Papyrakis, Elissaios; Gerlagh, Reyer

Working Paper
Natural Resources, Innovation, and Growth

Nota di Lavoro, No. 129.2004

Provided in Cooperation with:
Fondazione Eni Enrico Mattei (FEEM)

Suggested Citation: Papyrakis, Elissaios; Gerlagh, Reyer (2004) : Natural Resources, Innovation, and Growth, Nota di Lavoro, No. 129.2004, Fondazione Eni Enrico Mattei (FEEM), Milano

This Version is available at:
http://hdl.handle.net/10419/117998

Terms of use:
Documents in EconStor may be saved and copied for your personal and scholarly purposes.
You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.
If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.
Natural Resources, Innovation, and Growth
Elissaios Papyrakis and Reyer Gerlagh

NOTA DI LAVORO 129.2004

OCTOBER 2004
NRM – Natural Resources Management

Elissaios Papyrakis and Reyer Gerlagh, IVM, Institute for Environmental Studies, Vrije Universiteit

This paper can be downloaded without charge at:
The Fondazione Eni Enrico Mattei Note di Lavoro Series Index:
http://www.feem.it/Feem/Pub/Publications/WPapers/default.htm
Social Science Research Network Electronic Paper Collection:
http://ssrn.com/abstract=609764

The opinions expressed in this paper do not necessarily reflect the position of
Fondazione Eni Enrico Mattei
Corso Magenta, 63, 20123 Milano (I), web site: www.feem.it, e-mail: working.papers@feem.it
Natural Resources, Innovation, and Growth

Summary
This paper investigates the connection between resource abundance and innovation, as a transmission mechanism that can elucidate part of the resource curse hypothesis; i.e. the observed negative impact of resource wealth on income growth. We develop a variation of the Ramsey-Cass-Koopmans model with endogenous growth to explain the phenomenon. In this model, consumers trade off leisure versus consumption, and firms trade off innovation efforts versus manufacturing. For this model, we show that an increase in resource income frustrates economic growth in two ways: directly by reducing work effort and indirectly by inducing a smaller proportion of the labor force to engage in innovation.

Keywords: Natural resources, Growth, Innovation

JEL Classification: O13, O31, Q33

Address for correspondence:

Elissaios Papyrakis
IVM/VU
Institute for Environmental Studies
Vrije Universiteit
De Boelelaan 1087
1081 HV Amsterdam
The Netherlands
Phone: +31 20 44 49502
Fax: +31 20 44 49553
E-mail: elissaios.papyrakis@ivm.vu.nl
1. **INTRODUCTION**

Recent empirical evidence and theoretical work provides strong support to a resource curse hypothesis; i.e. natural resource wealth tends to impede rather than promote economic growth (Auty 1994, Sachs and Warner 1995, 1997, 1999a, 1999b, Leite and Weidmann 1999, Rodriguez and Sachs 1999, Gylfason 2000, 2001a, 2001b, Papyrakis and Gerlagh 2004). The expectations of many early development economists (Nurkse 1953, Rostow 1960, Watkins 1963) that natural capital would be an important pillar to build economic development proved at odds with outcomes. Resource riches such as oil reserves, fish banks and fertile land became associated with a slowdown in economic growth across the world during the last three decades. One of the most striking examples and manifests of the resource curse hypothesis is the disappointing performance of the oil cartel countries. Over the last four decades, the OPEC countries as a whole experienced a negative rate of GDP per capita growth (Gylfason 2001b). Venezuela ranked among the ten wealthiest nations at the beginning of 19th century, but despite its vast oil reserves, it is downgraded to the level of a developing country (Jones 2002). Similarly, Alaska is the only U.S. state with a negative growth rate over the last two decades, despite its extensive oil reserves and fishing industry.

Several theories have been developed and tested to explain the resource curse paradox. The main focal point of these analyses lies in the crowding-out effects of resource wealth, as resource wealth decreases the perceived need for growth supporting policies, prudent long-term planning and efficient management of available resources (Ascher 1999, Auty 2001, Gylfason 2001b, Usui 1997). Resource abundance retards economic growth by crowding-out its determinants (Sachs and Warner 2001). Resource rich countries tend to suffer from

The scope of this paper is on a crowding out effect of resource abundance mostly neglected in the literature: the crowding out of innovation or entrepreneurship. Sachs and Warner (2001) point out that wage premia in the resource sector may encourage innovators to engage in the primary rather than the R&D sector, but they do not further develop this idea. Since ultimately, technological progress and the discovery of new ideas and inventions drive growth, the effect of natural resources on R&D deserves particular attention. We develop a variation of the Ramsey-Cass-Koopmans model with endogenous growth, where individuals trade off consumption and leisure in terms of utility. We show that an increase of the resource base in the economy induces a reduction in the steady-state labor supply. Resource rents allow individuals to reduce their work effort (and related disutility) and use the resource revenues to pay for extra consumption. We show that the subsequent decline in labor intensity has two successive implications for economic growth. First, resource abundance reduces the total hours worked and total output. Secondly, resource abundance affects growth indirectly by inducing a smaller proportion of the labor force to engage in innovation.

The paper is organized as follows. Section 2 provides empirical evidence to the negative correlation between resource-abundance and different measures of innovation. Section 3 is devoted to a formal description of the endogenous growth Ramsey-Cass-Koopmans model,
while section 4 derives the dynamic equilibrium and main propositions linking resource abundance to poor economic performance. Section 5 concludes.

2. **Empirical Evidence: Resource-Abundance and Innovation**

Figures 1 to 4 show scatter plots that illustrate the correlation between different measures of innovation and natural wealth. Data on R&D expenditures are provided by the United Nations (2002). Natural wealth is defined as the share of natural capital in the total capital stock, calculated by the World Bank (1997). The estimated regression line and adjusted $R^2$ is quoted at the right-top corner of each scatter plot. Although earlier observations on natural capital would be preferable in order to avoid endogeneity of the independent variable, 1994 is the only year for which data on natural capital are available. Gylfason (2001) argues that the share of natural capital is still a good proxy for resource-abundance, since it is rather stable over time. Indeed, the results in all figures can be reproduced by using alternative measures of resource abundance, such as the Sachs and Warner (1995) measure of the share of primary exports in GDP in 1971 or the share of agricultural production in GDP for the same year.

Figure 1 shows a cross-country scatter plot of 42 observations (single countries) relating R&D expenditure as a share of GDP between 1990-2000 and the World Bank measure of natural wealth. The negative relationship between the two variables is significant at the 1% level. As can be seen, there is not a single country with a natural capital share above 10% having a share of R&D expenditures above the 2% level.
Figure 1. **Resource-Abundance and R&D Expenditure (Cross-country Sample)**

Figure 2 demonstrates a similar pattern between resource abundance and innovation for a sample of 52 countries. As a measure of innovation, we now consider the numbers of researchers and engineers employed in the R&D sector. Data on R&D employees are provided by the United Nations (2002). The scatter plot indicates a highly significant correlation between natural resources and employees in the R&D sector. The Central African Republic and Guinea-Bissau have a share of natural capital around 30 and 40%, respectively, and can be seen at the bottom-right side of the scatter plot having almost no researchers and engineers employed in the R&D sector.
Figure 2. Resource-Abundance and R&D Employees

Figure 3 focuses on the number of patents granted in 1998 as a proxy for innovation. Whereas Figures 1 and 2 measured innovation based on available data on the inputs needed in the R&D sector, Figure 3, instead, examines a proxy for the output of R&D. Data on patents are provided by the United Nations (2002). The scatter plot reveals again a negative statistical relationship between innovation measured as patents and resource abundance for a sample of 31 countries. The two countries with the highest number of patents granted were the resource scarce countries Japan and South Korea.
Finally, we turn from a cross-country to a cross-state comparison within the US. As a measure of resource abundance we use the share of the primary sector’s production in Gross State Product (GSP), which is the state equivalent to GDP. As a proxy for innovation we use the share of R&D expenditures in GSP. Data on natural resources and R&D are compiled from the Bureau of Economic Analysis (2003) of the U.S. Ministry of Commerce and the Industry, Research and Development System (IRIS) of the National Science Foundation (2003), respectively. Figure 4 shows that the negative correlation between resource abundance and innovation carries over to the state level. We notice that Alaska and Wyoming have the most extensive primary sectors in the U.S. and the lowest amount of funds allocated to research.
Figure 4. Resource-Abundance and R&D Expenditure (Cross-state Sample for the U.S.)

The figures above demonstrate a tendency of resource-abundant countries and states to innovate less. We should, though, keep in mind that it is likely that our data underestimate the magnitude of the negative correlation between natural resources and innovation. Most resource abundant countries are relatively poor and do not provide data for any R&D activities. Therefore, many resource abundant countries are excluded from the samples. Secondly, not all ideas are patented. To the extent that some ideas are not patented or not produced in the R&D sector, some innovation is not captured by our dataset. Furthermore, the people engaged in R&D are not equally productive and talented nor are all patents of the same value. Therefore, our data measure innovation in a rather quantitative than qualitative manner.
3. MODEL SET UP

3.1. Consumers

In this section we analyze a Ramsey-Cass-Koopmans type of model, where infinitely-living households choose over time both the level of consumption and the share of time devoted to leisure in order to maximize their intertemporal utility. We also incorporate in our analysis an endogenous growth channel, where returns to technology investments (which can alternatively be conceived as knowledge or labor quality) depend positively on the level of labor input in the economy. The intuition is straightforward. Innovation and education become more productive when work effort increases. In other words, the harder we work, the more efficient, innovative and knowledgeable we become.

We assume that the economy consists of identical infinitely-lived agents. Population $N(t)$ remains constant at each point in time. Thus,

$$N(t) = N. \quad (1)$$

For the type of model we employ, a stable population level is a convenient assumption that precludes an ever-increasing growth rate for income per capita and allows the economy to converge to a balanced growth path.

Individuals divide their available time between work and leisure. A proportion $l(t)$ of their time is devoted to work and the rest to leisure activities. Therefore, the level of labor input $L(t)$ in the economy is determined respectively by:

$$L(t) = l(t)N. \quad (2)$$
Each representative household maximizes the following inter-temporal utility function:

\[ U = \int_{0}^{\infty} u[c(t), l(t)]e^{-\rho t} dt , \]  

(3)

where \(c(t) = C(t)/N\) denotes consumption per person at time \(t\), \(C(t)\) stands for total consumption, \(\rho\) is the rate of time preference and it is assumed to be time-invariant and positive, implying that agents value future utility less comparatively to current utility. Thus, \(U(t)\) is a weighted sum of all future discounted utility flows \(u[c(t), l(t)]\), where \(u[c(t), l(t)]\) represents the instantaneous utility function (also referred to as felicity function) of each agent at a given date.

We assume that the instantaneous utility function \(u[c(t), l(t)]\) is separable with respect to its two arguments and depends positively on the consumption level \(c(t)\) and negatively on the work intensity \(l(t)\). In other words, we assume that there is a disutility of working effort and agents obtain satisfaction from leisure activities. For convenience, we assume a logarithmic consumption utility function and a labor disutility function with constant elasticity \(\sigma\). Also, we omit any time references for the rest of the analysis, unless there is need for clarification.

\[ u(c, l) = \ln c - l^{1+\sigma}. \]  

(4)

Each household faces the following budget constraint when maximizing utility:

\[ \dot{v} = w\dot{l} + \frac{Q}{N} + r\dot{v} - c , \]  

(5)
where \( v = V/N \) stands for total value of assets hold per person, the dot denotes the derivative over time, \( wl \) and \( Q/N \) stand for wage and resource income per person, and \( r \) for the real interest rate obtained per unit of asset value. Each household, thus, maximizes utility subject to the budget constraint of equation (5). Therefore, we set up the following Hamiltonian:

\[
H = \int_0^\infty (\ln c - I^{1+\sigma})e^{-\rho t} + \mu [wl + Q/N + rv - c].
\]  

(6)

The first order conditions with respect to the control variables \( c \) and \( l \) and the dual variable \( \mu \) lead to the Ramsey Rule (7) and equation (8), which describe the evolution of consumption over time and the substitution possibilities between consumption and leisure respectively:

\[
\frac{\dot{c}}{c} = r - \rho
\]  

(7)

\[
(1+\sigma)l^\sigma/c = w
\]  

(8)

3.2. Producers

It is assumed that there are four sectors in our economy. First, there is a manufacturing sector with constant returns to scale with respect to its inputs labor and intermediates. The price of the final good produced in the manufacturing sector is normalized to unity. Following Romer (1990), we adopt the conventional specification of a continuum of intermediate capital goods, indexed by \( i \in [0,A] \). Each intermediate capital good \( i \) represents a distinctive design, and the amount of designs \( A \) measures the total stock of knowledge. All designs are imperfect
substitutes, the level of substitution captured by a parameter $0 < \alpha < 1$. Together, this leads to the following Cobb-Douglas production function for the manufacturing sector:

$$Y_M = (\gamma L)^{1-\alpha} \int_0^\beta x_i^\alpha di,$$  

(9)

where $0 < \gamma < 1$ is the share of laborers working in the manufacturing sector, and $x_i$ is the input of capital of type $i$.

Firms in the manufacturing sector produce competitively and choose the level of labor and intermediate capital goods that maximize their profits:

$$\max_{L, x_i} \gamma L^{1-\alpha} \int_0^\beta x_i^\alpha di - w L - \int_0^\beta p_i x_i di,$$  

(10)

where $w$ and $p_i$ denote the labor wage (in the manufacturing sector) and the price of durable good $i$, respectively. The first order conditions imply that each firm in the manufacturing sector faces the following demand for labor and durable goods:

$$w = (1-\alpha)(\gamma L)^\alpha \int_0^\beta x_i^\alpha di = \frac{(1-\alpha)Y_M}{\gamma L}$$  

(11)

$$p_i = \alpha(\gamma L)^{1-\alpha} x_i^{\alpha-1}$$  

(12)

The first order conditions, given by equations (11) and (12), illustrate that firms pay labor and capital the value of their marginal products.

Secondly, there is a capital goods sector, where all capital intermediates are produced. Every durable good $x_i$ is produced by a distinct firm using a distinct patent (idea). This implies
that all manufacturers of intermediate goods can exert monopolistic power, since their goods are imperfect substitutes, whose characteristics are determined by a specific design. Patent and copyright laws are allowing the specific firm that purchases and owns the design to use exclusively the corresponding idea and produce the related intermediate good. After incurring the fixed cost of innovation or the design purchase, each firm in the intermediate sector produces each durable good proportional to its capital input. In this way, intermediates can also be understood as durables, implying that $K = \int_0^A x_i \, di$, where $K$ is a measure of the total capital stock.

Firms producing in the intermediate-goods sector buy the ownership for a design at price $P_A$, and after incurring the fixed cost of the design purchase, maximize profits $\pi$:

$$\max_{x_i} \pi_i = p_i(x_i)x_i - rx_i,$$  \hspace{1cm} (13)

where $p_i(x_i)$ is the demand function for each durable good from the side of the manufacturing sector firms, as shown in equation (12). Therefore, $p_i(x_i)x_i$ equals the revenues of each firm operating in the intermediate-goods sector. The second part of the maximization represents the interest cost firms face when producing each durable good $x_i$. As stated above, each firm in the intermediate sector transforms one unit of raw capital into one unit of intermediate good.

The first order condition with respect to $x_i$ provides us with:

$$\frac{dp_i(x_i)}{dx_i}x_i + p_i(x_i) = r,$$
and after taking account of the demand function for durables (12), we can see that the monopoly price of each durable good is a mark up over marginal cost that is equal for every design:

\[ p_i = p = r/\alpha \]  

(14)

As equation (14) reveals, all intermediate capital goods sell at the same price. Since the demand function (12) refers to each individual intermediate good produced, equation (14) implies that each durable good is purchased and employed by the manufacturing sector by the same amount \( x \). Therefore, we have:

\[ K = \int_0^A x_i dt = Ax \]  

(15)

The profits make the ownership of a design a valuable asset with price \( P_A \), and, as such, they constitute a return to this asset value:

\[ rP_A = \pi + \dot{P}_A. \]  

(16)

On a balanced growth path, the equation simplifies to \( rP_A = \pi \).

Third, we assume an R&D sector where designs for new intermediate goods are produced as in Romer (1990). This sector adds to the knowledge base. It employs a fraction \( 1 - \gamma \) of the labor input, which is the remainder of the labor force not employed in the manufacturing sector. The production function of knowledge has constant returns to scale with respect to labor. This specification abstracts from duplication of effort; nor is there a positive spillover
between researchers in the R&D sector. Furthermore, the production of designs depends positively on the stock of knowledge already discovered, on a one-to-one base. This implies that the growth rate of innovation (the rate of design accumulation) is independent of the level of knowledge. The stock of knowledge is freely available to all researchers in the R&D sector as a public good, and this fosters innovation. Thus, designs evolve according to:

\[ \dot{A} = A(1 - \gamma)L. \]  

(17)

Knowledge is produced in the innovation sector, where labor earns its marginal value. Every design invented is sold to a firm in the intermediate-goods sector for a price \( P_A \). Marginal productivity of labor in the innovation sector thus becomes:

\[ w = AP_A. \]  

(18)

Last, we assume there is a resource sector exploiting the natural resource endowments of the economy (e.g. oil reserves, mines, fishing banks, timber etc.). The production of the resource sector \( Q \) depends on the resource endowment available \( G \) (for instance the oil reserves discovered or the stock of fish) and the stock of physical capital \( K \). The first component is obvious. The larger the resource base available, the larger is the potential to process and exploit the resource endowment. Resource booms make a larger amount of natural resources available for the resource sector to be exploited. The second component assumes that as a side effect of capital accumulation, natural resources are exploited more effectively. We take the simple proportional production function,
\[ Q(K, G) = GK. \] \hfill (19)

3.3. Closure

The production function for the manufacturing sector, after taking account of the capital-intermediate identity (15), becomes:

\[ Y_M = (\gamma L)^{1-a} A x^a = (A \gamma L)^{1-a} K^a \] \hfill (20)

Equation (20) reveals that production in manufacturing resembles the neoclassical Solow model. The commodity flows are closed by setting total output, or income, \( Y \), from the manufacturing and resource sectors, equal to consumption \( C \) plus capital accumulation \( \dot{K} \):

\[ Y = (A \gamma L)^{1-a} K^a + KG = C + \dot{K}. \] \hfill (21)

4. Analysis

4.1. Dynamic Equilibrium

In this sub-section, we determine the equations that govern the dynamics for consumption, the capital stock, labor supply and the share of labor involved in innovation.

First, we determine the share of labor employed in the manufacturing sector versus the innovations sector. We compare wages for labor employed in the innovation sector and manufacturing sector, and the rate of returns to the two assets, knowledge \( A \) and capital \( K \).
Labor arbitrage between the manufacturing and innovation sector ensures equal wages. Thus (11) and (18) make:

\[ AP_A = \frac{(1-\alpha)Y_M}{\gamma L} \]  

(22)

Next, we determine the level of the interest rate \( r \) for capital \( K \). From the demand function (14), we know that the interest rate is the product of the parameter \( \alpha \) and the durables price \( p \). After substituting for the price \( p \) from (12), the amount of each durable demanded and produced \( x \) from (15) and taking account of the production function in the manufacturing sector (9), we know that the level of interest rate \( r \) is proportional to the ratio of the manufactured output to capital:

\[ r = \alpha^2 \frac{Y_M}{K}. \]  

(23)

We then proceed to calculate the interest earned on knowledge.

The immediate profits of each firm in the intermediate-goods sector can be calculated by incorporating equations (12), (14) and (15) into (13):

\[ \pi_i = \pi = \alpha(1-\alpha)(\gamma L)^{1-\alpha} x^\alpha = \alpha(1-\alpha) \frac{Y_M}{A} \]  

(24)

Taking account of equations (24) and (16) determining the price of patents \( P_A \) and the level of monopolistic profits \( \pi \), in balanced growth, equation (22) becomes:

\[ r = \alpha \gamma L. \]  

(25)
After incorporating equation (23) into (25), we can express the share of the labor input engaged into the manufacturing sector in terms of the ratio of the output (in manufacturing) to capital:

$$\gamma = \frac{\alpha Y_M}{L K} = \frac{\alpha Y_M}{lN K}$$  \hspace{1cm} (26)

For the analysis of dynamics, it is useful to write equations in intensive forms. From equation (21), we can derive the intensive form of total income in the economy by dividing the left-hand-side by labor in effective terms $AL$:

$$\hat{y} = \gamma^{1-\alpha} \hat{k} + Gk,$$  \hspace{1cm} (27)

where lower letter variables with hats denote variables expressed relative to effective labor supply, $\hat{y} = K/AL$, $\hat{k} = K/AL$, $\hat{c} = C/AL$.

Substituting for the output in the manufacturing sector from equation (20) into (23) allows us to express the interest rate in terms of capital per effective labor,

$$r = \alpha \hat{k}^{\alpha-1} \gamma^{1-\alpha},$$  \hspace{1cm} (28)

and the share of laborers in the manufacturing sector from (26) as

$$\gamma = \left(\frac{\alpha}{lN}\right)^{\frac{1}{\alpha}} \hat{k}^{\frac{\alpha-1}{\alpha}}.$$  \hspace{1cm} (29)

We rewrite equation (7) in its intensive form, and substitute (17) and (28):
\[
\frac{\dot{c}}{c} = r - \rho - \frac{A}{A} \frac{\dot{l}}{l} = \alpha^2 k^{\alpha-1} \gamma^{1-\alpha} - \rho - (1-\gamma)lN - \frac{l}{l}. \tag{30}
\]

Subsequently, we rewrite equation (21) in its intensive form substituting (27):

\[
\frac{\dot{k}}{k} = \gamma^{1-\alpha} k^{\alpha-1} + G - \frac{c}{k} - \frac{l}{l} (1-\gamma)lN. \tag{31}
\]

These two equations show that consumption and capital dynamics depend on labor supply dynamics. To solve for \(\dot{l}/l\), we first express the level of labor wage in terms of capital per labor \(k\). From equation (11) and (20), we can calculate:

\[
w = (1-\alpha)k^a \gamma^{-a} A^{1-a}. \tag{32}
\]

Combining equations (8) and (32), provides us with the following equation:

\[
(1+\sigma)l^\sigma c = (1-\alpha)k^a \gamma^{-a} A^{1-a}, \tag{33}
\]

which can be expressed in terms of effective labor as:

\[
(1+\sigma)l^{\sigma+\alpha} \hat{c} = (1-\alpha)k^a \gamma^{-a}. \tag{34}
\]

Together, we have four equations that determine the dynamics for \(\hat{c}\) (30), \(\hat{k}\) (31), and the levels of \(\gamma\) (29) and \(l\) (34). For use in the steady state analysis, we also derive equations that describe the labor supply \(l\) and use \(\gamma\) dynamics. Equation (34) implies that \(l\) evolves according to:
\[
\frac{\dot{l}}{l} = \frac{\alpha - 1}{\alpha} \frac{\dot{k}}{k} - \frac{1}{\alpha c} \frac{\dot{c}}{c} - \frac{\alpha \gamma}{1 + \sigma \gamma}
\]  \hspace{2cm} (35)

From equation (29) we can see that \(\gamma\) evolves according to:

\[
\frac{\dot{\gamma}}{\gamma} = \frac{\alpha - 1}{\alpha} \frac{\dot{k}}{k} - \frac{1}{\alpha l} \frac{\dot{l}}{l}
\]  \hspace{2cm} (36)

Combining equations (35) and (36), we see that \(l\) evolves according to:

\[
\frac{\dot{l}}{l} = \frac{1}{\sigma} \left( \frac{\dot{k}}{k} - \frac{\dot{c}}{c} \right)
\]  \hspace{2cm} (37)

4.2. Steady State

Along a balanced growth path, capital \(K\), consumption \(C\), output \(Y\) and technology \(A\) grow at the same rate, which implies that the levels of \(\hat{k}, \hat{c}\) and \(\hat{y}\) remain constant along the path. It can be seen from equations (36) and (37) that the working intensity \(l\) and the labor input share \(\gamma\) remain constant as well. Therefore, along the balanced growth path equations (30) and (31) become:

\[
\alpha^2 k_{ss} \gamma_{ss}^{1-\alpha} - \rho - (1-\gamma_{ss}) l_{ss} \neq 0
\]  \hspace{2cm} (38)

\[
\gamma_{ss}^{1-\alpha} k_{ss} + G - \frac{c_{ss}}{k_{ss}} -(1-\gamma_{ss}) l_{ss} \neq 0
\]  \hspace{2cm} (39)
where the subscript SS denotes the steady-state value of each variable along the balanced growth path.

Equations (29) and (34) evaluated at the steady-state, give the following levels for labor supply $l$ and the share of laborers employed in innovation,

$$(1 + \sigma)l_{ss}^{1+\sigma}c_{ss} = (1 - \alpha)k_{ss}\gamma_{ss}^{-\alpha},$$  

$$\gamma = \left(\frac{\alpha}{l_{ss}N}\right)^{1+\sigma} = \left(\frac{\alpha}{l_{ss}k_{ss}}\right)^{1+\sigma}.$$  

Along with equations (38) and (39), these two equations constitute a system of four equations depending on the four steady-state levels $\hat{c}_{ss}$, $\hat{k}_{ss}$, $l_{ss}$ and $\gamma_{ss}$. Substitution of these four equations produces one equation linking resource income to labor supply $l_{ss}$:

$$G = \rho \frac{1 + \alpha}{1 + \alpha N} \frac{N}{\alpha} + \frac{1 - \alpha}{1 + \sigma} l_{ss}^{1+\sigma} - \frac{1 + \alpha}{1 + \alpha N} N^2 (1 - \alpha)l_{ss}^{1-\sigma}$$  

The right-hand-side of equation (42) is strictly decreasing in labor supply, $l_{ss}$, so that there is only one steady-state value, and we can derive that

$$\frac{dl_{ss}}{dG} = \left[-\sigma \frac{1 - \alpha}{1 + \sigma} l_{ss}^{1-\sigma} - \frac{1 + \alpha}{1 + \alpha N} N^2 (1 - \alpha)\right]^{-1} < 0$$  

This shows that an increase in resource abundance as captured by $G$ results in a decrease of labor intensity at the steady state. Individuals trade off consumption and leisure in terms of
utility. An increased amount of resource wealth gives them the opportunity to enjoy the same level of utility for a reduced labor effort. In other words, resource abundance increases leisure and reduces man-made output. We state this finding as the first proposition:

**PROPOSITION 1.** The steady state level of labor supply $l_{ss}$ is decreasing in the resource base $G$. 

The rate of knowledge accumulation at the steady-state is given by equation (17). We label the steady state rate of knowledge accumulation by $\chi_{ss} = (\dot{A}_{ss} / A_{ss})$, 

$$\chi_{ss} = (1-\gamma_{ss})l_{ss}N$$  \hspace{1cm} (44)

From equations (41) and (51), in the appendix, we derive the ratio of the labor force engaged in the R&D sector $(1-\gamma_{ss})$:

$$1-\gamma_{ss} = 1 - \frac{N + \rho l_{ss}^{-1}}{1 + \alpha N}$$  \hspace{1cm} (45)

Equation (45) implies that a decrease in labor intensity at the steady-state due to an increase in resource endowments, as indicated by equation (43), decreases the ratio of the labor force engaged in the R&D sector. Therefore, the accumulation of knowledge decreases for two reasons. First, the reduction in labor intensity directly retards knowledge accumulation. Secondly, the decrease in labor intensity reduces the rate of knowledge accumulation indirectly by lowering the percentage of the labor force engaged in the R&D sector. From
equation (44), we can see that technological progress depends negatively on the level of resource endowments (both directly and indirectly):

\[
\frac{d\chi_{ss}}{dG} = \left( (1 - \gamma_{ss})N + \frac{\rho}{(1 + \alpha N)l_{ss}} \right) \frac{dl_{ss}}{dG} < 0, \tag{46}
\]

where the derivative \( \frac{dl_{ss}}{dG} \) is negative from equation (43).

Therefore, a resource-abundant country with a large natural resource base \( G \) will experience a lower labor intensity \( l_{ss} \) at the steady state and a lower rate of knowledge accumulation \( \chi_{ss} \). The economy will grow at a slower pace. This is our major finding:

**Proposition 2. Steady state economic growth \( \chi_{ss} \) is decreasing in the resource base \( G \).**

5. **Conclusions**

During the past decades, economists tried to explain why resource abundant countries embark on a development path that leads to stagnation and economic decline rather than affluence and prosperity. Resource wealth did not prove to be the panacea to underdevelopment. On the contrary, resource dependence exacerbated poverty and retarded economic growth over the past three decades. With a few exceptions, such as those of Botswana, Norway and Iceland, resource-abundant countries tend to belong to the list of development failures.
Several indirect mechanisms through which natural resources frustrate income growth have been identified in the literature. Resource wealth can deteriorate the terms of trade, reduce human capital accumulation, increase corruption and rent-seeking, increase public spending and result in political instability. In this paper, we investigate a transmission channel not extensively discussed in the literature: the relationship between resource abundance and innovation. Innovation is undoubtedly one of the main determinants of economic growth, by enhancing the productivity of labor and capital. The pursuit of innovators for new ideas and designs is motivated by their interest in profiting from them. In our model, natural resources reduce the incentives of innovators to engage in R&D. This happens for two reasons. First, the discovery of resource reserves reduces the need to support consumption through labor income and therefore increases leisure and reduces work effort. Secondly, resource wealth negatively affects the allocation of entrepreneurial activity between the manufacturing and the R&D sector in favor of the former.

Extensions of the analysis should take into account the possibility that work effort may also be allocated in the primary sector, as suggested by Sachs and Warner (2001). In this case, the share of the labor force employed as researchers in the R&D sector will be directly affected by the amount of resource rents, rather than indirectly (through labor intensity) as happens in our model. Furthermore, a more extensive database should identify the correlation between resource abundance and innovation for a more extensive sample of countries and potentially disentangle the effect of natural resources into its components. It is possible that specific categories of natural resources, such as minerals and ores have stronger (or weaker) crowding-out effect on innovation than others.
Incorporating equation (41) into equations (38), (39) and (40) yields:

$$\frac{a-1}{l_{ss}^a} \frac{a-1}{k_{ss}^a} \left( \frac{\alpha}{N} \right)^{\frac{1}{a}} (1 + \alpha N) - \rho - l_{ss} N = 0, \quad (47)$$

$$\frac{a-1}{l_{ss}^a} \frac{a-1}{k_{ss}^a} \left( \frac{\alpha}{N} \right)^{\frac{1}{a}} (1 + \alpha) + G - \frac{c_{ss}}{k_{ss}} - l_{ss} N = 0, \quad \text{and} \quad (48)$$

$$\hat{c}_{ss} = \frac{N(1-\alpha)}{\alpha(1+\sigma)} l_{ss}^a k_{ss}. \quad (49)$$

Incorporating equation (49) into (48) yields:

$$\frac{a-1}{l_{ss}^a} \frac{a-1}{k_{ss}^a} \left( \frac{\alpha}{N} \right)^{\frac{1}{a}} (1 + \alpha) + G - \frac{1-\alpha}{1+\sigma} \left( \frac{\alpha}{N} \right)^{\frac{1}{a}} l_{ss}^a - l_{ss} N = 0. \quad (50)$$

Rearranging equation (47) yields:

$$\hat{k}_{ss}^a = (\rho + l_{ss} N) \left( \frac{\alpha}{N} \right)^{\frac{1}{a}} (1 + \alpha N)^{-\frac{1}{a}} l_{ss}^a. \quad (51)$$

Incorporating equation (51) into (50) solves for the steady-state value of labor intensity in equation (42).
REFERENCES


<table>
<thead>
<tr>
<th>NOTE DI LAVORO PUBLISHED IN 2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRIV 2.2003 Ilija SCHINDELE: Theory of Privatization in Eastern Europe: Literature Review</td>
</tr>
<tr>
<td>PRIV 3.2003 Wietze LISE, Claudia KEMFERT and Richard S.J. TOL: Strategic Action in the Liberalised German Electricity Market</td>
</tr>
<tr>
<td>KNOW 5.2003 Reyer GERLAGH: Induced Technological Change under Technological Competition</td>
</tr>
<tr>
<td>ETA 6.2003 Efrem CASTELNUOVO: Squeezing the Interest Rate Smoothing Weight with a Hybrid Expectations Model</td>
</tr>
<tr>
<td>SIEV 7.2003 Anna ALBERINI, Alberto LONGO, Stefania TONIN, Francesco TROMBETTA and Margherita TURVANI: The Role of Liability, Regulation and Economic Incentives in Brownfield Remediation and Redevelopment: Evidence from Surveys of Developers</td>
</tr>
<tr>
<td>NRM 8.2003 Eliassios PAPYRAKIS and Reyer GERLAGH: Natural Resources: A Blessing or a Curse?</td>
</tr>
<tr>
<td>CLIM 9.2003 A. CAPARRÓS, J.-C. PEREAU and T. TAZDAÏT: North-South Climate Change Negotiations: a Sequential Game with Asymmetric Information</td>
</tr>
<tr>
<td>KNOW 10.2003 Giorgio BRUNELLO and Daniele CHECCHI: School Quality and Family Background in Italy</td>
</tr>
<tr>
<td>CLIM 11.2003 Efrem CASTELNUOVO and Marzio GALEOTTI: Learning By Doing vs Learning By Researching in a Model of Climate Change Policy Analysis</td>
</tr>
<tr>
<td>KNOW 12.2003 Carole MAIGNAN, Gianmarco O. OTTAVIANO and Dino PINELLI (eds.): Economic Growth, Innovation, Cultural Diversity: What are we all talking about? A critical survey of the state-of-the-art</td>
</tr>
<tr>
<td>KNOW 15.2003 Tuzin BAYCAN LEVENT, Enno MASUREL and Peter NIJKAMP (lix): Diversity in Entrepreneurship: Ethnic and Female Roles in Urban Economic Life</td>
</tr>
<tr>
<td>KNOW 16.2003 Alexandra BITUSIKOVA (lx): Post-Communist City on its Way from Grey to Colourful: The Case Study from Slovakia</td>
</tr>
<tr>
<td>KNOW 17.2003 Billy E. VAUGHN and Katarina MLEKOV (lx): A Stage Model of Developing an Inclusive Community</td>
</tr>
<tr>
<td>KNOW 18.2003 Selma van LONDON and Arie de RUIJTER (lx): Managing Diversity in a Glocalizing World</td>
</tr>
<tr>
<td>PRIV 20.2003 Giacomo CALZOLARI and Alessandro PAVAN (lx): Monopoly with Resale</td>
</tr>
<tr>
<td>PRIV 22.2003 Marco LiCalzi and Alessandro PAVAN (lx): Tilting the Supply Schedule to Enhance Competition in Uniform-Price Auctions</td>
</tr>
<tr>
<td>PRIV 23.2003 David ETTINGER (lx): Bidding among Friends and Enemies</td>
</tr>
<tr>
<td>PRIV 24.2003 Hannu VARTIAINEN (lx): Auction Design without Commitment</td>
</tr>
<tr>
<td>PRIV 26.2003 Christine A. PARLOUR and Uday RAJAN (lx): Rationing in IPOs</td>
</tr>
<tr>
<td>PRIV 27.2003 Kjell G. NYBORG and Ilya A. STREBULAIEV (lx): Multiple Unit Auctions and Short Squeezes</td>
</tr>
<tr>
<td>PRIV 28.2003 Anders LUNANDER and Jan-Eric NILSSON (lx): Taking the Lab to the Field: Experimental Tests of Alternative Mechanisms to Procure Multiple Contracts</td>
</tr>
<tr>
<td>PRIV 30.2003 Emiel MAASLAND and Sander ONDERSTAL (lx): Auctions with Financial Externalities</td>
</tr>
<tr>
<td>ETA 31.2003 Michael FINUS and Bianca RUNDHAGEN: A Non-cooperative Foundation of Core-Stability in Positive Externality NTU-Coalition Games</td>
</tr>
<tr>
<td>KNOW 32.2003 Michele MORETTO: Competition and Irreversible Investments under Uncertainty</td>
</tr>
<tr>
<td>PRIV 33.2003 Philippe QUIRION: Relative Quotas: Correct Answer to Uncertainty or Case of Regulatory Capture?</td>
</tr>
<tr>
<td>KNOW 34.2003 Giuseppe MEDA, Claudio PIGA and Donald SIEGEL: On the Relationship between R&amp;D and Productivity: A Treatment Effect Analysis</td>
</tr>
<tr>
<td>ETA 35.2003 Alessandra DEL BOCA, Marzio GALEOTTI and Paola ROTA: Non-convexities in the Adjustment of Different Capital Inputs: A Firm-level Investigation</td>
</tr>
</tbody>
</table>
NOTE OF LAVORO PUBLISHED IN 2004

IEM 1.2004 Anil MARKANDYA, Suzette PEDROSO and Alexander GOLUB: Empirical Analysis of National Income and So2 Emissions in Selected European Countries

ETA 2.2004 Masaehisa Fujiita and Shlomo WEBER: Strategic Immigration Policies and Welfare in Heterogeneous Countries

PRA 3.2004 Adolfo DI CARLUCCIO, Giovanni FERRI, Cecilia FRALE and Ottavio RICCHI: Do Privatizations Boost Household Shareholding? Evidence from Italy

ETA 4.2004 Victor GINSBURGH and Shlomo WEBER: Languages Disenfranchisement in the European Union


PRA 7.2004 Sandro BRUSCO, Giuseppe LOPOMO and S. VISWANATHAN (Ixxv): Merger Mechanisms

PRA 8.2004 Wolfgang AUSSNEEGG, Pegaret PICHLER and Alex STOMPER (Ixxv): IPO Pricing with Bookbuilding, and a When-Issued Market

PRA 9.2004 Pegaret PICHLER and Alex STOMPER (Ixxv): Primary Market Design: Direct Mechanisms and Markets


PRA 11.2004 Bjarni BRENDSTRUP and Harry J. PAARSCH (Ixxv): Nonparametric Identification and Estimation of Multi-Unit, Sequential, Oral, Ascending-Price Auctions With Asymmetric Bidders

PRA 12.2004 Ohad KADAN (Ixxv): Equilibrium in the Two Player, k-Doubling Price Internet Auctions

PRA 13.2004 Maarten C.W. JANSSEN (Ixxv): Auctions as Coordination Devices

PRA 14.2004 Gadi FIBICH, Arieh GAVIOUS and Aner SELA (Ixxv): All-Pay Auctions with Weakly Risk-Averse Buyers

PRA 15.2004 Orly SADE, Charles SCHNITZLEIN and Jaime F. ZENDER (Ixxv): Competition and Cooperation in Divisible Good Auctions: An Experimental Examination

PRA 16.2004 Maria STRYSZOWSKA (Ixxv): Late and Multiple Bidding in Competing Second Price Internet Auctions

CCMP 17.2004 Slim Ben YOUSSEF: R&D in Cleaner Technology and International Trade


SIEV 19.2004 Anna ALBERINI, Paolo ROSATO, Alberto LONGO and Valentina ZANATTA: Information and Willingness to Pay in a Contingent Valuation Study: The Value of S. Erasmo in the Lagoon of Venice


NRM 21.2004 Jacqueline M. HAMILTON (Ixxvi): Climate and the Destination Choice of German Tourists

NRM 22.2004 Javier REY-MAJUEIRA PALMER, Javier LOZANO IBÁÑEZ and Carlos Mario GÓMEZ GÓMEZ (Ixxvi): Land, Environmental Externalities and Tourism Development

NRM 23.2004 Pius ODUNGA and Henk FOLMER (Ixxvi): Profiling Tourists for Balanced Utilization of Tourism-Based Resources in Kenya


NRM 26.2004 Juan Luis EUGENIO-MARTÍN, Noelia MARTÍN MORALÉS and Riccardo SCARPA (Ixxvii): Tourism and Economic Growth in Latin American Countries: A Panel Data Approach

NRM 27.2004 Raúl Hernández MARTÍN (Ixxviii): Impact of Tourism Consumption on GDP. The Role of Imports


NRM 29.2004 Marian WEBER (Ixxvii): Assessing the Effectiveness of Tradable Landuse Rights for Biodiversity Conservation: an Application to Canada's Boreal Mixedwood Forest

NRM 30.2004 Trond BJØRNDARL, Phoebe KOUNDOURI and Sean PASCOE (Ixxviii): Output Substitution in Multi-Species Trawl Fisheries: Implications for Quota Setting


CTN 33.2004 Wilson PEREZ: Divide and Conquer: Noisy Communication in Networks, Power, and Wealth Distribution


ETA 39.2004 Alberto CAVALIERE: Price Competition with Information Disparities in a Vertically Differentiated Duopoly

PRA 40.2004 Andrea BIGANO and Stef PROOST: The Opening of the European Electricity Market and Environmental Policy: Does the Degree of Competition Matter?

CCMP 41.2004 Micheal FINUS (Ixxix): International Cooperation to Resolve International Pollution Problems

KTHC 42.2004 Francesco CRESPI: Notes on the Determinants of Innovation: A Multi-Perspective Analysis
Sergio CURRARINI and Marco MARINI: Coalition Formation in Games without Synergies

Marc ESCRIVUELA-FILLAR: Cartel Sustainability and Cartel Stability

Sebastian BEROYETS and Nicolas GRAVEL: Using a Choice Experiment to Value Agricultural Biodiversity on Hungarian Small Farms: Agri-Environmental Policies in a Transition al Economy

Gernot KLEPPER and Sonja PETERSON: The EU Emissions Trading Scheme, Allowance Prices, Trade Flows, Competitiveness Effects

Scott BARRETT and Michael HOEL: Optimal Disease Eradication

Dinko DIMITROV, Peter BORM, Raul HENDRICKX and Shao CHIN SUNG: Simple Priorities and Core Stability in Hedonic Games

Francis BLOCH and Armando GOMES: Gains from a Heterogeneous Union


Ekin BIROL, Agnes GYOVAI and Melinda SMALE: Heterogeneous Agents: Implications for Equilibrium Assessment

Rabah AMIR, Effrosyni DIAMANTOUDI and Licun XUE: Merger Performance under Uncertain Efficiency Gains

CTN 43.2004

CTN 44.2004

NRM 45.2004

NRM 46.2004

NRM 47.2004

NRM 48.2004

CCMP 49.2004

CCMP 50.2004

GG 51.2004

CTN 52.2004

SIEV 53.2004

NRM 54.2004

NRM 55.2004

NRM 56.2004

CCMP 57.2004

CCMP 58.2004

NRM 59.2004

NRM 60.2004

CCMP 61.2004

NRM 62.2004

NRM 63.2004

CCMP 64.2004

CCMP 65.2004

E.C.M. RUIJGROK: Channels of Transmission of Environmental Policy to Economic Growth: A Survey of the Theory

Anna ALBERINI, Maureen CROPPER, Alan KRUPNICK and Nathalie B. SIMON: Willingness to Pay for Mortality Risk Reductions: Does Latency Matter?

Ingo BRAUER and Rainer MARGGRAF: The Formation of Networks with Transfers among Players

Valentina BOSETTI, Mariaester CASSINELLI and Alessandro LANZA: Using Data Envelopment Analysis to Evaluate Environmentally Conscious Tourism Management

Timo GOESCHL and Tuan LIN: Valuation of Ecosystem Services Provided by Biodiversity Conservation: An Integrated Hydrological and Economic Model to Value the Enhanced Nitrogen Retention in Renatured Streams

Timo GOESCHL and Tun LIN: Biodiversity Conservation on Private Lands: Information Problems and Regulatory Choices

Tom DEDEURWAERDERE: Bioprospection: From the Economics of Contracts to Reflexive Governance

Karin REHDOANZ and David MADISON: The Amenity Value of Climate to German Households

Koen SMEKENS and Bob VAN DER ZWAAN: Environmental Externalities of Geological Carbon Sequestration Effects on Energy Scenarios

Valentina BOSETTI, Mariaester CASSINELLI and Alessandro LANZA: Using Data Envelopment Analysis to Evaluate Environmentally Conscious Tourism Management

Timo GOESCHL and Danilo CAMARGO IGLIORI: Property Rights Conservation and Development: An Analysis of Extractive Reserves in the Brazilian Amazon

Barbara BUCHNER and Carlo CARRARO: Economic and Environmental Effectiveness of a Technology-based Climate Protocol

Elissaios PAPYRAKIS and Reyer GERLAGH: Resource-Abundance and Economic Growth in the U.S.

Györgyi BELA, György PATAKI, Melinda SMALE and Mariann HAJDÚ: Conserving Crop Genetic Resources on Smallholder Farms in Hungary: Institutional Analysis

E.C.M. RULIGROK and E.E.M. NILLESEN: The Socio-Economic Value of Natural Riverbanks in the Netherlands


Giannis YARDAS and Anastasios XEPAPADEAS: Uncertainty Aversion, Robust Control and Asset Holdings

Anastasios XEPAPADEAS and Constantina PASSA: Participation in and Compliance with Public Voluntary Environmental Programs: An Evolutionary Approach

Michael FINUS: Modesty Pays: Sometimes!

Trond BJØRNDAL and Ana BRASÍO: The Northern Atlantic Bluefin Tuna Fisheries: Management and Policy Implications

Alejandro CAPARRÓS, Abdelhakin HAMMOUDI and Tariq TAZDAÏT: On Coalition Formation with Heterogeneous Agents

Massimo GIOVANNINI, Margherita GRASSO, Alessandro LANZA and Matteo MANERA: Conditional Correlations in the Returns on Oil Companies Stock Prices and Their Determinants

Alessandro LANZA, Matteo MANERA and Michael MCALEER: Modelling Dynamic Conditional Correlations in WTI Oil Forward and Futures Returns

Margarita GENIUS and Elisabetta STRAZZERA: The Copula Approach to Sample Selection Modelling: An Application to the Recreational Value of Forests

Rob DELINK and Ekko van IERLAND: Pollution Abatement in the Netherlands: A Dynamic Applied General Equilibrium Assessment

Rosella LEVAGGI and Michele MORETTO: Investment in Hospital Care Technology under Different Purchasing Rules: A Real Option Approach

Salvador BARBERA and Matthew O. JACKSON: On the Weights of Nations: Assigning Voting Weights in a Heterogeneous Union

Alex ARENAS, Antonio CABRALES, Albert DÍAZ-GUILERA, Roger GUIMERA and Fernando VEGA-REDONDO: Optimal Information Transmission in Organizations: Search and Congestion

CTN 70.2004

IEM 71.2004

IEM 72.2004

SIEV 73.2004

CCMP 74.2004

ETA 75.2004

CTN 76.2004

NRM 77.2004

GG 78.2004

NRM 79.2004

NRM 80.2004

NRM 81.2004

SIEV 71.2004

SIEV 72.2004

E.C.M. RUIJGROK: The Northern Atlantic Bluefin Tuna Fisheries: Management and Policy Implications

Alejandro CAPARRÓS, Abdelhakin HAMMOUDI and Tariq TAZDAÏT: On Coalition Formation with Heterogeneous Agents

Massimo GIOVANNINI, Margherita GRASSO, Alessandro LANZA and Matteo MANERA: Conditional Correlations in the Returns on Oil Companies Stock Prices and Their Determinants

Alessandro LANZA, Matteo MANERA and Michael MCALEER: Modelling Dynamic Conditional Correlations in WTI Oil Forward and Futures Returns

Rosella LEVAGGI and Michele MORETTO: Investment in Hospital Care Technology under Different Purchasing Rules: A Real Option Approach

Salvador BARBERA and Matthew O. JACKSON: On the Weights of Nations: Assigning Voting Weights in a Heterogeneous Union

Alex ARENAS, Antonio CABRALES, Albert DÍAZ-GUILERA, Roger GUIMERA and Fernando VEGA-REDONDO: Optimal Information Transmission in Organizations: Search and Congestion

Francis BLOCH and Armando GOMES: Contracting with Externalities and Outside Options

Rabah AMIR, Effrosyni DIAMANTOUDI and Licun XUE: Merger Performance under Uncertain Efficiency Gains

CTN 77.2004

Francis BLOCH and Matthew O. JACKSON: The Formation of Networks with Transfers among Players

CTN 78.2004

CTN 79.2004

CTN 80.2004

CTN 81.2004
on the Islands of the Venice Lagoon: A Spatially-Distributed Hedonic-Hierarchical Approach

Economy

for Security of Energy Supply

and Public Policy Implications

Evidence from a Three-Country Contingent Valuation Study

Using Ecosystem Indicators: An Ecological Economics Perspective

in Transition Economies

Privatisation

in Italy

Cities. Centralisation versus devolution

CCMP

94.2004

Pierre-André JOUVET, Philippe MICHEL, and Gilles ROTILLON: Equilibrium with a Market of Permits

CCMP

95.2004

Bob van der ZWAAN and Reyer GERLAGH: Climate Uncertainty and the Necessity to Transform Global Energy Supply

CCMP

96.2004

Francesco BOSELLO, Marco LAZZARIN, Roberto ROSON and Richard S.J. TOL: Economy-Wide Estimates of the Implications of Climate Change: Sea Level Rise

CTN

97.2004

Siddhartha BANDYOPADHYAY and Mandar OAK: Party Formation and Coalitional Bargaining in a Model of Proportional Representation

GG

99.2004

Hans-Peter WEIZKAR, Michael FINUS and Juan-Carlos ALTAMIRANO-CABRERA: The Impact of Surplus Sharing on the Stability of International Climate Agreements

SIEV

100.2004

Chiara M. TRAVISI and Peter NIKAMP: Willingness to Pay for Agricultural Environmental Safety: Evidence from a Survey of Milan, Italy, Residents

SIEV

101.2004

Chiara M. TRAVISI, Raymond J. G. M. FLORAX and Peter NIKAMP: A Meta-Analysis of the Willingness to Pay for Reductions in Pesticide Risk Exposure

CCMP

102.2004

Valentina BOSETTI and David TOMBERLIN: Real Options Analysis of Fishing Fleet Dynamics: A Test

SIEV

103.2004

Alessandra GORIA e Gretel GAMBARELLI: Economic Evaluation of Climate Change Impacts and Adaptability in Italy

PRA

104.2004

Massimo FLORIO and Mara GRASSENLI: The Missing Shock: The Macroeconomic Impact of British Privatisation

PRA

105.2004

John BENNETT, Saul ESTRIN, James MAW and Giovanni URGA: Privatisation Methods and Economic Growth in Transition Economies

PRA

106.2004

Kira BÖRNER: The Political Economy of Privatization: Why Do Governments Want Reforms?

PRA

107.2004

Pehr-Johan NORBACK and Lars PERSSON: Privatization and Restructuring in Concentrated Markets

SIEV

108.2004

Angela GRANZOTTO, Fabio PRANOVI, Simone LIBRALATO, Patrizia TORRICELLI and Danilo MAINARNO: Competition between Artisanal Fishery and Manila Clam Harvesting in the Venice Lagoon by Using Ecosystem Indicators: An Ecological Economics Perspective

CTN

109.2004

Somdeb LAHIRI: The Cooperative Theory of Two Sided Matching Problems: A Re-examination of Some Results

NRM

110.2004

Giuseppe DI VITA: Natural Resources Dynamics: Another Look

SIEV

111.2004

Anna ALBERINI, Alistair HUNT and Anil MARKANDYA: Willingness to Pay to Reduce Mortality Risks: Evidence from a Three-Country Contingent Valuation Study

KTHC

112.2004

Valeria PAPPONETTI and Dino PINELLI: Scientific Advice to Public Policy-Making

SIEV

113.2004

Paolo A.L.D. NUNES and Laura ONOFRI: The Economics of Warm Glow: A Note on Consumer’s Behavior and Public Policy Implications

IEM

114.2004

Patrick CAYRADE: Investments in Gas Pipelines and Liquefied Natural Gas Infrastructure What is the Impact on the Security of Supply?

IEM

115.2004

Valeria COSTANTINI and Francesco GRACCEVA: Oil Security. Short- and Long-Term Policies

IEM

116.2004

Valeria COSTANTINI and Francesco GRACCEVA: Social Costs of Energy Disruptions

IEM

117.2004

Christian EGENHOFER, Kyriakos GIALOLOU, Giacomo LUCIANI, Maroeska BOOTS, Martin SCHEEPERS, Valeria COSTANTINI, Francesco GRACCEVA, Anil MARKANDYA and Giorgio VICINI: Market-Based Options for Security of Energy Supply

IEM

118.2004

David FISK: Transport Energy Security: The Unseen Risk?

IEM

119.2004

Giacomo LUCIANI: Security of Supply for Natural Gas Markets. What is it and What is it not?

IEM

120.2004

L.J. de VRIES and R.A. HAKVOORT: The Question of Generation Adequacy in Liberalised Electricity Markets

KTHC

121.2004

Alberto PETRUCCI: Asset Accumulation, Fertility Choice and Nondegenerate Dynamics in a Small Open Economy

NRM

122.2004

Carlo GIUPPONI, Jaroslav MYSLAK and Anita FASSIO: An Integrated Assessment Framework for Water Resources Management: A DSS Tool and a Pilot Study Application

NRM

123.2004

<table>
<thead>
<tr>
<th>Journal</th>
<th>Year</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETA</td>
<td>124.2004</td>
<td>Paul MENSINK: Instant Efficient Pollution Abatement Under Non-Linear Taxation and Asymmetric Information: The Differential Tax Revisited</td>
</tr>
<tr>
<td>NRM</td>
<td>125.2004</td>
<td>Mauro FABIANO, Gabriella CAMARSA, Rosanna DURSI, Roberta IVALDI, Valentina MARIN and Francesca PALMISANI: Integrated Environmental Study for Beach Management: A Methodological Approach</td>
</tr>
<tr>
<td>PRA</td>
<td>126.2004</td>
<td>Irena GROSFELD and Iraj HASHI: The Emergence of Large Shareholders in Mass Privatized Firms: Evidence from Poland and the Czech Republic</td>
</tr>
<tr>
<td>CCMP</td>
<td>127.2004</td>
<td>Maria BERRITTELLA, Andrea BIGANO, Roberto ROSON and Richard S.J. TOL: A General Equilibrium Analysis of Climate Change Impacts on Tourism</td>
</tr>
<tr>
<td>NRM</td>
<td>129.2004</td>
<td>Elissaios PAPYRAKIS and Reyer GERLAGH: Natural Resources, Innovation, and Growth</td>
</tr>
<tr>
<td>Series</td>
<td>Title</td>
<td>Editor</td>
</tr>
<tr>
<td>--------</td>
<td>------------------------------------------------------------</td>
<td>----------------------------</td>
</tr>
<tr>
<td>2003</td>
<td>CLIM Climate Change Modelling and Policy</td>
<td>Marzio Galeotti</td>
</tr>
<tr>
<td></td>
<td>GG Global Governance</td>
<td>Carlo Carraro</td>
</tr>
<tr>
<td></td>
<td>SIEV Sustainability Indicators and Environmental Valuation</td>
<td>Anna Alberini</td>
</tr>
<tr>
<td></td>
<td>NRM Natural Resources Management</td>
<td>Carlo Giupponi</td>
</tr>
<tr>
<td></td>
<td>KNOW Knowledge, Technology, Human Capital</td>
<td>Gianmarco Ottaviano</td>
</tr>
<tr>
<td></td>
<td>IEM International Energy Markets</td>
<td>Anil Markandya</td>
</tr>
<tr>
<td></td>
<td>CSRM Corporate Social Responsibility and Management</td>
<td>Sabina Ratti</td>
</tr>
<tr>
<td></td>
<td>PRIV Privatisation, Regulation, Antitrust</td>
<td>Bernardo Bortolotti</td>
</tr>
<tr>
<td></td>
<td>ETA Economic Theory and Applications</td>
<td>Carlo Carraro</td>
</tr>
<tr>
<td></td>
<td>CTN Coalition Theory Network</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>CCMP Climate Change Modelling and Policy</td>
<td>Marzio Galeotti</td>
</tr>
<tr>
<td></td>
<td>GG Global Governance</td>
<td>Carlo Carraro</td>
</tr>
<tr>
<td></td>
<td>SIEV Sustainability Indicators and Environmental Valuation</td>
<td>Anna Alberini</td>
</tr>
<tr>
<td></td>
<td>NRM Natural Resources Management</td>
<td>Carlo Giupponi</td>
</tr>
<tr>
<td></td>
<td>KTHC Knowledge, Technology, Human Capital</td>
<td>Gianmarco Ottaviano</td>
</tr>
<tr>
<td></td>
<td>IEM International Energy Markets</td>
<td>Anil Markandya</td>
</tr>
<tr>
<td></td>
<td>CSRM Corporate Social Responsibility and Management</td>
<td>Sabina Ratti</td>
</tr>
<tr>
<td></td>
<td>PRIV Privatisation, Regulation, Antitrust</td>
<td>Bernardo Bortolotti</td>
</tr>
<tr>
<td></td>
<td>ETA Economic Theory and Applications</td>
<td>Carlo Carraro</td>
</tr>
<tr>
<td></td>
<td>CTN Coalition Theory Network</td>
<td></td>
</tr>
</tbody>
</table>