statistical relationship between R^i and Z^i may explain the negative correlation between R^i and G^i in the second regression of Table 1. Furthermore, when the vector Z^i is sufficiently rich to fully capture most of the indirect negative effects of resource abundance on growth, we expect that its inclusion in our regressions would eliminate the negative coefficient of resource-abundance on growth. In other words, if resource-abundance affects growth solely through the intermediate transmission channels captured by the vector Z^i, we expect the coefficient of resource-abundance to drop to a value close to zero ($\alpha_2 \approx 0$). In case that either natural resources frustrate economic growth directly or not all intermediate transmission channels through which resource abundance affects growth are accounted for, the coefficient of resource-abundance is expected to sustain its negative sign. As our next step, we thus extend the vector Z^i, by adding progressively variables commonly used to explain growth, such as investment, schooling, openness, R&D expenditure and corruption, and we examine the magnitude and significance of the resource-abundance coefficient α_2.[7]

In column entry (3), we include the share of industrial machinery production in GDP in 1986 as a proxy for investment. Data are provided by the Bureau of Economic Analysis of the U.S. Ministry of Commerce. The variable refers to the beginning of the period 1986-2001 in order to avoid endogeneity problems. Of those investment measures available, we find industrial machinery

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[7] Acemoglu *et al*. (2002) use the same argument to give substance to their claim that income levels around 1500 (proxied by measurements of urbanization and population density) affected long-term income per capita solely through institutions.

production most likely to be favorable to economic growth, rather than constructions for instance.[8] Investment contributes positively and considerably to growth as expected. An increase in the investment level of one standard deviation increases growth by 0.78 x 0.29 = 0.23 per cent. In the long term, this leads to a permanent income increase of 13 per cent.[9] The coefficient for natural resources becomes smaller and less significant (the significance level falls to 11%).

In the subsequent column entry we include as independent variables, the contribution of educational services in GDP in 1986 (*Schooling*), which we consider a proxy for investments in human knowledge. Next, we include a proxy for *Openness*, for which we use the ratio of net international migration for the 1990-99 for each state relative to the population of the state in 1990. We expect a more open economy to receive more foreigners compared to a closed economy. We observe that schooling and openness contribute positively to economic growth as expected, and when added as explanatory variables they strongly decrease the magnitude and significance of the coefficient for natural resources. In column (5) of Table 1, where we take account of the first three transmission channels (investment, schooling and openness), the coefficient of resource-abundance has been reduced by a factor seven compared to column entry (2) and has become totally insignificant. This suggests that a large part of the resource-curse hypothesis is explained through these indirect transmission channels.

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[8] We also used a measure of financial depth (the percentage of GSP attributed to finance, insurance and real estate) as a proxy for investment and verified the robustness of the positive correlation between this measure and growth, and the negative correlation between this measure of investment and resource-abundance. A discussion and empirical investigation on the relationship between investment and financial depth is given by Gylfason and Zoega (2001). Acemoglu and Zilibotti (1997) also make the point that low levels of financial depth slows down capital accumulation because of the presence of indivisible projects.

[9] 0.78 x (– 0.29) / (–1.69) = 0.13, see equation (4).

Finally, in column entries (6) and (7) we incorporate two more explanatory variables in our regression analysis. In column (6) we include the share of R&D expenditure in GSP for 1987 as a proxy for innovation and endogenous technological progress.[10] In column (7) we include the number of prosecuted corrupted public officials over 1991-2000 per 100000 citizens as a proxy of corruption in the economy. Data are provided by the Criminal Division of the United States Department of Justice. The coefficients of both variables have the expected sign. Innovation promotes growth and corruption inhibits it. R&D is not highly significant, though. But we must keep in mind that spillover effects of R&D activities are not likely to be constrained by state boundaries. The coefficients for R&D will thus seriously underestimate the country-wide effect on growth. Also, innovation may affect growth through some other indirect channels such as investments as well, so that part of its positive effect is captured through this coefficient (their direct correlation is significant at the 5% level). We observe that the coefficient of resource abundance has approached zero at the last column entry and has become almost totally insignificant (94% insignificance level).

Overall, the sequence of regressions in Table 1 reveals that adding explanatory variables steadily reduces both the magnitude and significance of the coefficient of resource-abundance. This leads to two conclusions. First, natural resources are not harmful to growth *per se*. They tend to frustrate economic growth mainly through indirect channels (investment, schooling, openness, innovation and corruption). Second, the list of indirect channels is rich enough to capture all indirect effects since the remaining coefficient shows a negligible impact of resource-abundance on growth insofar as this is not captured through the other variables.

[10] We additionally checked for the impact of landlockedness on economic growth. We found the coefficient insignificant and of the wrong sign (positive).

TABLE 1. *Growth regressions as in equation* (1)

Dependent variable: $G_{1986\text{-}2000}$	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Constant	21.50	20.44	19.34	20.54	27.43	26.97	27.97
$Ln\,Y_{86}$ (0.19)	–1.90*** (–3.76)	–1.77*** (–3.77)	–1.69*** (–3.82)	–1.83*** (–4.02)	–2.57*** (–3.38)	–2.53*** (–4.70)	–2.59*** (–4.99)
Natural Resources (0.06)		–4.72*** (–3.00)	–3.43** (–2.18)	–2.66 (–1.57)	–0.70 (–0.40)	–0.34 (–0.19)	–0.14 (–0.08)
Investment (0.78)			0.29*** (2.60)	0.26** (2.20)	0.34*** (2.90)	0.31** (2.60)	0.21* (1.74)
Schooling (0.44)				0.27 (1.20)	0.35 (1.61)	0.29 (1.34)	0.34 (1.60)
Openness (0.17)					1.43** (2.23)	1.17* (1.80)	1.28** (2.04)
R&D (0.97)						0.15 (1.63)	0.10 (1.12)
Corruption (1.65)							– 0.11** (–2.08)
R^2 adjusted	0.22	0.33	0.40	0.41	0.46	0.48	0.52
N	49	49	49	49	49	49	49

Note: Standard deviations for independent variables in parentheses, based on the sample *N*=49 of regression (7); t-statistics for coefficients in parentheses. Superscripts *, **, *** correspond to a 10, 5 and 1% level of significance.

4. TRANSMISSION CHANNELS

In this section we further investigate the transmission channels. Specifically, we estimate the impact of resource-abundance on investment, schooling, openness, R&D and corruption, and the indirect effect, thereof, on economic growth, and subsequently we calculate the relative importance of each transmission channel compared to one another.

Before turning to our empirical investigation, we discuss the variables that entered the regression analysis and we evaluate their probability to act as a transmission channel. We start with investments.

Natural resource wealth decreases the need for savings and investments, since natural resources provide a continuous stream of future wealth that makes future welfare seem less dependent on the transfer of man-made capital to future periods (Corden 1984, Gylfason and Zoega 2001). Additionally, world prices for primary commodities tend to be more volatile than world prices for other goods. Therefore, an economy based on primary production will shift relatively often from booms to recessions and this creates uncertainty for investors in natural resource economies (Sachs and Warner 1999b, Herbertsson *et al.* 1999). Furthermore, natural resource abundance increases rents in the primary sector that cause a reallocation of factors of production from the manufacturing sector towards the expanded primary sector. Sachs and Warner (2001) mention the wage premium in the primary sector as a factor that signifies such changes. The reallocation and decreased investment levels enhance each other. Often, the manufacturing sector is characterized by increasing returns to scale and positive externalities. A decrease in scale of the manufacturing sector further decreases the productivity and profitability of investments, accelerating the decrease in investments (Sachs and Warner 1995, 1999a, Gillis *et al.* 1996, Gylfason 2000, 2001a). Gylfason and Zoega (2001) analyze the rate of optimal saving and the maturity of the financial system in an economy and its negative relation to the share of natural resources in national output.

As a second transmission channel we consider the role of resource-abundance in explaining educational quality. Gylfason, Herbertsson and Zoega (1999) show empirically an inverse relationship across countries between school enrolment rates for all school levels and resource-abundance. Increases in resource income lead to a contraction of the manufacturing sector for which human capital is an important production factor. The need for higher education declines, and so does the returns to education (Gylfason 2001a). Due to a higher level of non-wage income, private and public incentives to accumulate human capital are reduced (Gylfason and Zoega 2001). It is also claimed that natural resource abundance creates a false sense of confidence: “easy riches lead to sloth" (Sachs and Warner 1995). An expanding primary sector does not need a high-skilled labor force, and there is no feeling of urgency to increase spending on education. This restricts the future expansion of other sectors that require educational quality (Gylfason 2000, 2001a, 2001b, Sachs and Warner 1999b) and technological diffusion in the economy (Nelson and Phelps 1966).

The third transmission channel we consider is the impact of natural resources on the degree of openness in the economy, measured by the ratio of net immigrants during 1986-2000 to the population at the beginning of the period. We acknowledge the fact that our proxy of openness is not obvious. A better measure might have been the amount of exports and imports in GSP for each region, but this measure is not available to us. Economies that are open to trade tend also to be open in terms of accepting immigrants: a well-known example is the Netherlands during their Golden Age (Rodrik (1997 ch.2) claims that open economies tend to have a more elastic labor demand and therefore are more eager to accept immigrants). This theme has been elaborated on in the recent pioneering work by Collins *et al.* (1999), who provide empirical support through panel data analysis to a strong complementarity between trade-openness and labor mobility (immigration).

Our data show that resource-abundance is indeed negatively correlated with the degree of openness for our sample of U.S. regions. The mechanisms that link resource abundance to openness must be different for the state level when compared to the country level. At a state level, resource abundance cannot lead to a raise in trade tariffs or to import quotas; a relation that is often found in cross-country analyses (Auty 1994, Sachs and Warner 1995). There is also no overvaluation of the local currency (Sachs and Warner 1995, Torvik 2001, Gylfason 2000, 2001a, 2001b, Rodriguez and Sachs 1999). Resource abundance may harm, though, the openness of regional economies within a country in a different manner. Resource-dependent sectors often suffer from uncertainty due to the high volatility of prices of primary commodities (that tend to follow a negative trend over time, see Cashin *et al.* 2002). In order to protect regional employees working in these sectors, local governments may transfer funds to their support (or exert pressure to the central government to do so). If these funds were utilized more efficiently for alternative purposes, this could create a temporary loss of jobs for the regional population (and voters). Local trade unions from the resource-based sectors may deter the development of an institutional and regulatory environment that fosters competition. If resource-abundance is also related to rent-seeking and corruption, as it is often mentioned in the literature (Gray and Kaufmann 1998, Ascher 1999, Leite and Weidmann 1999, Gylfason 20012), then a climate of shirking and opportunism may increase the potential hazards of trade (North 1991). In the literature, people in the coal-rich Appalachia region (Virginia, West Virginia and Kentucky) are described as relative antagonistic towards the government and foreigners (Santopietro 2002, Hansen 1966). Essentially, the arguments show a similarity between regional and national governments that both have an increased incentive to protect the perceived interests of domestic people when natural resource income grows.

As a next transmission channel we consider the effect of resource-abundance on innovation (R&D). This linkage receives less attention in the “Dutch Disease” literature, but our data unambiguously point to a link from natural resource abundance to R&D expenditures. Sachs and Warner (2001) suggest that resource-abundance may crowd-out entrepreneurial activity and innovation by encouraging potential innovators and entrepreneurs to engage in the primary sector. To the extent that entrepreneurial talent is limited, the crowding-out effect of innovation can be potentially large. Furthermore, as Murphy, Shleifer and Vishny (1991) point out, when talented individuals start firms, they innovate and foster growth. When they become rent-seekers, they only redistribute wealth and reduce economic growth. In countries where rent-seeking activities give higher rewards to talent than entrepreneurship, innovation is likely to be crowded-out and the economy stagnates.

The last transmission channel we investigate considers the relation between resource-abundance and corruption. Natural resources provide an easy way of receiving rents (Krueger 1974) and increase the returns to bribing the administration in order to gain access to these resource rents (Gray and Kaufmann 1998, Leite and Weidmann 1999, Torvik 2002). Additionally, natural resources are often associated with the emergence of politically powerful interest groups that attempt to influence politicians prone to corruption in order to adopt policies that may favor particular interests as opposed to the general public interest (Mauro 1998). Rent-seeking can breed corruption and cause a distortion in the allocation of resources (Shleifer and Vishny 1993).

Now we turn to the data. Our basis specification of the dependence of the variables Z^i on resource income is given by:

$$Z^i = \beta_0 + \beta_1 R^i + \mu^i, \qquad (5)$$

where Z^i, β_0, β_1, and μ^i are specified for investment, schooling, openness, R&D and corruption. Table 2 lists the results for the estimated equation (5). Our results indicate that resource-abundance leads to lower investment, schooling, openness, R&D expenditure and higher levels of corruption. All coefficients are consistent with the negative correlation between resource-abundance and economic performance. The schooling variable has the most significant relation to natural resource abundance at the 1% level, and resource-abundance alone accounts for 17% of the variation in educational quality across different states. Interestingly, we also find a strongly significant coefficient for R&D and natural resources by themselves explain more than 11% of variation in R&D expenditures. On the other hand, the corruption channel seems to be relatively weak, since it is only significant at the 16% level.

TABLE 2. *Indirect transmission channels, estimation of equation* (5)

	Investment (8)	Schooling (9)	Openness (10)	R&D (11)	Corruption (12)
Constant	1.23	0.86	0.22	1.50	2.70
Natural Resources (0.06)	–4.45** (–2.36)	–3.32*** (–3.24)	–0.75* (–1.75)	–6.16*** (–2.64)	5.96 (1.42)
R^2 adjusted	0.09	0.17	0.04	0.11	0.02
N	49	49	49	49	49

Note: t-statistics for coefficients in parentheses. Superscripts *, **, *** correspond to a 10, 5 and 1% level of significance.

To test the robustness of our results we use an alternative specification for the transmission channels by incorporating initial income ($\ln(Y_0^i)$ in equation (5). The specification describing the transmission variables becomes:

$$Z^i = \gamma_0 + \gamma_1 \ln(Y_0{}^i) + \gamma_2 R^i + \sigma^i. \tag{6}$$

Estimations of equation (6) for all five transmission channels are provided in Appendix 4. Two findings stand out. First, the coefficient for initial income is insignificant in all transmission channels except for the openness channel, and second, the coefficients for natural resource abundance remain almost unchanged. From this, we conclude that income is not a major determinant for most of the variables captured by the vector Z^i, and this reduces the probability of endogeneity for the same set of variables. It's more likely that the variables captured in the vector Z^i affect income levels rather than the other way round. We choose equation (5) as the basis for our further analysis.

Since openness, though, appears to depend on income levels, we test an alternative specification adopting a measurement of openness based on 1990 data (*Openness90*) as an instrument for our index of *Openness* over the whole period. The two measures are strongly correlated at the 95% level and the instrumental variable is uncorrelated with the error term ε^i of equation (1). In Appendix 5, we present a two-stage least-squares (2SLS) estimation of equation (1) including all explanatory variables and treating average *Openness* as endogenous. Panel A reports the 2SLS estimates of the coefficients of all growth-determining variables and Panel B gives the corresponding first stages. We find no major qualitative differences as compared to our previous results (reported in Table 1) but significance drops for most coefficients.

As resource-abundance explains part of the variation in investment and other variables, by substitution of equation (5) into (1) we can calculate the overall (direct and indirect) impact of natural resources on growth:

$$G^i = (\alpha_0+\alpha_3\beta_0) + \alpha_1 \ln(Y_0^{\,i}) + (\alpha_2+\alpha_3\beta_1)R^i + \alpha_3\mu^i + \varepsilon^i, \qquad (7)$$

where $\alpha_2 R^i$ denotes the direct effect of natural resources on growth, $\alpha_3\beta_1 R^i$ indicates the indirect effect of natural resource abundance on growth,[11] and μ^i are the residuals of (5). The estimated values for the coefficients α_1, $\alpha_2+\alpha_3\beta_1$, and α_3 of equation (7) are listed in column (13) of Table 3. Alternatively, we adopt the specification provided by equation (6) for the openness channel (since openness is the only variable where initial income appears to be a significant factor) and maintain the transmission specification of equation (5) for the remaining variables. Results are provided in column (14) of Table 3. Finally, the last column of the table presents estimations when we substitute equation (6) into (1), in order to account for the possible impact of initial income on all transmission variables. Comparing the results presented in Table 3 reveals that the coefficient of initial income in equation (7) is likely to be slightly overestimated, when initial income is excluded as an explanatory factor for the various transmission variables. Additionally, the coefficient for natural resources is likely to be slightly underestimated, though the difference is small. Qualitatively, the conclusions derived from

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[11] Note that $\alpha_3\beta_1$ is an inproduct of two vectors of five elements.

the second regression in Table 1 on the relative importance of initial income and natural resource abundance are consistent with the results of Table 3.

TABLE 3. *Growth regression, taking account of indirect effects as in equation* (7)

Dependent variable: $G_{1986\text{-}2000}$	(13)	(14)	(15)
Constant	28.66	22.20	20.44
Ln Y_{75} (0.19)	–2.59*** (–4.99)	–1.94*** (–4.67)	–1.77*** (–4.44)
Natural Resources (0.06)	–4.46*** (–3.33)	–4.66*** (–3.49)	–4.72*** (–3.53)
Investment (μ_1; μ_1; σ_1) (0.74)	0.21* (1.74)	0.21* (1.74)	0.21* (1.74)
Schooling (μ_2; μ_2; σ_2) (0.40)	0.34 (1.60)	0.34 (1.60)	0.34 (1.60)
Openness (μ_3; σ_3; σ_3) (0.17)	1.28** (2.04)	1.28** (2.04)	1.28** (2.04)
R&D (μ_4; μ_4; σ_4) (0.90)	0.10 (1.12)	0.10 (1.12)	0.10 (1.12)
Corruption (μ_5; μ_5; σ_5) (1.62)	–0.11** (–2.08)	–0.11** (–2.08)	–0.11** (–2.08)
R^2 adjusted	0.52	0.52	0.52
N	49	49	49

Note: Standard deviations for independent variables in parentheses; t-statistics for coefficients in parentheses. The parentheses next to the variable names represent the sequence of residuals used in each regression. Superscripts *, **, *** correspond to a 10, 5 and 1% level of significance.

Additionally, we quantify the relative importance of each transmission channel in explaining the overall negative impact of natural resources on economic growth. The direct effect is given by α_2 and the indirect effect by $\alpha_3\beta_1$, as can be seen from equation (7). Results are listed in Table 4.[12] Consistent with the drop of the natural resource coefficient in Table 1, the largest part of the 'resource curse' can be attributed to the indirect channels.

TABLE 4. *Relative importance of transmission channels, as in equation* (7)

Transmission channels	α_3 (Table 1)	β_1 (Table 2)	Contribution to $\alpha_2+\alpha_3\beta_1$	Relative Contribution
Natural Resources			–0.14	3%
Investment	0.21	–4.45	–0.93	21%
Schooling	0.34	–3.32	–1.13	25%
Openness	1.28	–0.75	–0.96	22%
R&D	0.10	–6.16	–0.62	14%
Corruption	–0.11	5.96	–0.66	15%
Total			**–4.46**	**100%**

Schooling appears to be the most important transmission channel, accounting for one fourth of the negative impact of resource-abundance on growth for the U.S. regions.

5. SOME EXAMPLES

Modifying the structural representation of equation (7), can further our understanding of the growth experience of particular States. Equation (8) attributes growth differences relative to the average growth rate (2.47%) to differences in resource-abundance, investment, schooling and openness (the portion of them not explained by natural resources) from their mean values.

$$G^{i} - G^{a} = \alpha_1[\ln(Y_0)^{i} - \ln(Y_0)^{a}] + (\alpha_2 + \alpha_3\beta_1)(R^{i} - R^{a}) + \alpha_3\mu^{i} + \varepsilon^{i}, \tag{8}$$

where the *i* superscript represents a single state, the α superscript represents the average state, μ are the residuals of equation (5) (which are basically the part of all explanatory variables Z not explained

[12] We also calculate the relative importance of each transmission channel for the alternative transmission specifications provided by equation (6). Appendix 6 lists results. As illustrated in Tables 10 and 11, a slightly larger

by resource-abundance R) and ε is the error term of equation (7). In this way we can interpret relatively high and low growth rates over the 1986-2000 period in terms of each explanatory factor and an unexplained residue ε. To put it in other words, we can see whether a high or low growth level is due to convergence, due to resource-abundance (including the indirect effect through the transmission channels), due to the other explanatory variables (whose influence is captured by the vector μ^i) or finally due to some unexplained factors (namely the error term ε^i).

Table 5 presents the divergent growth experience of four resource-abundant states. Alaska and Louisiana are presented in the first two columns of the table. These two states experienced disappointingly low growth rates over the period. The large contribution of the resource-abundant factor (third row entries) identifies them as typical examples of the resource-curse. The direct and indirect effects of resource abundance on growth explain almost half of the negative growth differential for Louisiana, and one quarter of the negative growth differential for Alaska. The last two columns of Table 5 present New Mexico and Texas. Both states experienced above-average growth rates, despite the presence of an extensive resource base in their economies. Other things equal, New Mexico and Texas would have experienced growth rates of –0.25 and –0.19 percent point below the average, respectively, due to their resource abundance. New Mexico's remarkable growth performance is attributed mostly to convergence and the R&D sector (apart from the unexplained residuals). Texas seems to have benefited from its openness. The two last examples illustrate that the natural resource curse can be avoided.

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role for the openness channel is found when initial income is accounted for in the transmission specifications.

TABLE 5. *Growth differentials from the average value among U.S. regions (Resource-abundant States)*

	Alaska	Louisiana	New Mexico	Texas
$G^{i} - G^{a}$	–3.33	–1.21	0.92	0.16
$\alpha_1[\ln(Y_0)^{i} - \ln(Y_0)^{a}]$	–1.73	–0.05	0.43	–0.12
$(\alpha_2 + \alpha_3\beta_1)(R^{i} - R^{a})$	–0.85	–0.58	–0.25	–0.19
$\alpha_3\mu^{i}$ -investment	–0.03	–0.05	–0.12	0
$\alpha_3\mu^{i}$ -schooling	0.04	0.11	–0.06	–0.03
$\alpha_3\mu^{i}$ -openness	0.16	–0.03	0.14	0.35
$\alpha_3\mu^{i}$ –R&D	0.01	–0.03	0.27	0.01
$\alpha_3\mu^{i}$ -corruption	–0.12	–0.29	0.15	0.08
ε^{i} (error term)	–0.80	–0.30	0.37	0.07

In a similar fashion, Table 6 pays attention to the economic performance of four resource-scarce regions. The first two columns analyze the growth experience of Rhode Island and South Carolina. In these two states, resource-scarcity has gone hand in hand with above-average economic growth levels. The absence of an extensive primary sector in these economies seems to have been beneficial. For South Carolina, resource-scarcity can explain most of the growth differential from the average value and for Rhode Island it can explain more than 60%. Both states have additional features of interest that supported their economic growth. Rhode Island’s growth experience has been supported by high educational standards. South Carolina’s growth rate can also be attributed to convergence.

The following two columns present the somewhat disappointing economic performance of Missouri and Ohio. Although both states did not suffer from indirect negative effects of resource abundance, the other fundamentals of their economies did not support an above-average growth rate. Missouri's low economic growth is largely attributed to a bad performance in terms of openness and investment. Ohio's unsatisfactory performance can be explained by its relatively low investment and high corruption levels.

TABLE 6. *Growth differentials from the average value among U.S. regions (Resource-scarce States)*

	Rhode Island	South Carolina	Missouri	Ohio
$G^i – G^a$	0.26	0.14	–0.31	–0.14
$\alpha_1[\ln(Y_0)^i–\ln(Y_0)^a]$	–0.06	0.44	–0.01	0
$(\alpha_2+ \alpha_3\beta_1)(R^i–R^a)$	0.16	0.17	0.13	0.16
$\alpha_3\mu^i$ -investment	–0.12	0	–0.10	0.13
$\alpha_3\mu^i$ -schooling	0.32	–0.12	0.05	–0.04
$\alpha_3\mu^i$ -openness	–0.06	–0.20	–0.16	–0.20
$\alpha_3\mu^i$ –R&D	–0.04	–0.06	0.03	0
$\alpha_3\mu^i$ -corruption	–0.01	–0.07	–0.09	–0.19
ε^i (error term)	0.07	–0.02	–0.14	0

6. CONCLUSIONS

Recent theoretical work and empirical evidence have demonstrated a strong association between natural resource dependence and poor economic performance. The belief of many early development economists that resource exploitation would lead to economic prosperity proved unrealistically optimistic, given recent economic experiences. Nowadays, resource-abundant countries are among the most troubled states around the world; they tend to underinvest in education and infrastructure; they suffer from rent-seeking and corruption; they fail to diversify their economies, and neglect the necessity to constrain government ineffectiveness; they suffer from crushing poverty and long-term stagnation. In short, resource wealth did not enable countries to improve the living standards of their citizens. It seems that countries rich in oil reserves, gas, or tropical timber embarked on a different development path, which did not lead to sustained economic growth, compared to many nowadays rich resource-scarce economies.

The natural resource curse, as described above, is typically considered a problem for developing countries that spoil their wealth instead of managing it efficiently. In this paper, we show that the curse is not restricted to the international arena, but it also holds across regions within the highly developed U.S.. We used U.S. state-level data and showed that resource-scarce states have a comparative advantage in development compared to resource-abundant states. Many of the economic ailments restraining long-term growth in resource-abundant countries are also found across resource-rich regions.

This is an important finding for two reasons. First, it casts doubt on the common hypothesis that regions within a country converge to the same steady-state income level. There may be a substantial and persistent divergence between regions that deserves its own analysis. Second, it demonstrates that even in a relatively homogeneous sample, resource abundance can have a substantial negative impact through affecting various economic fundamentals such as investment levels, schooling rates, and openness. A better understanding of the indirect resource-curse mechanisms is essential for adopting policy measures that can prevent the negative impact of natural resources on economic growth. The natural resource curse is not a problem of countries with weak institutions, but it is a common threat to both developing and developed economies.

We have various extensions in mind of our analysis. First, we should try to decompose our measure of resource abundance into its constituent parts and test whether the results of our analysis hold for different classifications and definitions of resource wealth. Auty (2001) points out that economic growth across countries after the mid 1970’s is likely to be more negatively correlated with resource wealth created by mining rather than farming. Therefore, the distinction of the resource rents source may provide valuable information to the causes of the resource curse. Furthermore, the period of our investigation is diverse in the following respect. The first half of the period before the mid 90’s is characterised by relatively low rates of economic growth. After the mid 70’s there was a considerable productivity growth slowdown relative to the post-war average (see e.g. Jorgenson and Fraumeni 1992) that lasted approximately till the mid 90’s for the U.S. (Jones 2002). After the mid 90’s economic growth rates rose substantially and economists often refer to the corresponding period as the “New Economy” (Gordon 2000, Nordhaus 2002). Therefore, a further analysis should try to investigate the characteristics of different sub-periods within the overall period and the respective growth determinants. This would improve our insight on the driving forces of convergence and divergence across regions.

Appendix 1: List of Variables Used in the Regressions

G	Average annual growth in real GSP (Gross State Product) per person between 2000-1986, $G=(\ln(Y_{2000}/Y_{1986})/21)\text{x}100\%$. GSP data from the Bureau of Economic Analysis of the U.S. Ministry of Commerce (BEA 2003).
Ln Y_{86}	The log of real GSP per capita in 1986 (Chained (1996) U.S. Dollar Prices) (Data from the Bureau of Economic Analysis of the U.S. Ministry of Commerce) (BEA 2003).
Nat	The share of the primary sector's production (agriculture, forestry, fishing and mining) in GSP for 1986 (values in the range of 0 to 1) (Data from the Bureau of Economic Analysis of the U.S. Ministry of Commerce) (BEA 2003).
Investment	The share of industrial machinery production in GDP in 1986 (Data from the Bureau of Economic Analysis of the U.S. Ministry of Commerce) (BEA 2003).
Schooling	The contribution of educational services in GDP in 1986. Data from the Bureau of Economic Analysis of the U.S. Ministry of Commerce (BEA 2003).
Openness	The ratio of net international migration (the difference between migration to an area from outside the United States and migration from that area) for the 1990-99 for each state to the population of the state in 1990. Data from the U.S. Census Bureau (U.S. Census Bureau 2003).
R&D	The share of R&D expenditure in GSP for 1987. Data provided from the Industry, Research and Development System (IRIS) of the National Science Foundation (NSF 2003).
Corruption	The number of prosecuted corrupted public officials over 1991-2000 per 100000 citizens. Data from the Criminal Division of the United States Department of Justice (U.S. Department of Justice 2003).

Appendix 2: Long-term Income Effects

In this appendix, we derive the long-term income effects of equation (2). We assume that economic growth G for region i depends on its initial income Y_0, resource abundance R, and a vector of other explanatory variables Z, as described in equation (1). Since G^i represents income growth over a period of T years, we can re-write equation (1) as:

$$(\ln(Y_T^i) - \ln(Y_0^i))/T = \alpha_0 + \alpha_1 \ln(Y_0^i) + \alpha_2 R^i + \alpha_3 Z^i + \varepsilon^i \,, \tag{9}$$

and after rearranging terms, we derive income for state i at the end of the period (year T).

$$\ln(Y_T^i) = \alpha_0 T + (\alpha_1 T+1)\ln(Y_0^i) + \alpha_2 T R^i + \alpha_3 T Z^i + T\varepsilon^i. \tag{10}$$

We use the equation above to calculate the difference in expected income (for that reason the error terms are eliminated) between two scenarios labelled k and j. Both scenarios assume the same level of initial income, so that we abstract from any convergence impacts on long-term growth ($\Delta\ln(Y_0)=\ln(Y_0^j)-\ln(Y_0^k)=0$). On the other hand, these two scenarios differ in the level of the other explanatory variables and are, thus, distinguished by their own characteristics ($R^k;Z^k$) and ($R^j;Z^j$). This allows us to focus on income differences generated either by the resource-abundance factor or the vector of the other explanatory variables Z:

$$\mathrm{E}(\Delta\ln(Y_T)) = \alpha_2 T\,\Delta R + \alpha_3 T\,\Delta Z. \tag{11}$$

where $\Delta\ln(Y_t)=\ln(Y_t^j)-\ln(Y_t^k)$, $\Delta R=R^j-R^k$, and $\Delta Z=Z^j-Z^k$. To assess the long-term effects of R and Z on income, we assume ΔR and ΔZ constant over time, and we study propagation of income differences over time. After two periods of T years, income differences are equal to:

$$\mathrm{E}(\Delta\ln(Y_{2T})) = (\alpha_1 T+2))(\alpha_2 T\Delta R + \alpha_3 T\Delta Z). \tag{12}$$

After three periods, we have

$$E(\Delta \ln(Y_{3T})) = (1+(\alpha_1 T+1)+ (\alpha_1 T+1)^2))(\alpha_2 T\Delta R + \alpha_3 T\Delta Z) . \quad (13)$$

For $t \rightarrow \infty$ the first term on the right hand side reduces to

$$(1 + (\alpha_1 T+1) + (\alpha_1 T+1)^2 + (\alpha_1 T+1)^3 + \ldots) = 1/(1-(\alpha_1 T+1)) = -1/(\alpha_1 T). \quad (14)$$

and equation (2) follows.

Appendix 3: Growth Regressions as in Equation (1) for all 51 States

TABLE 7. *Growth regressions as in equation* (1) *for all 51 states*

Dependent variable: $G_{1986\text{-}2000}$	(16)	(17)	(18)	(19)	(20)
Constant	12.47	13.13	11.15	14.77	17.74
LnY_{86}	–1.00**	–1.03***	–0.87**	–1.26***	–1.58***
(0.25)	(–2.50)	(–2.85)	(–2.41)	(–3.15)	(–3.38)
Natural Resources		–5.28***	–4.29**	–2.93*	–1.94
(0.06)		(–3.27)	(–2.63)	(–1.70)	(–1.04)
Investment			0.25**	0.20*	0.24*
(0.78)			(2.11)	(1.67)	(1.94)
Schooling				0.43**	0.48**
(0.50)				(2.00)	(2.23)
Openness					0.83
(0.17)					(1.30)
R^2 adjusted	0.10	0.25	0.30	0.34	0.35
N	51	51	51	51	51

Note: Standard deviations for independent variables in parentheses, based on the sample *N*=51; t-statistics for coefficients in parentheses. Superscripts *, **, *** correspond to a 10, 5 and 1% level of significance.

Appendix 4: Transmission Channels with Initial Income as an Additional Explanatory Variable

TABLE 8. *Indirect transmission channels, estimation of equation* (6)

	Investment (21)	Schooling (22)	Openness (23)	R&D (24)	Corruption (25)
Constant	3.76	–3.98	–4.82	–5.92	1.90
Ln Y_{75}	–0.25	0.48	0.50***	0.74	0.08
(0.19)	(–0.44)	(1.61)	(4.76)	(1.06)	(0.06)
Natural Resources	–4.42**	–3.47***	–0.91***	–6.39***	5.93
(0.06)	(–2.29)	(–3.43)	(–2.55)	(–2.73)	(1.40)
R^2 adjusted	0.07	0.19	0.34	0.11	0.01
N	49	49	49	49	49

Note: t-statistics for coefficients in parentheses. Superscripts *, **, *** correspond to a 10, 5 and 1% level of significance.

Appendix 5: Two-Stage Least-Squares Estimation of Growth Regression (1)

TABLE 9. *2SLS regression of equation* (1) *with international migration in 1990 (Openness90) as an instrument for average Openness*

Panel A: Dependent variable: $G_{1986\text{-}2000}$	(26)
Constant	26.10
Ln Y$_{86}$	–2.39***
(0.19)	(–4.51)
Natural Resources	–0.63
(0.06)	(–0.36)
Investment	0.19
(0.78)	(1.53)
Schooling	0.31
(0.44)	(1.46)
Openness	0.88
(0.17)	(1.34)
R&D	0.12
(0.97)	(1.28)
Corruption	–0.11**
(1.65)	(–2.01)
R^2 adjusted	0.50
N	49

Panel B: Dependent variable: *Openness*	
Openness90	1.04***
(1.65)	(29.87)
R^2 adjusted	0.95
N	49

Note: Standard deviations for independent variables in parentheses, based on the sample *N*=49 of regression (7); t-statistics for coefficients in parentheses. Superscripts *, **, *** correspond to a 10, 5 and 1% level of significance.

Appendix 6: Relative Importance of Transmission Channels with Alternative Specifications

TABLE 10. *Relative importance of transmission channels. Specification* (6) *adopted for the Openness Channel and specification* (5) *for the rest.*

Transmission channels	α_3	β_1 (γ_2 for openness)	Contribution to the overall effect (column (14) of Table 3)*	Relative Contribution
Natural Resources			–0.14	3%
Investment	0.21	–4.45	–0.93	20%
Schooling	0.34	–3.32	–1.13	24%
Openness	1.28	–0.91	–1.16	25%
R&D	0.10	–6.16	–0.62	14%
Corruption	–0.11	5.96	–0.66	14%
Total			**–4.66**	**100%**

* The coefficient of resource-abundance after substituting equation (5) for openness and equation (6) for the rest of the transmission variables into (1).

TABLE 11. *Relative importance of transmission channels. Specification* (6) *adopted for all transmission channels.*

Transmission channels	α_3	γ_2	Contribution to the overall effect (column (15) of Table 3)*	Relative Contribution
Natural Resources			–0.14	3%
Investment	0.21	–4.42	–0.93	20%
Schooling	0.34	–3.47	–1.18	25%
Openness	1.28	–0.91	–1.16	25%
R&D	0.10	–6.39	–0.64	13%
Corruption	–0.11	5.93	–0.65	14%
Total			**–4.72**	**100%**

* The coefficient of resource-abundance after substituting equation (6) into (1)for all transmission variables.

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(lix) This paper was presented at the ENGIME Workshop on “Mapping Diversity”, Leuven, May 16-17, 2002

(lx) This paper was presented at the EuroConference on “Auctions and Market Design: Theory, Evidence and Applications”, organised by the Fondazione Eni Enrico Mattei, Milan, September 26-28, 2002

(lxi) This paper was presented at the Eighth Meeting of the Coalition Theory Network organised by the GREQAM, Aix-en-Provence, France, January 24-25, 2003

(lxii) This paper was presented at the ENGIME Workshop on “Communication across Cultures in Multicultural Cities”, The Hague, November 7-8, 2002

(lxiii) This paper was presented at the ENGIME Workshop on “Social dynamics and conflicts in multicultural cities”, Milan, March 20-21, 2003

(lxiv) This paper was presented at the International Conference on “Theoretical Topics in Ecological Economics”, organised by the Abdus Salam International Centre for Theoretical Physics - ICTP, the Beijer International Institute of Ecological Economics, and Fondazione Eni Enrico Mattei – FEEM Trieste, February 10-21, 2003

(lxv) This paper was presented at the EuroConference on “Auctions and Market Design: Theory, Evidence and Applications” organised by Fondazione Eni Enrico Mattei and sponsored by the EU, Milan, September 25-27, 2003

(lxvi) This paper has been presented at the 4th BioEcon Workshop on “Economic Analysis of Policies for Biodiversity Conservation” organised on behalf of the BIOECON Network by Fondazione Eni Enrico Mattei, Venice International University (VIU) and University College London (UCL) , Venice, August 28-29, 2003

(lxvii) This paper has been presented at the international conference on “Tourism and Sustainable Economic Development – Macro and Micro Economic Issues” jointly organised by CRENoS (Università di Cagliari e Sassari, Italy) and Fondazione Eni Enrico Mattei, and supported by the World Bank, Sardinia, September 19-20, 2003

(lxviii) This paper was presented at the ENGIME Workshop on “Governance and Policies in Multicultural Cities”, Rome, June 5-6, 2003

(lxix) This paper was presented at the Fourth EEP Plenary Workshop and EEP Conference “The Future of Climate Policy”, Cagliari, Italy, 27-28 March 2003

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