EDUCATION AND HEALTH IN THE OECD: A MACROECONOMIC APPROACH

Autoras: *Cecilia Albert* (UAH)*
María A. Davia (UCLM)*

P. T. N.º 5/07

PRELIMINARY VERSION, please do not quote without permission.

(*) Financial help from the Spanish Institute from Fiscal Studies (INSTITUTO DE ESTUDIOS FISCALES,) is warmly acknowledged. The paper has also benefited from the hospitality of the Institute for Social and Economic Research in the University of Essex; a crucial part of the data set, namely, the human capital indicators, were gathered in the project during a research visit at ISER in 2006.

Edita: Instituto de Estudios Fiscales
N.I.P.O.: 602-07-012-X
I.S.S.N.: 1578-0252
Depósito Legal: M-23772-2001

INDEX

ABSTRACT

The aim of this paper is to analyze the determinants of health from a macroeconomic perspective, paying particular attention to the role of education attainment in the determination of health. We construct a time-series cross-section data base with economic and non economic variables for 30 OECD countries which covers information form 1960 to 2003. We have estimated several specifications of a health production function adapting Grossman's human capital model to a macroeconomic approach. Results show that education has mainly a long-term impact on health; its effect remains in the presence of very relevant inputs in the health production function, such as income and expenditure on health, but fades away when other inputs (habits and other health resources) are present in the health production function.

1. INTRODUCTION

Education and health are two forms of human capital. Governments are interested on how (and how much) to influence both of them in order to improve welfare. The main difference between these two types of human capital is that education increases productivity both in market and non market activities, whereas health determines both the quantity and the quality of time available for market and non market activities (Grossman, 1972). This difference may lead to the conclusion that investment on health services may be a priority versus investing on schools, since productivity may not increase if no healthy time is available. We might even say that education investments are not possible without health investments; without "healthy time" there are no possible increases in productivity. Even if this were true, it is worth wondering whether it is possible to improve health indicators in a country by increasing the educational attainment of its population. In order to answer this question we must be able to empirically demonstrate that *there is* a causal link between education and health. Several pieces of work, most of which use microeconomic databases, have tackled this problem (See Grossman, 1999 for a very interesting survey of many of them).

Papers from a macroeconomic approach are but a minority in this literature. This is, among other things, due to the lack of harmonised time series across countries of both independent indicators for health indicators and its determinants until very recently (Or, 2000). The aim of this piece of work is contributing to this strand of the literature analysing the effect of education on health from a macroeconomic perspective. Specifically, in this paper we estimate macroeconomic health production functions for 30 OECD countries since 1960 to 2003. For the sake of consistency we have estimated health using two different proxies: life expectancy and what we will call "potential years of life lost due to health problems". Our explanatory variables are economic factors (income), public and private effort –expenditure on health– and some proxies of healthy lifestyles and, last but not least, the educational attainment indicators (school expectancy and percentage of university graduates in the adult population).

The nuance we add to previous literature is precisely the focus on educational attainment amongst the determinants of health. In order to add this variable we have merged two sources of data: we have taken education variables (school expectancy and percentage of university graduates in the adult population) from UNESCO yearbooks[1] since the sixties, and we have combined

[1] Data on education attainment in Canada has been obtained directly from the Canadian Censuses and only for 1981-1996 due to difficulties to link data from different yearbooks in UNESCO.

them with the OECD Health Database 2005. Merging information on education in the OECD-HD2005 offers a great opportunity to contribute to the literature on this issue, both from Economics of Education and Health Economics fields.

We have estimated an Error Correction Model (hereinafter, ECM) in order to determine the effect of education and income on health both in the short run and in the long run in the presence of several other inputs. The ECM has been complemented with the inclusion of fixed effects (a country-specific dummy variable), which allows us to control for the idiosyncratic time-invariant characteristics of every country. By estimating the ECM with fixed effects we control for non stationarity of both dependent and independent variables and unit heterogeneity. Moreover, we also control for panel heteroscedasticity and horizontal correlation by applying panel corrected standard errors (PCSE) to the OLS estimation of the model instead of the usual OLS standard errors. All these details will be fully explained in the methodological section.

This piece of research outstandingly confirms that the most important determinant of health status across countries is education, even in the presence of income and other variables, although its relevance tends to fade when other determinants, such as expenditure and (un)healthy habits are included in the model. This result remains despite the variable used to approach health (life expectancy and potential years of life lost) and education (school expectancy and percentage of university graduates in the adult population). This is a remarkable result and confirms evidence already obtained with microeconometric databases.

The paper goes as follows: after a review of the empirical literature and some hints about our theoretical framework we will introduce the data-set and the methodology used. Section 6 summarises the main results and section 7 concludes and points at some further work to be done in the near future.

2. THEORETICAL FRAMEWORK

The idea that activities that enhance human productivity are a way of investment coined the concept of “human capital”. This concept stems from Theodore W. Schultz’s speech in the 1960 annual meeting of the American Economic Association. The application of Irving Fisher’s concept of capital to human beings moved Gary Becker (1962) to take ability and knowledge as a way of capital which is the result of investment in education. Ten years later Michael Grossman (1972) was a pioneer in the study of health in the framework of the already well known human capital theory. He was particularly concerned about explaining the link between both basic types of human capital: health and education. In his model, education plays a crucial role in the demand for health since it contributes to the efficiency in the self-provision of health. Grossman’s point of view has a counterpoint in Victor R. Fuchs (1982), who also points to the striking correlation between number of years of schooling and mortality, in particular for the United States. Yet he would not explain this correlation on the basis of *any* human capital argument, but on the correlation between education and preference for the future.

It is important to devote some time to the different individual motivations to invest in different types of human capital: physical capital, education and health. The only reason to invest in physical capital is economic in nature. The decision to invest in education is only partially economic in nature; a person may value education not only because it contributes to future income but also because it contributes to present enjoyment of knowledge in itself.

Having a good health status increases productivity, but this fact is not very relevant when agents make decisions about their own health or their relatives, since health is valuable in itself. Non market aspects of health are more relevant than market aspects (Weil, 2005). This feature of health is present in part of the empirical literature in human capital and economic growth. The same literature has paid attention to difficulties to made health and the externalities of investments in health.

The positive link between education and health is due to the fact that education may influence several of the individual decisions that may determine "quality of life". For instance, education may affect the selection of occupation and type of job, ability to select adequate diets and healthy habits, not to mention efficiency in the use of health care resources. The relation between education and health is endogenous, either because one determines the other or because education and health are determined by a common set of unobservable variables. This explains for the efforts devoted to seeking an instrumental variable that enables the empirical contrast of the connection between health and education. This requires paying attention to the links between health and income on the one hand and education and income on the other hand.

Beyond doubt, the link between education and health is very influenced by the relation between both variables and income. The empirical literature on economic growth considers health as one of the most important factors. This is something that Grossman (2005) has observed as an empirical generality: "Multicollinearity and autocorrelation problems in this type of studies make coefficients in key variables instable and only a few variables are always significant in the explanation of economic growth, with health being amongst them". The well known specialists in economic growth theories Barro and Sala-i-Martín (1995) find that a 13 years increase in life expectancy would lead to a 1,4% increase in the rate of economic growth. The economic historian Robert Fogel (1994) estimated that health and nutrition improvement accounted for about 30% of Britain's income growth rate or about 1.15% per capita per annum in the 200 years from 1780 to 1990. This resulted from the confluence of two factors: an increase in both the number of available persons for work and the effort they could make. From a different point of view, Acemoglu *et al* (2001) consider that differences in income between rich and poor countries are due, amongst other things, to the institutional context that make differences in health among rich and poor countries persistent. Since institutions tend to perpetuate differences in health, even if differences in income were eradicated, poor countries would be less healthy than rich countries.

Empirical evidence in the opposite direction, i.e., with macroeconomic conditions and cultural factors being determinants of health mostly consists on studies focused on developing countries and usually linked to international institutions, such as the World Bank, the World Health Organization and the OECD. One example is Or (2000) who computes a health production function with the OECD Health Data files in the 2000 edition. He is provided with information from 1970 to 1992 for 21 OECD countries. His research objective is finding evidence on the effect of medical and non medical resources, social and economic factors and life-style indicators on health. He estimates a health production function where the dependent variable is potential years of life lost and the explanatory variables are per capita GDP, total and public expenditure, alcohol, fat and sugar intake, and consumption expenditure on tobacco. Among the inputs in the health production function he includes an indicator of labour force qualifications: the proportion of white collar workers in total workforce, which turns out to be the most significant variable in his fixed effects panel estimates. The main difference with the present piece of work lies in our independent indicators for educational attainment; we explore the influence of two "direct" indicators of educational attainment[2] on health (the outcome of the health production function). Moreover, Or's estimations do not deal with non stationarity of dependent and independent variables, whereas we do take it into account with the applied modified version of the Error Correction Model. Finally, In using panel corrected standard errors instead of OLS we also control for horizontal heteroskedasticity.

Rhum (2002) is another piece of work adopting a macroeconomic perspective. He uses aggregate data for 23 OECD countries from 1960 to 1997. His aim is to show that, unlike the previous results in the literature, health status is countercyclical, since during economic downturns agents have more time to devote to health care. He takes several health status proxies, namely, the total mortality rate and deaths from nine leading causes as cancer, accidents or suicides. The methodology is based on weighted least squares, using the square

[2] Namely, the proportion of university graduates among the adult population and school expectancy.

root on national population as weights in order to control for heterogeneity. The main result of that piece of research is that economic downturns have negative effects on physical health. But, unlike the present work, it does not explicitly include any education indicator. Ruhm did include education attainment indicators in different papers (2000 and 2005), where he developed a similar strategy, but this time using U.S. databases[3], so that his results are not comparable to ours. Even though these papers are not focused on the particular impact of education on health, it is still worth mentioning Rhum obtains in them a positive impact of education on the health outcome estimated.

We try to enrich the above outlined evidence adopting the most standard approach to this problem: the human capital model or the production function of health in a reduced form of a structural model. The main contributions to this approach are based on microeconomic models and evidence, and here we translate them into macroeconomic models. According to this model, health is one of the best known non monetary returns to education (see Grossman, 2005 for a review of the literature on non monetary returns to education, health-related ones included). We base our empirical contribution on this theoretical framework and try to explain health outcomes at an aggregate level by the education achievements of the population, in the presence of macroeconomic conditions (particularly income and expenditure) and other indicators. Moreover, our estimations control for unobserved individual heterogeneity, which accounts for country specificities dealing with institutional and cultural aspects that we cannot explicitly include in the specification of our model and/or are time invariant.

3. THE DATA AND SOME INITIAL DESCRIPTIVE ANALYSIS

The OECD-HD2005 is a very interesting tool for the analysis of the relation between income, education and health. This is due to the availability of long series (the longest ones comprise from 1960 to 2003) of relevant variables[4]. We show here two health indicators: life expectancy for both genders and number of years of life lost for every 1000 in habitants (under 70 years old) due to health reasons[5].

[3] He uses the *Behavioral Risk Factor Surveillance System* in 2000 and the National Health Interview in the 2005 paper.

[4] A more detailed explanation of what is the OECD-HD2005 and its structure may be found in www.oecd.org.

[5] These are all the reasons for death except what it is called “external reasons”. These are deaths due to traffic accidents and fatal accidents in general, suicides, violence and crime, secondary effects from drugs or complications during medical treatments.

Unfortunately, the variables related to education attainment of the population are available in the OECD-HD2005 for the period 1989-2003 only. In order to get as much advantage as possible of the long series in the rest of variables, we have added two series of education attainment from UNESCO statistical yearbooks up to 1999; they are available online since then. We have withdrawn two human capital indicators from them that had been registered at censuses every decade[6] since 1961: proportion of population over 25 years old with tertiary education attainment and school expectancy (number of years expected in the education system under the current conditions, i.e., coverage levels). Given that these data were gathered every ten years, we have made use of interpolations for the years between censuses. We have in this way completed the long series we needed to perform our long-term aggregate health production functions.

In the production function we use information about national income as a control variable. We have tried two proxies for this variable: per capita GDP and labour productivity. We also include a set of indicators of resources devoted to health such as public and private expenditure on health as a percentage of the GDP, per capita (public and private) expenditure on health, number of working doctors per 1000 inhabitants, and average acute care bed days (we have chosen them because they are the most expensive ones). At last we also include information on food consumption, such as total fat intake, fruits and vegetables, total protein, sugar and alcohol intake and proportion of adult daily smokers. These are inputs that may be proxies of (un)healthy behaviour or lifestyles.

Table 1 displays the number of valid cases in the main variables of the data-base as an average over the period (1960-2003). It shows that the number of valid observations varies a lot across countries[7], which means that the more covariates we will include in the models, the more missing values will affect the quality of the estimations. The dependent variables of the models (health indicators) and the main explanatory variables (national income and the human capital indicators) have something more than 1100 observations each, and the same applies to variables relative to nutrition. As we introduce other variables, such as public and private expenditure, number of doctors and length of stay in intensive care units the samples will get smaller. Some variables are particularly incomplete: unemployment rates and proportion of smokers are not available in almost any country until 1982. And there are many missing cases in average number of visits to doctors per person as well. We have interpoled missing values when valid previous and later values in the series where available at a reasonable distance.

[6] Since censuses are not published simultaneously in all countries, we had to look up the relevant information in all yearbooks from 1960 up to 1999. Educational attainment from censuses is available in UNESCO web page since 1999.

[7] Abbreviations for country names in the text are official short names in English as given in ISO 3166-1.

Table 1

OVERALL DESCRIPTIVE STATISTICS

Variables	Obs	Mean	Std. Dev.	Min	Max	Few observations in
Year	1320	1981.5	12.70324	1960	2003	
Life expectancy	***1309***	***73.02***	***4.68***	***48.3***	***81.8***	
Years lost (000)	***1137***	***5249.01***	***2307.19***	***1773***	***18431***	AUT, ITA, RCH, RSV, TUR
School expect.	***1146***	***11.39***	***4.31***	***0.7***	***21.1***	***DIN, LUX***
Higher education	***1166***	***13.08***	***9.18***	***0.1***	***48***	***DIN, LUX, TUR***
Real GDP	1142	14278.88	6281.76	1570.89	44008.5	RCH, RSV
Real GDP/worker	1108	31812.56	12675.35	4470.84	103135.5	GER, POL, RCH, RSV
PIB per capita	1187	11498.12	9065.59	498	53828	HUN, POL, RCH, RSV
Unempl. rate	600	7.33	4.24	1.2	23.9	Generalised lack of data up to 1982
Expense on health as a % of GDP	1000	6.82	1.97	1.5	15	HUN, ITA, MEX, POL, RCH, RSV
Public expend p.c.	937	738.76	624.93	9	3367	BEL, HUN, ITA, MEX, POL, RCH, RSV, CHE
Private expend p.c.	945	277.89	346.91	7	3131	BEL, HUN,MEX, POL, RCH, RSV, CHE
Doctors per 1000	1008	1.98	0.81	0.3	4.4	GER, ES, IRE, ITA, MEX, RSV
Visits to doctors	688	5.56	3.13	1	15	GER, BEL,ES,USA, HUN, IRE, ITA, NOR, NZL, RSV, CHE
Length of stay ICU	1018	17.26	10.16	4	58.1	GER, MEX, UK, RSV
Fat intake	1154	119.22	28.78	14.3	170.8	LUX, RCH, RSV
Protein intake	1154	96.87	11.50	55.7	139.7	LUX, RCH, RSV
Sugar intake	1154	41.30	11.23	1.6	71.9	LUX, RCH, RSV
Fruits and Legumes intake	1154	187.60	68.18	50.9	458	LUX, RCH, RSV
Alcohol consumpt	1207	10.11	4.02	0.8	22.6	KOR, GR, MEX, RCH
% of smokers	696	32.82	8.19	17	61	generalised lack of data up to 1980
Number of countries	30	—	—	—	—	—

Table A1 in the appendix displays average values of all the variables for every country along the period 1960-2003. We will only mention here the extreme values of the key health and education indicators. Life expectancy does not vary very much across countries, with the exception of Turkey (60 years), which remains well below the rest. Japan, Norway and the Netherlands enjoy the highest life expectancy, near 76 years in average along the observation period. As for potential years of life lost due to health reasons for every hundred thousand inhabitants[8], the huge figure of Mexico (11142) is far above the rest. The second country affected by health problems is Portugal, well behind (8194). As for the healthiest country, according to this way of measuring health, Sweden holds the first position (3561 years lost per 1000 inhabitants), followed by Iceland (3704) and Norway (3793). As for the education indicators, Turkey (5.44) and Mexico (8) register the lowest school expectancies and Denmark (17) the highest. When measured through proportion of adults with higher education, we see again in Turkey the lowest values (2%), very low values as well in Italy and Portugal (around 5%) and, in the opposite extreme, Canada (29) and Denmark (24).

The remaining of the section shows a series of figures intended to reflect the relation between health and education, income and inputs in the production function (namely, health expenditure and healthy habits). Panel 1 is made of four graphs (1A, 1B, 1C, 1D) showing these links in 2003. A simple cross-section of the data may show that countries with a higher level of income and a higher expenditure on health are those with a higher life expectancy. The correlation is not so clear for the proportion of smokers. Something similar, but less clear, happens as regards our education indicator. A certain level of positive correlation between education and health is noticeable although with a significant dispersion across countries. For instance, Poland and Austria register similar school expectancies but very different life expectancies. Hungary is a worth mentioning case for having an average school expectancy but a low life expectancy.

A similar pattern may be found for the variable "potential years lost" but it is not shown here for space reasons.

---

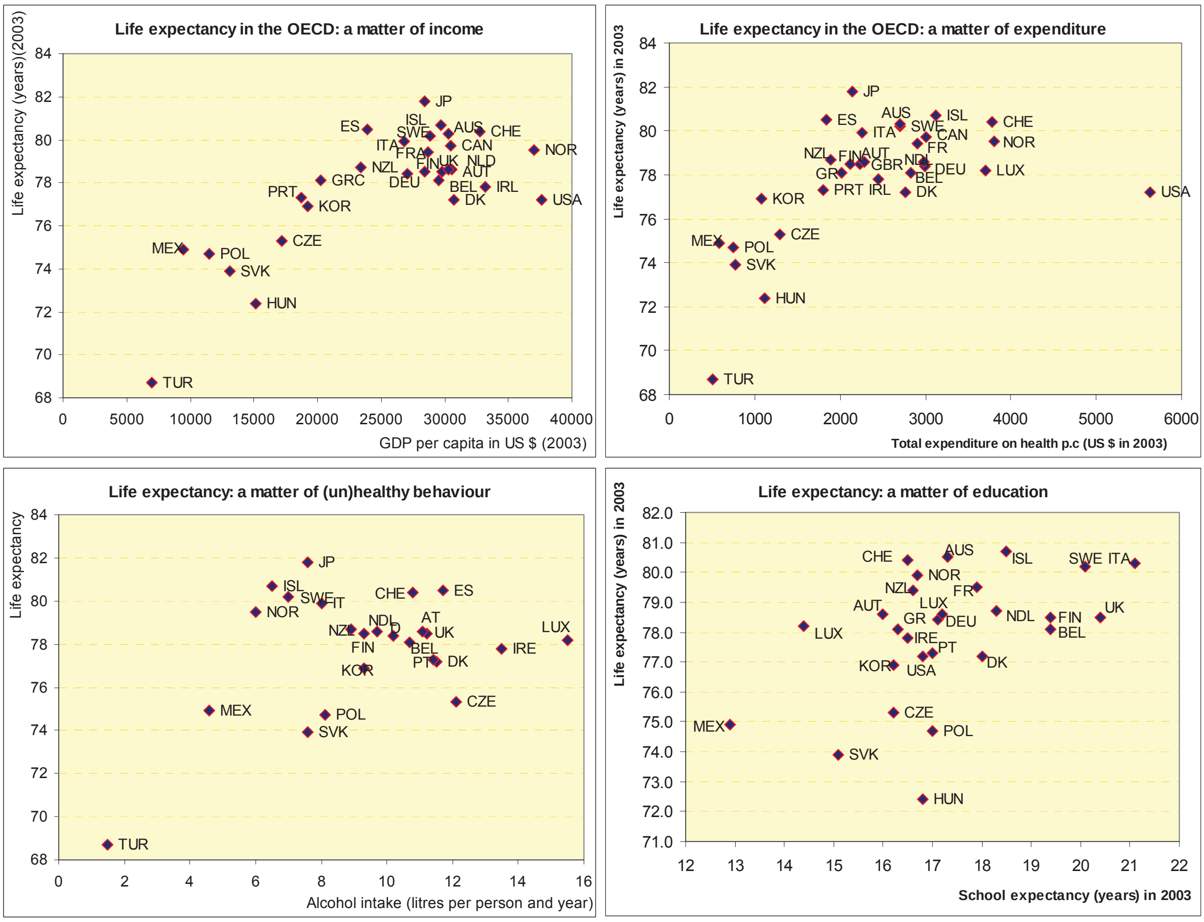
[8] As Or (2000) explains, for each country i and for each year t, the standardised PYLL (expressed per 100000 population) is calculated as follows:

$$PYLL_{it} \quad \sum_{a\ 0}^{l-1} (1-a)\left(\frac{d_{at}}{p_{at}}\right)\left(\frac{P_a}{P_n}\right) * 100000$$

where a stands for age, l is the upper age limit chosen for the measure (in this data-base, 70), da is the number of deaths at age a, pat refers to the number of persons aged a in the reference population, and Pn refers to the total number of persons aged 0 to l-1 in the reference population.

Figure 1

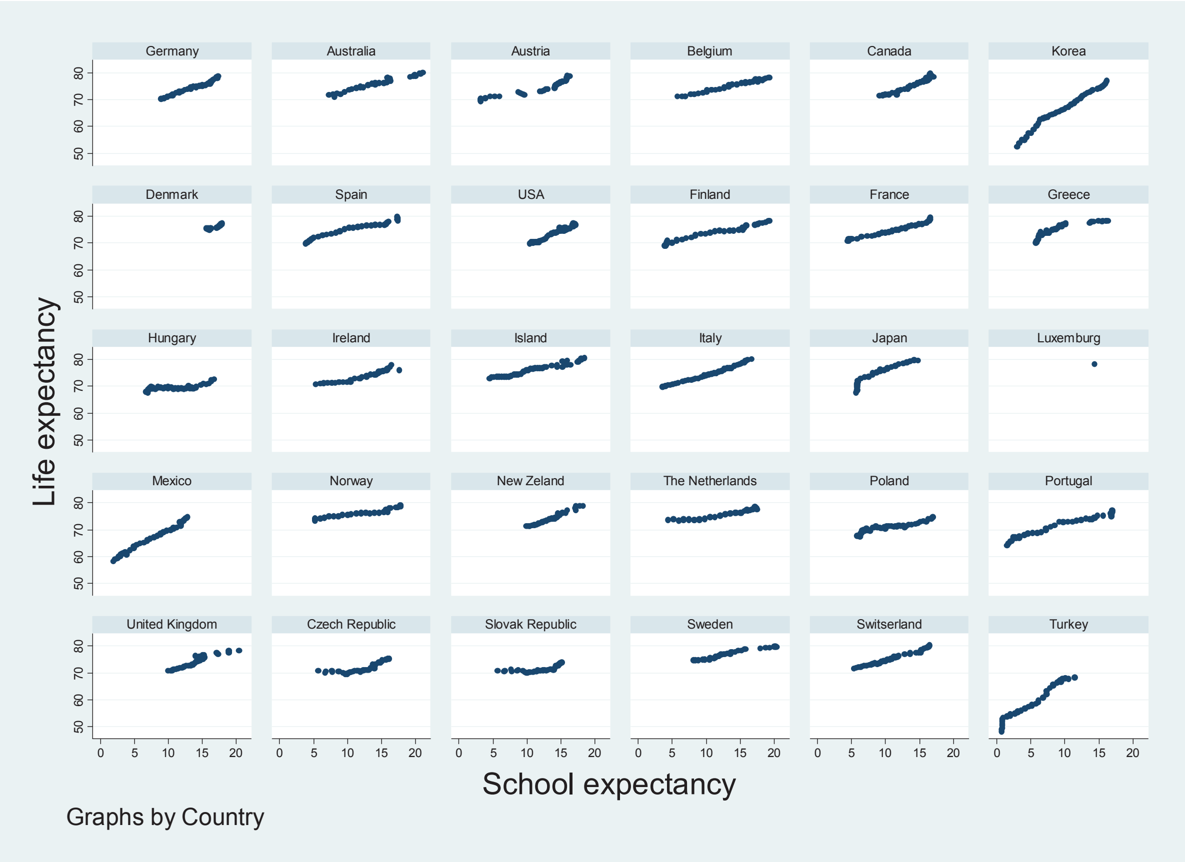
SCATTER PLOTS OF PER CAPITA INCOME, PER CAPITA EXPENDITURE, *PER CAPITA* CONSUMPTION OF ALCOHOL AND SCHOOL EXPECTANCY ON LIFE EXPECTANCY



In order to confirm different patterns across countries we have observed this relation between education and health along the observation window. Figures 2 and 3 consist on two sets of scatter plots for evolution of both education and health indicators at an aggregate level. In figure 2 we may see that there is a positive link between health and education in all countries, although the intensity of the relation differs across countries. The correlation is particularly outstanding in Korea, Turkey and Mexico. These three countries are precisely the ones which have experienced the most pronounced advancement in their improvement in education attainment. In the remaining, more developed, countries the relation is still positive, but smoother.

Figure 2

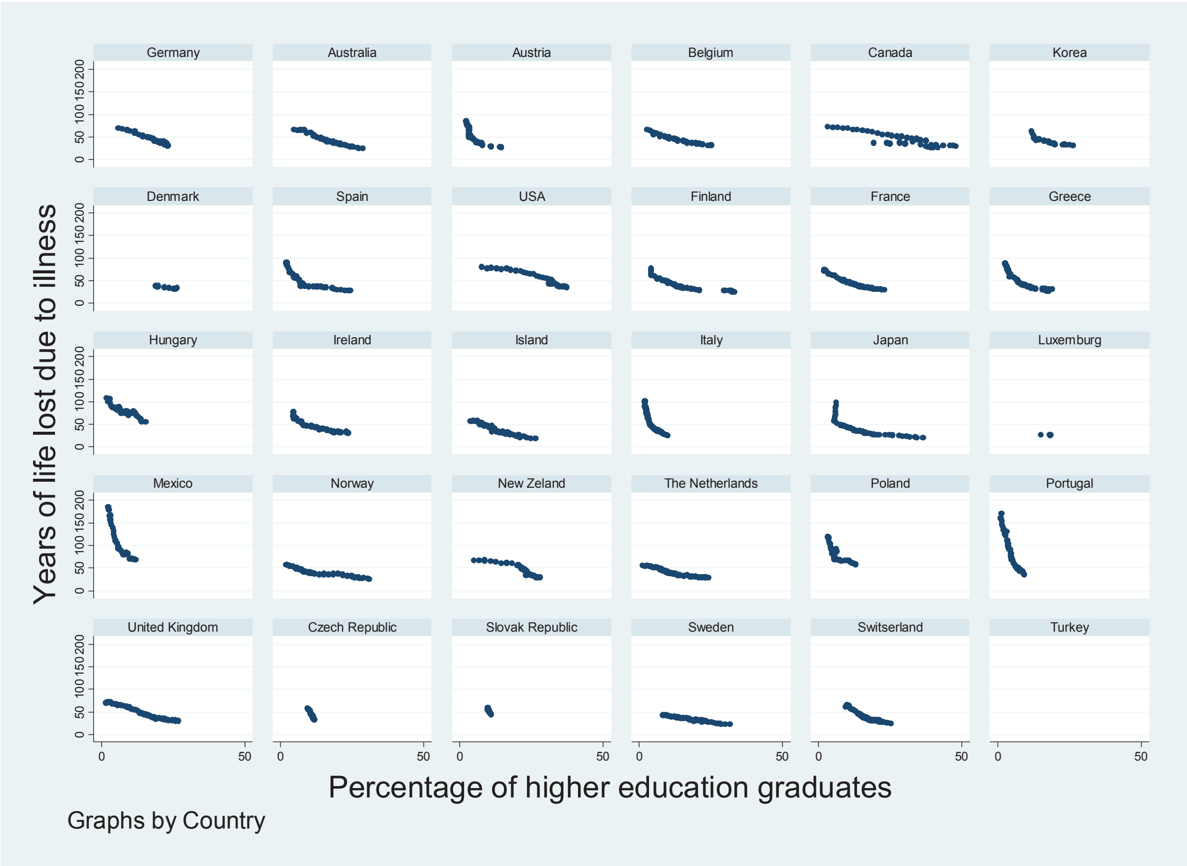
SCATTER PLOT OVER POOLING OF WAVES, BY COUNTRY: SCHOOL EXPECTANCY AGAINST LIFE EXPECTANCY



In figure 3 we look at the same correlation, this time based on two different variables. As a health indicator we have used the number of years of life lost by every 100000 (under 70 years-old) workers due to health reasons. Education attainment is measured through the proportion of high education graduates in the country. This is the case of Mexico and Portugal.

Figure 3

LOST YEARS OF LIFE EVERY 100000 (UNDER 70 YEARS OLD) INHABITANTS AND PROPORTION OF HIGHER EDUCATION GRADUATES



4. METHODOLOGY

The data set we have constructed by merging of OECD-HD2005 and UNESCO yearbooks is a time-series cross-section (TSCS) data set. This type of data is characterised by repeated observations on fixed units, such as nations. Such databases have been widely used by macreconomists, particularly in the analysis of growth. Models for TSCS data often allow for spatial correlated errors as well as for panel heteroskedasticity (Beck and Katz, 1995). Moreover, the relevant variables are very often affected by nonstationarity. This is the case of the main variables used in our model, both dependent (life expectancy and potential years of life lost due to health problems) and independent (school expectancy, proportion of university graduates, GDP per worker, expenditure on health, and the like). This makes it impossible to estimate it via a simple OLS regression in levels, since the result can be a spurious regression (Podestà, 2006). We instead model one variant of first differences, which solve the non stationarity problem.

As Beck and Katz (1996) argue, in the presence of nonstationarity/unit root TSCS data, two different specifications appear available: the FDM (first differences model) and the ECM (Error Correction Model). Podestà (2006) explains why ECM suits very well in the type of data we are handling and the type of problem we are dealing with: first of all, in this model the dependent variable is not expressed in levels but in differences. But ECM is not just a first difference model; it represents the best pooled TSCS specification for modelling progress in health since it is able to capture long-run effects even in the presence of non stationary processes. Our ECM specification is as follows:

$$\Delta H_{it} \quad \beta_0 H_{it-1} + \beta_1 \Delta Y_{it} + \beta_2 Y_{it-1} + \beta_3 \Delta S_{it} + \beta_4 S_{it-1} + \Sigma \lambda^j z^j_{it} + \alpha_i + e_{it} \qquad (1),$$

where $z^j \quad (E, D, L)$ and $\lambda^j \quad (\lambda^1, \lambda^2, \lambda^3)$ respectively. H is the health indicator, S refers to the education attainment proxy of the specification, E refers to different expenditure on health indicators, D gathers information about number of doctors and other health care measures, and L means variables related to lifestyles. The parameter for the lagged dependent variable in levels (β_1) represents equilibrium properties. The parameter φ_j for a lagged independent level variable, x_{t-1}, measures the long-term effect of that variable, at the same time as the parameter for a change variable, x_j it represents the short-term impact of x_{it} on y_{it}. We have added several variables in levels (z^j_{it}) whose coefficients (λ^j) are not split into short-term and long-term impact. We had to do this as a compromise between the inclusion of inputs in the equation and degrees of freedom. Finally, fixed effects, namely, one dummy variable for every country (our unit of analysis) have been included.

Our final specification, a partial version of Error Correction Model with fixed effects estimated by OLS using panel corrected standard errors, is meant to be a compromise between the need to deal with unit heterogeneity and non stationarity without losing too many degrees of freedom. Following Podestá (2006) recommendations, we have tried to guide our model specification not only with the econometric theory, but also with the economic model we have in mind: the human capital approach to the production/demand of health. We may wonder to which extent the human capital model of health production requires being contrasted on a variable expressed in levels or in first differences. The effect of the main inputs in the production function does very likely require several years. Moreover, the original model by Grossman (1972) does explain accumulation of health upon an initial stock (adding inputs and taking into account depreciation). That is why deal with dynamics in the econometric specification since we understand that health production is a dynamic process, based on an already existing stock of health in the population, with both short-term and long-term impacts of the main inputs. Finally, we control for unobserved heterogeneity since we are aware that many country specific characteristics are unobserved in our model and may influence health, such as climate and diet, not to mention the national health institutional setups.

As for the specification, the dependent variables are life expectancy (in years) and potential number of years lost due to health reasons. The sets of explanatory variables consist on several proxies for inputs in the health production function and education. The human capital economists have tried to understand the positive link between education and health and microeconomic empirical analysis has confirmed it once and again exploring three hypotheses[9]: productive efficiency, allocative efficiency and the time preference hypotheses. In the first hypothesis, this link is due to the fact that educated agents will be more efficient in the use of health care services and, therefore, in the production of health. In the second approach (allocative efficiency hypothesis) education is seen as a driving force (similar to a catalyst) in health related decisions. Educated individuals are more aware of the consequences of unhealthy habits and will tend to invest more time and resources on health care. In the third approach, the time preference hypothesis, those agents with a low time discount rate who prefer future consumption to present consumption tend to invest more resources on human capital and, therefore, invest more on education and health, so that the positive link between both variables is not causal (Fuch, 1982 and Farrell and Fuchs, 1982). There are many difficulties to contrast these three hypotheses, which are well documented in the literature through microdata-sets. In our case, we will take this literature into account in the interpretation of these results, although we are aware that not all issues in the microeconomic arena are easy to translate into aggregate approaches.

A final remark must be done: all our dependent and independent continuous variables are expressed in natural logarithms, so that the regression coefficients can be interpreted as constant elasticities.

5. RESULTS

Table 2 displays the main results of the ECM model applied to life expectancy taking school expectancy as the human education attainment. For the sake of robustness we have developed an ECM model as well, this time displayed in table 3 where the dependent variable is "potential years of life lost due to health reasons" and the education indicator is percentage of university

[9] Grossman (1999 and 2005) display a very rich literature survey on these topics.

graduates in the adult population. We have as well run specifications of these models with not control for unobserved heterogeneity. We do not include them in the body of the text since the results are not only sometimes counterintuitive but are also instable when sample diminishes and the global goodness of fit of the models is quite poor. Nevertheless, the interested reader may see these results in tables A2 and A3 in the appendix.

Broadly speaking, we may confirm that, regardless the variable we use to identify health or education, education turns to be a very relevant predictor of health, even in the presence of relevant inputs, such as income and expenditure on health. Nevertheless, as we include more and more inputs, education does not always lose explanatory power although, since many of the inputs we are including in the health production function are clearly correlated with economic development and, therefore, with education attainment of the population. In all of these models the coefficient of the lagged dependent variable is negative and lower than 1 in absolute value. This may be interpreted as the presence of some (given the low values of the coefficient) cointegration between the dependent variables and the set of explanatory variables. We will proceed to comment the main results of every specification in the next paragraphs. Particular attention is due to those lagged and differenced variables (namely, income and education indicators). They must be interpreted carefully. Parameters of lagged explanatory variables reflect the long-term effect of those variables, whereas parameters in differenced explanatory variables show short-term effects of one unit change in those variables.

As explained above, table 2 displays the ECM with fixed effects for the health production function that takes life expectancy as dependent variable. This means that positive coefficients mean that a unit change in variable *x* contributes to a unit change in the natural logarithm of life expectancy. As for the main explanatory variables, we observe that, when we control for fixed effects and look into within country changes, we see a clear and persistent long-run effect of education on health, and the short-run effect is not significant any longer. This could mean that, investment in education is a long-term way of investment. Therefore, education returns at an individual and an aggregate level are only noticeable when a long observation window is considered. This is consistent with the result we already observed when comparing figure D in panel 1 with figure 1.

The coefficient of the education indicator does not always loose explanatory power as more and more inputs are included in the health production function, except when unit heterogeneity is not controlled for. This may confirm the allocation efficiency hypothesis (Rosenzweig and Schultz, 1989). One of the available ways to test for this hypothesis is precisely controlling for more and more inputs and observing how the significance in the education coefficient fades away (Grossman, 2005; p 15: "To fully test the allocative efficiency hypothesis, one needs to estimate the health production function and show that the schooling coefficient is zero once all inputs are included"): "When unit heterogeneity is controlled for, this hipótesis is no longer confirmed".

The impact of education is so strong that it cancels the effect of income, which is not significant in none of the specifications, neither in the short or the long-run. This result might not be as striking as it looks like if we remember that the richest countries in the world are in our data-set. This result seems to be compatible with the income inequality hypothesis, which predicts that income inequality is correlated with health inequalities. In his seminal work, Wilkinson (1992) finds a strong negative correlation between the proportion of accumulated income by the poorest 70% of the population and life expectancy in nine of the industrialised countries of the OECD.

Some other inputs have a small but significant impact on the improvement of health. The effect of public expenditure may be read as follows: increases in public expenditure in one country explain increases in life expectancy in that precise country in a significant way, whereas private expenditure does not seem to be influential.

Some of the variables that register inputs have not a particularly clear pattern. That is the case of number of doctors and average length of stay in acute care units. The effect, when significant, differs across specifications, probably because they are clearly correlated with expenditure on education.

As for (un)healthy habits we do also find interesting results. Those countries that have experienced increases in fat intake are as well those where life expectancy has increased most. Something similar occurs with Fruit and vegetables. Nevertheless, increases in protein intake are linked with a lower pace in the improvement of health along the observation period. As for sugar or alcohol consumption and smoking habits, we have not observed the expected negative sign. We expect this to be the result of loss of sample size when these inputs are included in the models. As a consistency check we have also run models with the smallest of the available simples across specification, namely, the available simple for specification 6. The aim of this checking was distinguishing to which extent sample size is influencing the significance of the main explanatory variables. We observed that long run effects of education on health persist despite the reduction in the sample size.

Table 2

**DETERMINANTS OF INCREASES IN LIFE EXPECTANCY.
ERROR CORRECTION MODEL (controlling for unobserved unit heterogeneity – fixed effects)**

	(1)	(2)	(3)	(4)	(5)	(6)
Life expectancy (in lags)	-0.050*** (6.558)	-0.056*** (6.368)	-0.055*** (5.045)	-0.080*** (6.178)	-0.073*** (4.524)	-0.159*** (5.646)
School expectancy (differenced)	***0.005 (1.489)***	***0.005* (1.701)***	***0.005 (1.550)***	***0.005 (1.382)***	***0.004 (1.039)***	***0.005 (0.826)***
School expectancy (in lags)	***0.004*** (4.873)***	***0.004*** (5.167)***	***0.003*** (3.755)***	***0.002** (2.260)***	***0.002* (1.937)***	***0.004** (1.993)***
Real GDP per worker (differenced)		0.003 (0.584)	0.008 (1.476)	0.008 (1.433)	0.006 (0.945)	0.004 (0.571)
Real GDP per worker (lagegd)		0.001 (1.157)	0.002 (1.251)	-0.001 (0.390)	0.000 (0.096)	0.001 (0.357)
Total expenditure on health (% of GDP)			0.000 (0.326)			
Public expenditure on health-per capita, US$ PPC				0.002** (2.339)	0.001* (1.867)	0.002* (1.684)
Private expenditure on health-per capita, US$ PPC				0.000 (0.857)	-0.000 (0.497)	0.001 (1.345)
Number of active doctors per 1000 inhabitants					-0.001 (0.746)	
Average length of stay: acute care					-0.002* (1.949)	
Total fat intake (daily grams p.c.)						0.009** (2.364)
Total protein intake (daily grams p.c.)						-0.015** (2.543)
Total sugar intake (kilos p.c.)						-0.001 (0.837)
Fruits and vegetables (kilos p.c.)						0.008*** (3.749)
Alcohol consumption (litres p.c.)						-0.000 (0.033)
% of pop 15+ who are daily smokers						-0.002 (1.220)

(Continued)

	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	0.210*** (6.721)	0.232*** (6.575)	0.225*** (5.126)	0.329*** (6.250)	0.310*** (4.592)	0.641*** (5.403)
Observations	1114	983	819	761	573	529
Number of countries	29	29	29	28	28	27
Chi2 (all significant at 99%)	771.25	678.37	205.97	259.17	822.28	146.13
Chi2 degrees of freedom	31	32	31	29	29	32

Absolute value of t statistics in parentheses.

* significant at 10%; ** significant at 5%; *** significant at 1%.

Source: OECD Health 2005 database.

Table 3

DETERMINANTS OF INCREASES IN POTENTIAL YEARS OF LIFE LOST DUE TO HEALTH REASONS. ERROR CORRECTION MODEL (controlling for unobserved unit heterogeneity)

	(1)	(2)	(3)	(4)	(5)	(6)
Potential years of life lost (under 70) (lagged)	-0.061*** (5.055)	-0.076*** (4.927)	-0.089*** (4.851)	-0.121*** (5.763)	-0.123*** (4.814)	-0.184*** (4.433)
Percentage of University graduates (differenced)	***-0.006*** ***(0.253)***	***-0.001*** ***(0.035)***	***0.005*** ***(0.195)***	***-0.012*** ***(0.475)***	***-0.004*** ***(0.108)***	***-0.012*** ***(0.375)***
Percentage of University graduates (lagged)	***-0.030***** ***(4.791)***	***-0.031***** ***(4.661)***	***-0.029***** ***(4.274)***	***-0.021***** ***(2.945)***	***-0.009*** ***(0.885)***	***-0.056***** ***(3.390)***
Real GDP per worker (differenced)		-0.010 (0.169)	0.022 (0.362)	0.034 (0.540)	0.085 (1.219)	0.148** (2.158)
Real GDP per worker (lagged)		-0.013 (0.961)	-0.007 (0.477)	0.031* (1.841)	0.003 (0.115)	0.028 (0.770)
Total expenditure on health (% of GDP)			-0.027** (2.334)			
Public expenditure on health-per capita, US$ PPC				-0.020*** (2.721)	-0.014* (1.715)	-0.004 (0.390)
Private expenditure on health-per capita, US$ PPC				-0.010 (1.584)	0.001 (0.088)	-0.002 (0.245)
Number of active doctors per 1000 inhabitants					-0.012 (0.684)	0.012 (0.551)
Average length of stay: ACU					0.039*** (3.768)	0.028** (2.184)

(Continued)

	(1)	(2)	(3)	(4)	(5)	(6)
Total fat intake (daily grams p.c.)						-0.147*** (3.102)
Total protein intake (daily grams p.c.)						0.206*** (3.037)
Total sugar intake (kilos per capita)						-0.053*** (2.584)
Fruits and vegetables (kilos p.c.)						-0.070*** (2.832)
Alcohol consumption (litres p.c.)						0.012 (0.544)
% of population 15+ who are daily smokers						0.044** (1.972)
Intercept	0.569*** (5.215)	0.730*** (4.584)	0.832*** (4.222)	1.183*** (5.325)	1.036*** (3.913)	1.810*** (3.674)
Observations	959	888	769	718	522	377
Number of countries	29	29	29	28	27	26
Chi2 (all significant at 99%)	756.40	404.7	759.83	5686.45	288.42	435.37
Chi2 degrees of freedom	31	31	30	30	27	27

Absolute value of t statistics in parentheses.
* significant at 10%; ** significant at 5%; *** significant at 1%.
Source: OECD Health 2005 database.

Results in table 3 may well be used as a consistency check of estimations in table 2. Here the meaning of coefficients remains but we need to remember that a negative sign in the coefficient of x means that increases in x are linked to a decrease in the number of years lost due to health problems. Therefore a negative coefficient is linked to improvements in health, unlike the estimates in table 2.

In this new set of specifications (table 3), we observe a clear and persistent long-run relation between the presence of university graduates in the population and the lengthening of life. The coefficients decrease only in two specifications in table 3: in specification 4, in the presence of public expenditure on health. Countries that have increased their public expenditure on health have experienced stronger improvements in their health. And in specification 5, education loses significance in the presence of average length of stay, which is a two-sided indicator of both expenditure on health and morbidity. Probably this double nature explains the positive sign in the coefficient of this variable. Those countries that have experienced longer hospital stays in acute care units may have experienced as well stronger morbidity or accidents, which explain the reduction in life expectancy. Again, in specification 6, in the presence of several other inputs, this variable retains the positive sign. Now let us finally comment other inputs, namely, habits: countries where consumption of fruits and vegetables has increased more have experienced stronger health improvements. The same happens with the consumption of sugar and fat, and all the contrary happens with protein intake. On the one hand, this result does not look very intuitive, since we are aware that sugar and fat are not healthy, but on the other it is also true that as countries develop, together with an improvement in diet habits, there is also an increase in the intake of many types of food quite rich in sugar and fat (i.e., fast food and bakery). In this specification we may clearly see how countries where the proportion of adult smokers increase are more threatened in terms of loss of average years of life.

6. CONCLUSIONS

This piece of research shows that education has a leading role in the determination of health, even in the presence of income and many other inputs. We observe a persistent long-term relation between education and health, regardless the variable we use to measure both education and health. This is understandable if we keep in mind that education is a long-term investment and, therefore its potential effects are better noticed in a long term perspective. Education and income are quite correlated, and given that our data-set includes rich and middle income countries, so that differences in income are not significant enough.

The available TSCS techniques have allowed us to handle heteroskedasticity and non stationarity, and we have tried to do so with our ECM specifications. Moreover we have controlled for time-invariant unit heterogeneity via the inclusion of fixed effects.

Given that we have found that both increases in education attainment and expenditure on health have a positive impact on life expectancy, we could derive several conclusions in terms of policy: both expenditure on education and on health do contribute in the long run to improvements in welfare. They play different and complementary roles: expenditure on education and habits play a direct role on health, whereas expenditure on education contributes to produce health in a more efficient way. Therefore, governments should focus on both types of expenditure in the sake of increasing levels of health and welfare in the population.

Nevertheless, we may not conclude from this idea that present expenditure on education will mean future savings in health expenditure (in line with what Groot and van den Brink (2006)). This is due to the fact that more educated individuals are more efficient in the use of health care but do demand more preventive health care as well. We might therefore expect a restructuring of health care in the future, with an increase in the proportion of expenditure on preventive attention and a reduction of expenditure on palliative care. But what will happen with the level of expenditure as education attainment of the population increases is quite uncertain.

REFERENCES

ACEMOGLU, D.; JHONSON, J. and ROBINSON, J.A. (2001): "The Colonial Origins of Comparative Development: An empirical investigation", American Economic Review, 91 (4), 1369-1401.

BARRO, R.J. and SALA-I-MARTIN, X. (1995): *Economic growth*, New York, MarcGraw-Hill.

BECK, N. and KATZ, J.N. (1995): "What to do (and not to do) with Time-Series Cross-Section Data", The American Political Science Review, Vol 89 n.° 3, 634-647.

– (1996): "Nuisance vs. Substance: Specifying and Estimating Time-Series-Cross-Section Models". Political Analysis Vol 6, n.° 1, 1-36.

BECKER, G. (1962): "Investment in human capital: a Theoretical and empirical analysis", Journal of Political Economy, 70, 9-49.

FOGEL, R. (1994): "Economic growth, population theory, and physiology: the bearing of long term process on the making of economic policy", American Economic Review, 80, 3, 369-395.

FUCHS, V.R. (1982): "Time preference and health: an exploratory study", in: V.R. Fuchs, ed., Economic Aspects of Health (University of Chicago Press, Chicago) 93-120.

GROSSMAN, M. (1972): "On the Concept of Health Capital and the Demand for Health", Journal of Political Economy, 80, 223-255.

– (1999): "The Human Capital Model of the Demand for Health", NBER Working paper, n.° 7078, available at www.nber.org/papers/w7078.

– (2004): "The demand for health, 30 years later: a very personal retrospective and prospective reflexion", Journal of Health Economics, 23, 629-636.

– (2005): "Education and non market outcome", NBER working paper series, 11582.

GROOT, W. and VAN DEN BRINK, H.M. (2006): What does education do to our health? In OECD 2006: MEASURING THE EFFECTS OF EDUCATION ON HEALTH AND CIVIC ENGAGEMENT: PROCEEDINGS OF THE COPENHAGEN SYMPOSIUM.

OECD (2005): Health database 2005. CD-rom and guide book.

OR, Z. (2000): "Determinants of Health Outcomes in Industrialised Countries: A Pooled, Cross-Country, Time-Series Analysis". OECD Economic Studies n.° 30, 2000/1, pp 53-77.

PODESTÀ, F. (2006): Comparing Time Series Cross-Section Model Specifications: The Case of Welfare State Development.

ROSENZWEIG, M.R. and SCHULTZ, T.P. (1989): "Schooling, information and nonmarket productivity: contraceptive use and its effectiveness", International Economic Review 30, 457-477.

RUHM, C.J. (2000): "Are recessions good for your health?", The Quarterly Journal of Economics, 115(2), 617-650.

– (2005): Healthy living in hard times", Journal of health Economics, 24: 341-364.

UNESCO (various issues from 1961 to 1999): UNESCO statistical yearbooks.

WEIL, D.N. (2005): *Economic Gro*wth, Pearson Education.

WILKINSON, R.G. (1992): "Income distribution and life expectancy", British medical journal, 304, 165-68.

APPENDIX

Table A1

COUNTRY-SPECIFIC AVERAGE VALUES FOR EVERY VARIABLE INN THE DATA-SET

	lifexp	yearl	schoolex	highered	RGDPL	RGDPw	GDPpc	Unemp	ExpPIB	publexp	privexp	doctors	visits	stays	fat	protein	sugar	fruits	alcohol	tabaco
GER	73.60	5243	13.75	18.00	17436	42677	12813	7.45	9.14	1197	327	3.12	6.46	12.66	134.35	92.70	41.28	177.26	12.37	28.38
AUS	74.80	4692	14.16	17.53	17301	37804	12379	7.46	6.72	617	311	1.79	4.69	16.19	121.16	107.20	52.28	162.31	11.06	32.30
AT	73.37	5242	10.01	5.72	15217	33382	13004	4.78	6.43	656	273	1.98	5.55	16.79	142.63	96.86	42.85	197.25	12.83	36.30
BEL	73.84	5309	13.13	15.77	15611	38831	12253	9.04	7.14	—	—	2.52	7.07	15.38	142.80	97.69	40.29	188.37	11.71	30.95
CAN	75.41	4576	13.86	28.77	18269	38978	13254	8.87	7.78	824	319	1.79	5.50	11.94	124.54	96.09	46.75	208.74	8.76	31.38
KOR	66.30	4137	9.83	11.36	6519	16094	7478	3.36	4.44	211	294	0.97	9.70	12.67	42.18	77.83	18.45	196.59	9.02	33.86
DK	74.43	4546	16.88	24.34	18608	36022	13229	6.93	8.60	1193	206	2.46	5.73	12.07	133.41	90.75	50.18	135.84	10.40	44.21
ES	75.03	5122	10.69	9.44	11473	31147	9028	16.21	5.23	440	151	2.92	8.03	13.09	115.20	95.71	28.98	256.10	14.98	34.03
USA	73.56	5606	14.12	27.18	21551	45500	15917	6.01	9.48	783	1056	1.58	9.46	11.45	130.34	103.13	60.27	210.36	9.16	29.34
FIN	73.40	4583	10.59	13.79	14958	30540	11645	8.90	6.46	641	190	2.33	3.32	20.04	126.25	95.55	41.03	109.45	7.18	24.82
FR	74.78	4749	11.22	11.88	15523	35101	12393	7.57	7.24	810	246	2.49	5.83	17.31	144.57	110.29	37.30	205.65	18.32	28.31
GR	74.69	5065	9.40	9.27	10145	26093	8030	8.75	7.69	446	386	2.61	2.46	12.60	125.75	105.39	28.63	375.72	10.77	38.90
HUN	69.71	7902	11.14	8.20	8343	17924	10639	8.27	7.53	623	179	2.45	11.08	13.38	127.95	94.19	42.13	162.43	12.32	34.44
IRE	73.12	5305	11.94	12.56	11127	28912	10048	12.16	6.30	513	170	2.20	—	8.08	131.55	110.18	48.46	123.21	9.40	33.44
ISL	76.59	3704	11.87	13.86	16373	32978	13384	3.55	6.52	894	167	2.25	5.16	24.09	125.78	120.30	57.43	95.82	4.44	27.27
ITA	74.80	5602	10.72	4.96	14671	37044	11713	10.28	7.89	1272	368	4.08	6.38	14.91	126.56	102.08	30.50	285.10	13.36	27.77

(Continued)

	lifexp	yearl	schoolex	highered	RGDPL	RGDPw	GDPpc	Unemp	ExpPIB	publexp	privexp	doctors	visits	stays	fat	protein	sugar	fruits	alcohol	tabaco
JP	75.96	4202	9.26	16.85	15598	24834	11985	3.11	5.77	595	172	1.39	14.22	51.47	66.83	87.01	29.72	169.39	7.02	40.72
LUX	73.16	5263	14.40	17.68	21496	51428	18084	2.02	5.69	1255	135	1.67	6.19	22.83	—	—	—	—	14.32	32.21
MEX	67.20	11142	8.01	6.79	6552	20519	4354	3.08	5.57	192	239	1.42	1.93	4.20	74.11	78.43	42.92	133.69	4.65	26.24
NOR	75.94	3973	11.17	15.51	16599	35365	13537	3.29	6.42	909	164	2.06	—	14.63	134.89	96.09	43.12	144.76	4.89	35.39
NZL	73.90	5192	13.76	20.69	15117	35606	11361	6.71	6.56	703	175	1.60	3.76	12.03	121.84	98.84	50.80	195.37	9.45	29.02
NDL	75.78	4083	12.57	11.48	16036	39826	12582	6.94	7.87	887	436	1.91	5.10	34.91	134.73	94.61	47.66	184.83	9.25	43.17
POL	70.97	7480	10.61	6.81	6770	14496	8422	14.53	5.91	363	138	1.80	5.36	13.44	108.67	102.91	42.87	145.33	8.19	32.83
PT	71.38	8194	9.19	5.28	9038	20835	7280	5.61	6.36	434	241	2.00	2.72	16.24	98.07	91.02	27.48	222.06	15.93	19.46
RU	74.10	4990	13.92	13.97	15007	31221	11508	8.24	5.63	595	113	1.35	5.39	11.12	139.44	93.53	44.46	148.50	9.03	37.73
RCH	71.60	4560	11.85	7.64	12966	24219	13436	6.23	6.43	809	65	2.59	11.59	14.60	112.02	92.53	45.09	146.20	11.63	24.95
RSV	71.22	5077	11.79	7.33	10589	22435	9614	15.25	5.71	565	65	3.13	12.94	10.71	108.90	81.19	37.17	140.06	11.86	24.30
SWE	76.41	3561	13.59	20.69	16995	34399	12732	4.28	8.37	1166	161	2.13	2.66	20.59	121.61	93.99	45.21	136.43	6.38	24.51
CHE	75.87	4015	11.60	17.21	21728	43370	16073	3.07	7.57	1376	1148	2.38	3.40	23.04	148.53	92.63	49.78	217.15	12.93	28.14
TUR	59.85	—	5.44	1.36	4668	10493	3105	8.04	3.93	130	77	0.73	1.49	7.92	79.49	95.21	24.43	298.65	1.44	41.92

Table A2

DETERMINANTS OF INCREASES IN LIFE EXPECTANCY. ERROR CORRECTION MODEL (with no control for unobserved unit heterogeneity)

	(1)	(2)	(3)	(4)	(5)	(6)
Life expectancy (lagged)	-0.030*** (8.215)	-0.036*** (8.421)	-0.028*** (5.500)	-0.033*** (5.286)	-0.032*** (4.226)	-0.028*** (3.312)
School expectancy (differenced)	***0.007***** ***(2.075)***	***0.007***** ***(2.186)***	***0.007***** ***(2.169)***	***0.007**** ***(1.943)***	***0.006*** ***(1.518)***	***0.005*** ***(0.712)***
School expectancy (lagged)	***0.002****** ***(3.172)***	***0.002****** ***(3.440)***	***0.002****** ***(4.205)***	***0.001**** ***(1.811)***	***0.002***** ***(1.991)***	***0.000*** ***(0.168)***
Real GDP per worker (differenced)		0.006 (1.229)	0.007 (1.425)	0.008 (1.510)	0.007 (1.174)	-0.000 (0.018)
Real GDP per worker (lagged)		0.001 (0.997)	0.000 (0.321)	-0.001 (1.045)	-0.002* (1.843)	0.000 (0.331)
Total expenditure on health (% of GDP)			-0.001 (1.334)			
Public expenditure on health-per capita, US$ PPC				0.000 (1.201)	0.001* (1.947)	0.001** (1.977)
Private expenditure on health-per capita, US$ PPC				0.000*** (2.641)	0.000* (1.717)	-0.000 (0.667)
Number of active doctors per 1000 inhabitants					-0.001* (1.949)	
Average length of stay: acute care					0.001* (1.932)	
Total fat intake (daily grams p.c.)						-0.004*** (3.192)
Total protein intake (daily grams p.c.)						-0.001 (0.585)
Total sugar intake (kilos per capita)						-0.000 (0.122)
Fruits and vegetables (kilos p.c.)						0.001 (1.278)
Alcohol consumption (litres p.c.)						0.001*** (2.595)
% of population 15+ who are daily smokers						-0.001 (1.183)

(Continued)

	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	0.127*** (8.648)	0.151*** (8.933)	0.120*** (5.732)	0.140*** (5.449)	0.132*** (4.339)	0.139*** (3.905)
Observations	1114	983	819	761	573	529
Number of countries	29	29	29	28	28	27
Chi 2 (all of them significant at 99%)	1105.32	125.58	54.07	49.89	54.67	73.06
Chi2 degrees of freedom	3	5	6	7	9	13

Absolute value of t statistics in parentheses.
* significant at 10%; ** significant at 5%; *** significant at 1%.
Source: OECD Health 2005 database.

Table A3

DETERMINANTS OF INCREASES IN POTENTIAL YEARS OF LIFE LOST DUE TO HEALTH REASONS. ERROR CORRECTION MODEL (with no control for unobserved unit heterogeneity)

	(1)	(2)	(3)	(4)	(5)	(6)
Potential years of life lost (under 70) (lagged)	-0.012** (2.313)	-0.015** (2.197)	-0.013* (1.669)	-0.018* (1.819)	-0.009 (0.755)	-0.018 (1.079)
Percentage of University graduates (differenced)	***0.038** (1.971)***	***0.049** (2.442)***	***0.054** (2.499)***	***0.039 (1.610)***	***0.040 (1.207)***	***0.002 (0.046)***
Percentage of University graduates (lagged)	***-0.002 (0.732)***	***-0.000 (0.115)***	***-0.003 (1.062)***	***-0.002 (0.644)***	***0.002 (0.592)***	***0.005 (0.799)***
Real GDP per worker (differenced)		-0.028 (0.487)	0.035 (0.616)	0.013 (0.224)	0.039 (0.624)	0.110 (1.607)
Real GDP per worker (lagged)		-0.005 (0.727)	0.007 (1.078)	0.013** (1.972)	0.020** (1.976)	-0.015* (1.699)
Total expenditure on health (% of GDP)			0.000 (0.035)			
Public expenditure on health-per capita, US$ PPC				-0.004 (1.190)	-0.006 (1.326)	-0.007 (1.281)
Private expenditure on health-per capita, US$ PPC				-0.001 (0.472)	-0.001 (0.383)	0.005 (1.642)
Number of active doctors per 1000 inhabitants					0.011 (1.526)	-0.005 (0.525)

(Continued)

	(1)	(2)	(3)	(4)	(5)	(6)
Average length of stay: acute care					-0.000 (0.089)	0.005 (1.204)
Total fat intake (daily grams p.c.)						0.036** (2.376)
Total protein intake (daily grams p.c.)						0.022 (0.657)
Total sugar intake (kilos per capita)						-0.000 (0.021)
Fruits and vegetables (kilos per capita)						-0.018* (1.870)
Alcohol consumption (litres per capita)						-0.003 (0.398)
% of population 15+ who are daily smokers						-0.002 (0.243)
Intercept	0.077 (1.626)	0.111 (1.614)	0.066 (0.852)	0.124 (1.204)	0.023 (0.185)	-0.009 (0.048)
Observations	959	888	769	718	522	377
Number of country	29	29	29	28	27	26
Chi 2: only specification (6) is significant at 99%	9.84	12.62	16.18	15.54	19.74	46.11
Chi2 degrees of freedom	3	5	6	7	9	15

Absolute value of t statistics in parentheses.

* significant at 10%; ** significant at 5%; *** significant at 1%.

Source: OECD Health 2005 database.

METHODOLOGY

TIME SERIES CROSS SECTION DATA: AVAILABLE TECHNIQUES

This section is aimed to present the particular features of Time Series Cross Section (TSCS) and the existing techniques available to deal with both them. After introducing the particularities of these types of data sets and how they have been traditionally dealt with, we will pay particular attention to two issues: the treatment of dynamics and the ways to deal with unit heterogeneity. Our final specification, a partial version of Error Correction Model with fixed effects estimated by OLS using panel corrected standard errors, is meant to be a compromise between the need to deal with unit heterogeneity and non stationarity without losing too many degrees of freedom. As the reader will perceive along the text, this section is particularly indebted to several methodological papers by two of the pioneers in the analysis TCSC data: Beck and Katz (B&K), namely, Beck and Katz 1995, 1996, 2004 and Beck, 2001, 2005; and a final paper that wraps up their contributions and compares the specifications of several empirical articles about welfare state: Podestà (2006).

Following Podestá (2006) recommendations, we have tried to guide our model specification not only with the econometric theory, but also with the economic model we have in mind: the human capital approach to the production/demand of health. We control for unobserved heterogeneity since we are aware that many country specific characteristics are unobserved in our model and may influence health, such as climate and diet, not to mention the national health institutional setups. And we deal with dynamics since health production is a dynamic process, based on an already existing stock of health in the population, with both short-term and long-term impacts of the main inputs.

TSCS data: what are they and why we do they require particular attention?

The generic TSCS model looks as follows:

$$y_{it} \quad x_{it}\beta + \varepsilon_{it}; \qquad i \quad 1,..,N \text{ and } t \quad 1,\ldots,T \tag{1}$$

where x_{it} is a *k* vector of exogenous variables and observations are indexed by both unit (i) and time (t). At first sight it looks like panel data, but there are several worth mentioning differences which have particular consequences:

The first one is that N is “small” and T is “large”. Now, what is the threshold to define when this happens is a matter of opinion. Beck and Katz (2004) stressed that the critical issue is whether T is large enough to do serious averaging over time, and also whether it is large enough to make some econometric issues disappear. A sufficiently large T is about 20 or more, and our data-set fulfils this requirement. Later, Beck (2005) will contribute with a further nuance: in TSCS *N* is fixed. This means that units are important in TSCS, since we do not handle samples representative of a population, but a given group of countries. Finally, panel data are usually short and unable to say hardly anything about the time-series structure of the data, whereas TSCS may contribute to disentangle the dynamic nature of many issues.

But TSCS does not only have advantages; it also involves a number of statistical problems, such as the violation of standard OLS assumptions about the error process and nonstationarity. Regarding the first one, residuals for regression equations estimated from pooled TSCS data using OLS procedure tend to be autocorrelated (there is not temporal independence), crosssectionally correlated (the error processes are not independent from each other) as well heteroscedastic (the error processes have not the same variance). This means that there is no guarantee that the OLS standard errors will be correct. In addition, many series usually included in TSCS datasets tend to exhibit a high persistence over time involving nonstationarity (Podestà, 2006). This is the case of most of the variables in our model: life expectancy, years of life lost due to health problems, education attainment of the population, expenditure on health, and most of the inputs that may be included in a health production function are affected by nonstationarity.

Initial strategies to deal with TSCS specificities: GLS and PCSE

A traditional solution for the violation of OLS assumptions is generalised least squares (GLS) (Parks, 1967). The problem with this strategy it that it tries to correct the violation of OLS assumptions in TSCS instead of dealing explicitly with them. In a very influential paper, Beck and Katz (1995) claimed and showed that GLS inflate confidence intervals and proposed to retain OLS parameter estimates but replace OLS standard errors with panel corrected standard errors (PCSE).

The assumptions in TSCS if we want to estimate a model just using PCSE are as follows: Error covariance is constant, horizontal heteroskedasticity, spatial correlation does not vary along time, and temporal independence in errors is time-invariant and may also be invariant across units.

This means that PCSE address only two of the above-mentioned complications of the residuals: contemporaneous correlation and (perforce) heteroskedasticity. Therefore, this estimation procedure must be adopted only when a more serious problem is solved: autocorrelation. As Beck and Katz (1995) stress, any autocorrelation of the residuals must be tested and subsequently eliminated before OLS/PCSEs are calculated.

We now proceed to describe the available techniques to deal with autocorrelation.

Dealing with dynamics/autocorrelation

AR1 & LDV

Beck and Katz (1995, 1996) surveyed the two alternative approaches to address the autocorrelation problem. The first approach treats serial correlation as a nuisance and corrects for it by estimating an autoregressive model on residuals, i.e. AR (1) correction. This leaves us with a static specification of the model. Alternatively, the second approach (the one preferred by Beck and Katz) treats over-time persistence in the data as substantive information and re-estimates the model by including a lagged dependent variable (LDV) in the set of independent variables (Beck and Katz 1996).

The first strategy deployed to deal with autocorrelation in the errors is modelling the error structure following a AR1 serial correlation process: if we assume that the errors follow an AR1 process, letting L be the lag operator, with φ the AR parameter and, letting v_{it} representing the iid error process we can write the model with AR1 errors as:

$$y_{it} \quad \beta_{\overline{ar}1}x_{it} + v_{it}/(1-\varphi L) = \beta_{\overline{ar}1}x_{it} + \varepsilon_{it} + \varphi\varepsilon_{it-1} \tag{2}$$

where $\varepsilon_{it} \quad \varphi\varepsilon_{it-1} + v_{it}$; v_{it} is "iid" (identically distributed zero mean random variable) and we assume a common autoregressive process (a common φ for all units). The interpretation of the results of a model like this is as follows: a permanent one level unit change in x in AR1 models causes an immediate adjustment in y, increasing by β_{ar1}.

Alternatively, we may also explicitly express dynamics adding a lagged dependent variable (LDV) which ends up in an expression like[10]:

$$y_{it} \quad \varphi y_{it-1} + x_{it}\beta_{ldv} + \varepsilon_{it} \tag{3}$$

and assume as well a common autoregressive process (a common φ for every unit). This equation may be estimated using OLS. As for the interpretation of the results, in a LDV model y adjusts to the change in x geometrically: the initial impact of the change is β_{ldv} with a steady state impact $\beta_{ldv}/(1-\varphi)$.

There is an alternative to both LDV and AR1 that encompasses each of them:

$$y_{it} \quad \varphi y_{it-1} + \beta_{\overline{ar}1}x_{it} - \beta_{\overline{ar}1}\varphi x_{it-1} + v_{it} \tag{4}$$

which is a special case of the more general "autoregressive distributive lag" (ADL) model:

$$y_{it} \quad \varphi_{\overline{adl}}y_{it-1} + x_{it}\beta_{\overline{adl}} - x_{it-1}\gamma_{adl} + v_{it} \tag{5}$$

where γ_{adl} is assumed to be zero in the dynamic model and in the static model with serially correlated errors it is assumed to be equal to $-\ \varphi\beta_{adl}$.

Beck and Katz (1996) observed that, instead of estimating model in equation (5) researchers tend in practice to transform away the serial correlation and then estimate equation (1) using PCSE to control for horizontal heteroscedasticity. In this approach the dynamics are simply a nuance that lead to estimation difficulties, once those difficulties are dealt with, the analyst concentrates on the parameter of interest, namely, β in equation (1). They think that this way to proceed ignores a very important part of the model.

[10] Note that in a model like (3) we should remember not to interpret the φ coefficient causally, that is, not to conclude that a unit change in last years´s y causes a φ unit change in current y.

Moreover, making the dynamics explicit (which is exactly what LDV methods do) has more advantages: it is not only usually simple to estimate and interpret (even if testing indicates small remaining serial correlation) but it allows us to explicitly consider issues of unit root TSCS data. TSCS models have unit roots if the estimated value of φ in equation (3) is 1, and unit roots are a serious problem. In the presence of unit roots, specifications in levels are econometrically unfounded. This is precisely our problem, since most of the variables typically used for analysing health improvements along time and along economic development cannot be considered to be stationary.

FDM

If the LDV specification suffers from unit roots, then the (re)specification of the model constitutes also one remedy to deal with the nonstationarity problem (Podestà, 2006). Namely, the strategy consists on differencing integrated time series to achieve stationarity and of treating the resulting series as the proper object of analysis. This means moving from the model in levels to a specification in changes, i.e., FDM (first difference model):

$$\Delta y_{it} \quad \Delta x_{it}\beta_{fd} + v_{it} \tag{6}$$

Equation (6) concentrates only on the short run, omitting any information about long-run adjustments that the data may contain. For this reason, the FDM may not be an optimal solution from a substantive point of view. It focuses on systematic associations between the annual changes in the variables and does not allow for any long-run adjustment modelling (Podestà, 2006). If the theory we are using some long-run effects, then this strategy is clearly insufficient.

ECM

As it was mentioned above, the FDM is quite effective in tackling nonstationarity, but sometimes it is not the best solution from a theoretical point of view. If the theoretical model underneath the empirical specification claims for short as well as long-term connections between variables, then the alternative specification to FDM is the ECM. In our opinion, the ECM represents the best pooled TCSC specification for modelling life expectancy development since it is able to capture long run effects even in the presence of non-stationary processes.

The "autoregressive distributive lag" (ADL) model in equation (5) is equivalent to the single equation DHSY (Davidson, Hendry, Srba and Yeo, 1978) Error Correction Model (ECM).

$$\Delta y_{it} \quad \beta_{adl}\Delta x_{it} + \varphi_{dhsy}\left(y_{it-1} - \gamma_{dhys}x_{it-1}\right) + v_{it} \tag{7}$$

where $\varphi_{dhsy} = 1 - \varphi_{adl}$ and

$$\gamma_{dhsy} = \frac{\gamma_{adl} + \beta_{adl}}{1 - \varphi_{adl}}$$

In this specification φ_{dhsy} represents equilibrium properties. ECM prescribes testing for cointegration by directly estimating the model; Specifically, y_{it} and x_{it} are cointegrated if $-1 <= \varphi_{dhsy} < 0$ while they are not cointegrated if $\varphi_{dhsy} = 0$.

$$\Delta y_{it} = \beta_{adl} \Delta x_{it} + \varphi_{dhsy} \left(y_{it-1} - \gamma_{dhys} x_{it} - 1 \right) + v_{it} \qquad (8)$$

which may be also expressed as

$$\Delta y_{it} = \beta_{adl} \Delta x_{it} + \varphi_{dhsy} y_{it-1} - \varphi_{dhsy} \gamma_{dhsy} x_{it-1} + v_{it} \qquad (8)'$$

where φ_{dhsy} represents the rate at which y_{it} and x_{it} return to their long-run equilibrium relationship. This model may be estimated via OLS with PCSE.

As stressed by Beck and Katz (2004), DHSY-ECM is equivalent to ADL but may have certain advantages: if the LDV model has serially correlated errors (as it is our case) then we need to move to a first differences version of the model (namely, the DHSY- ECM) to remove those serially correlated errors before proceeding to the estimations. The new specification (DHSY) has a more sophisticated interpretation than ADL and LDV: The parameter for a lagged independent variable, x_{it-1}, measures the long-term effect of that variable, at the same time as the parameter for a change variable, Δx_{it}, represents the short term impact of x_{it} on y_{it}[11].

A further property of the ECM model may be explained as follows (Podestà, 2006): although the dependent variable is measured in changes, Δy_{it}, such a model allows capturing the maturation effect of inputs (education and income in particular). In fact, given that

$$y_{it} = y_{it-1} + \Delta y_{it},$$

ECM provides a time path for life expectancy or years lost due to health problems and life expectancy in levels.

The ADL (DHSY-ECM) model nests the LDV and the AR1 models, which is one of the reasons we have chosen such specification, and is a good compromise between AR1 and LDV, although is may ask too much of the data since it consumes many degrees of freedom (it requires the estimation of two parallel parameters for every explanatory variable). That is why we have tried to get some leverage by allowing two kinds of independent variables: x_{it} and z_{it}. x_{it} represent those variables where adjustments are instantaneously or nearly so

[11] In other words: y initially responds to the level shift in x by increasing in β_{adl} units, with the long-run change in y being $(\beta_{adl} - \gamma_{adl})/(1-\varphi)$ (Beck, 2005).

(income and education) whereas z_{it} are those whose speed of adjustment is similar to the speed of adjustment if the error process (that is, variables that could easily move from the measured to the unmeasured category and vice-versa, such as habits and different measures of health care inputs). The final specification looks like:

$$\Delta y_{it} \quad \varphi_{dhsy} y_{it-1} + \beta_{adl} \Delta x_{it} - \varphi_{dhsy} \gamma_{dhsy} x_{it-1} + \zeta z_{it} + v_{it} \tag{9}$$

And we estimate it using OLS corrected with PCSE. We hope having reached in this way a compromise between estimability and verisimilitude, taking advantage of the benefits of the DHSY model without losing many degrees of freedom.

In order to assess the quality of the ECM model we must run a Lagrange-multiplier test. If the LM test shows that the residual of this model is neither highly persistent over time nor autocorrelated we can appropriately apply PSCE procedure. We have run that test and cheked that none of our ECM specifications is affected by autocorrelation. Results, not included in the results section for the sake of brevity, are available from the authors upon request.

Dealing with unit heterogeneity: our final specification

Once we have dealt with nonstationarity and the dynamic nature of the model, we still face the typical cross-sectional issues linked to TSCS data: horizontal heteroskedasticity and unit heterogeneity. To deal with heteroskedasticity we make use of PCSE. But yet we must remember that a critical assumption of TSCS is that pooling is perfectly possible, since all units are characterized by the same regression equations at all points in time (Beck and Katz, 1995). This is not usually the case, since in TSCS the units of observation are of interest by themselves. They are not sampled (as it happens with panel data), but fixed. Units are specific and we must respect this specificity. There are two ways of doing so: either we think this specificity affects the error term (in which case we use fixed effects) or we assume it affects the coefficients of the explanatory variables (and we move to and random coefficients models).

In order to capture unit effects in the error term, one may allow the intercept term to vary across units and/or over time. Controlling for fixed effects (a dummy variable for every unit) we make heterogeneity across units explicit[12]. It means accepting that every unit (country) may have a different

[12] It is important to stress that here we must use fixed and non random effects since units are fixed and not sampled (we are not interested in extending inference to a larger, hypothetical, population of similar countries). But fixed effects are costly: they are clearly collinear with any independent variables that are unchanging attributes of the units. Therefore, they force us to drop such unchanging variables from the specification. And although we can estimate the equation with control for fixed effects with slowly changing independent variables, the fixed effects will soak up most of the explanatory power of those slowly changing variables.

intercept, which responds to different time-invariant unobserved factors, such as institutions:

$$\Delta y_{it} \quad \varphi_{dhsy} y_{it-1} + \beta_{adl} \Delta x_{it} - \varphi_{dhsy} \gamma_{dhsy} x_{it-1} + \zeta z_{it} - fi + v_{it} \tag{10}$$

Since our favourite specification includes country dummy variables, we *de facto* estimate an ECM that captures the long-run effect with respect to intra-unit variation only. This is because country dummies inclusion replaces the dependent an independent variables with their within country variation over time (Greene, 2003).

Although we prefer the ECM version which controls for fixed effects, we have computed our ECM specification with and without fixed effects in order to test whether the long-run equilibrium exists with respect to both intra-unit and the inter-unit variation.

By using a fixed effects specification to control for unobserved heterogeneity, we allow each unit to have its own intercept. But our model assumes that coefficients are homogeneous across countries. Relaxing this assumption would lead us to deal with random coefficient models (Beck and Katz, 2006), which is beyond the scope of the present paper and will be dealt with in future research. Our aim in this paper is to focus on the dynamic nature of the problem and treat heterogeneity across units in terms of different intercepts as a first approach.

Finally, we will mention a problem that arises when adding a fixed effect to our specification, since we are explicitly deploying an LDV in our model; it is stressed by Beck, N. and J.N. Katz (2004): when we include a series of dummy variables for each unit in the pooled model, we face the least square dummy variable (LSDV) estimator. The LSDV is equivalent to demeaning all the variables by their individual specific means. But there is a problem: since the demeaning procedure makes use of all available time periods it induces to a correlation between the demeaned LDV and the demeaned error term. That is,

$$\tilde{y}_{it-1} \quad y_{it} - \frac{1}{T_i} \sum_{t\ 1}^{Ti} y_{it-1}$$

$$\tilde{\varepsilon}_{it-1} \quad \varepsilon_{it} - \frac{1}{T} \sum_{t\ 1}^{Ti} \varepsilon_{it}$$

and, therefore, $E[\tilde{y}_{it-1}, \tilde{\varepsilon}_{it}] \neq 0$

This correlation renders the LSDV estimators of φ and β biased. This bias is well-known and it is called Hurwitz bias (and, more recently, Nickell bias) (Beck (2005)). Given that LSDV is biased, there have been several alternative estimators proposed. One of them is the Andersen Hsiao estimator (AH) suggested by Andersen and Hsiao (1982). An alternative is Generalized Method of Moments (GMM) by Arellano and Bond (1991). Finally, the third option is the

Kiviet (1995) approach. All of them face several problems. The AH estimator is based, according to Beck and Katz (2004), on weak instruments. GMM instruments (lagged variables) are more efficient than AH but seldom used in the analysis of TSCS. Finally, Kiviet procedure is only available for balanced panel data[13] and is computationally very costly.

Beckman and Katz (2004) show that the LSDV performs about as well as more complicated methods, such as the Kiviet estimator, and better than the Andersen Hsiao estimator (both of which are designed for panels). Using Monte Carlo simulations they show that, in general, Hurwitz bias is not likely to be higher than 10% when $20 < T < 50$, so that Kiviet estimator and LSDV work equally well when T is twenty or more. The advantage of LSDV is that is flexible enough to deal with other specification problems. Therefore we have not tried to deal with this bias since the three available strategies to tackle this problem (LSDV estimator, AH IV estimator and Kiviet correction to LSDV) are not free of costs. And given that our data-set has enough observations to trust LSDV (more than 20 observations per country), we have finally opted for a computationally feasible LSDV version of a partial ECM.

[13] Giovanni S.F. Bruno developed the Stata module XTLSDVC in 2005 (Bruno (2005b): it calculates bias corrected LSDV estimators for the standard autoregressive panel data model using the bias approximations in Bruno (2005a), who extends the results by Kiviet (1995) to unbalanced panels. This method is computationally very costly, as Kiviet's. But given we have renounced to solve the LSDV bias and we have chosen the ECM model because of its consistency with our theoretical framework, we have not used this bias correction either. Moreover, we did try it, but results emphasised significance of the lagged variable and inputs in the production function lost most of their explanatory power.

REFERENCES

ANDERSON, T.W. and HSIAO, C. 1982: "Formulation and Estimation of Dynamic Modles Using Panel Data." Journal of Econometrics 18, 47–82.

ARELLANO, M. and BOND, S.R. 1991: "Some Tests of Specification for Panel Dat: Monte Carlo Evidence and an Application to Employment Equations." Review of Economic Studies 58, 277–297.

BECK, N. and KATZ, J.N. (1995): What to do (and not to do) with Time-Series Cross-Section Data. *The American Political Science Review*, Vol. 89, n.º 3 (Sep., 1995), pp. 634-647.

– (1996): Nuisance vs. Substance: Specifying and Estimating Time-Series-Cross-Section Models, *Political Analysis* Volume 6, number 1, pp. 1-36.

– (2001): TIME-SERIES–CROSS-SECTION DATA: What Have We Learned in the Past Few Years? *Annual Review of Political Science* Vol. 4, 271-293.

– (2005): *Time-Series–Cross-Section Issues: Dynamics, Continuous;* mimeo, *New York University*.

– (2006): *Time-Series–Cross-Section Methods;* mimeo, *New York University*.

BECK, N. and KATZ, J.N. (2004): *Time-Series–Cross-Section Issues: Dynamics, 2004;* mimeo, *New York University/Pasadena*.

BRUNO, G.S.F. (2005): XTLSDVC: Stata module to estimate bias corrected LSDV dynamic panel data models. Statistical Software Components from Boston College Department of Economics with number S450101.

– (2005b): Approximating the bias of the LSDV estimator for dynamic unbalanced panel data models. Economics Letters, 2005, vol. 87, issue 3, pages 361-366

DAVIDSON, J.; HENDRY, D.; SRBA, F. and YEO, S. (1978): "Econometric Modelling of the Aggregate Time-Series Relationship Between Consumers' Expenditures and Income in the United Kingdom." Economic Journal 88, 661–92.

PODESTÀ, F. (2006): Comparing Time Series Cross-Section Model Specifications: The Case of Welfare State Development, *Quality and Quantity, Volume 40, number, 539-559.*

GREENE, W.H. (2003): Econometric Analysis. Fifth ed. Upper Saddle River, N.J.: Prentice Hall.

KIVIET, JAN F. (1995): "On Bias, Inconsistency, and Efficiency of Various Estimators in Dynamic Panel Models." Journal of Econometrics 68, 53–78.

PARKS, R. (1967): "Efficiency estimation of a system of regression equations when disturbances are both serially and contemporaneously correlated". Journal of the American Statistical Association, vol 62 pp. 500-509.

SÍNTESIS

PRINCIPALES IMPLICACIONES DE POLÍTICA ECONÓMICA

El objetivo de este trabajo ha sido analizar los determinantes de la salud desde una perspectiva macroeconómica, prestando una atención especial a la educación. El análisis se realiza para 30 países de la OCDE durante el periodo 1960-2003. Concretamente hemos estimado varias especificaciones de dos funciones de salud que se diferencian tanto por la variable dependiente que mide la salud (hemos utilizado dos aproximaciones al nivel de salud: la esperanza de vida y los años potenciales de vida perdidos) como por variables explicativas que hacen referencia al nivel educativo (hemos incluidos dos indicadores de educación: la esperanza escolar y el porcentaje de graduados universitarios en la población adulta). Además, se han incluido otras variables como la renta *per capita*, la productividad del trabajo, el gasto sanitario total y desagregado según fuese público o privado, además del número de médicos por cada 1000 habitantes. Por último, también hemos podido contar con algunas variables que reflejan los hábitos saludables como son los indicadores de consumo de proteínas y azúcar, fruta y vegetales y alcohol.

La aportación fundamental del trabajo ha sido la construcción de una base de datos que incluyera las variables fundamentales que explican la salud para la mayoría de los países de la OCDE en el periodo de tiempo más largo posible. Se ha utiliza esencialmente la base de datos *OECD Health database 2005* (en adelante OCDE-HD2005), tanto por su potencialidad para un análisis descriptivo como para la aplicación de técnicas econométricas y en especial las relacionadas con datos de panel (concretamente con *time-series cross-section*). Sin embargo, en esta fuente de información los indicadores de educación están disponibles tan sólo para el período comprendido entre 1989 y 2003, por lo que utilizamos los anuarios de la UNESCO para construir dos indicadores: la esperanza escolar (el número medio de años durante los cuales un niño de cinco años de edad espera estar en el sistema educativo durante su vida, dada la tasa de cobertura) y el porcentaje de individuos con cualquier tipo de educación superior en el país. La base de datos construida cuenta con alrededor de 1.100 observaciones[14] y contiene la información mínima imprescindible para nuestro estudio.

La técnica utilizada para la estimación de la función de salud es la denominada Modelo de Corrección del Error (*Error Correction Model*, ECM) que nos ha permitido determinar el efecto de la educación en la renta sobre la salud tanto en el corto como en el largo plazo. El ECM ha sido complementado con la incorporación de efectos fijos (una *dummy* específica de cada país), lo que nos ha hecho posible controlar por las

[14] El número de casos, como podrá verse más adelante en la tabla 1 del borrador de la parte macroeconómica, oscila considerablemente entre variables.

características específicas e invariantes a lo largo del tiempo de cada país. Los detalles de esta metodología se explican en el anexo que aparece en el documento.

El resultado fundamental del trabajo es que la influencia positiva de la educación sobre la salud se produce en el largo plazo y no en el corto. Esta relación positiva se mantiene incluso cuando incluimos en la ecuación la renta y algunos otros *inputs*.

Dado que hemos constatado que incrementos en la educación e incrementos en los gastos sanitarios tienen un impacto positivo sobre la salud, pueden apuntarse algunos aspectos de interés para la política sanitaria. La educación y los hábitos saludables tienen un impacto directo sobre la salud, de manera que los gastos en educación pueden hacer más eficiente la producción de salud e influir positivamente en el estado de salud de la población en el futuro, incluso en países desarrollados. Por esta razón, los gobiernos deberían tener en cuenta este beneficio de la educación cuando evalúan sus políticas educativas y sanitarias.

Sin embargo, el hecho de que un mayor gasto en servicios sanitarios mejore la salud no implica que incrementos actuales del gasto sanitario mejore la salud futura ya que el hecho de que los individuos con un mayor nivel educativo sean más eficiente en la producción de salud no quiere decir que no demanden más servicios sanitarios y en especial servicios preventivos. Por lo tanto, parece razonable esperar que, salvo que se reestructuren los servicios sanitarios en un futuro, se producirá un incremento del gasto sanitario.

NORMAS DE PUBLICACIÓN DE PAPELES DE TRABAJO DEL **INSTITUTO DE ESTUDIOS FISCALES**

Esta colección de *Papeles de Trabajo* tiene como objetivo ofrecer un vehículo de expresión a todas aquellas personas interasadas en los temas de Economía Pública. Las normas para la presentación y selección de originales son las siguientes:

1. Todos los originales que se presenten estarán sometidos a evaluación y podrán ser directamente aceptados para su publicación, aceptados sujetos a revisión, o rechazados.

2. Los trabajos deberán enviarse por duplicado a la Subdirección de Estudios Tributarios. Instituto de Estudios Fiscales. Avda. Cardenal Herrera Oria, 378. 28035 Madrid.

3. La extensión máxima de texto escrito, incluidos apéndices y referencias bibliográfícas será de 7000 palabras.

4. Los originales deberán presentarse mecanografiados a doble espacio. En la primera página deberá aparecer el título del trabajo, el nombre del autor(es) y la institución a la que pertenece, así como su dirección postal y electrónica. Además, en la primera página aparecerá también un abstract de no más de 125 palabras, los códigos JEL y las palabras clave.

5. Los epígrafes irán numerados secuencialmente siguiendo la numeración arábiga. Las notas al texto irán numeradas correlativamente y aparecerán al pie de la correspondiente página. Las fórmulas matemáticas se numerarán secuencialmente ajustadas al margen derecho de las mismas. La bibliografía aparecerá al final del trabajo, bajo la inscripción "Referencias" por orden alfabético de autores y, en cada una, ajustándose al siguiente orden: autor(es), año de publicación (distinguiendo a, b, c si hay varias correspondientes al mismo autor(es) y año), título del artículo o libro, título de la revista en cursiva, número de la revista y páginas.

6. En caso de que aparezcan tablas y gráficos, éstos podrán incorporarse directamente al texto o, alternativamente, presentarse todos juntos y debidamente numerados al final del trabajo, antes de la bibliografía.

7. En cualquier caso, se deberá adjuntar un disquete con el trabajo en formato word. Siempre que el documento presente tablas y/o gráficos, éstos deberán aparecer en ficheros independientes. Asimismo, en caso de que los gráficos procedan de tablas creadas en excel, estas deberán incorporarse en el disquete debidamente identificadas.

Junto al original del Papel de Trabajo se entregará también un resumen de un máximo de dos folios que contenga las principales implicaciones de política económica que se deriven de la investigación realizada.

PUBLISHING GUIDELINES OF WORKING PAPERS AT THE **INSTITUTE FOR FISCAL STUDIES**

This serie of *Papeles de Trabajo* (working papers) aims to provide those having an interest in Public Economics with a vehicle to publicize their ideas. The rules governing submission and selection of papers are the following:

1. The manuscripts submitted will all be assessed and may be directly accepted for publication, accepted with subjections for revision or rejected.

2. The papers shall be sent in duplicate to Subdirección General de Estudios Tributarios (The Deputy Direction of Tax Studies), Instituto de Estudios Fiscales (Institute for Fiscal Studies), Avenida del Cardenal Herrera Oria, nº 378, Madrid 28035.

3. The maximum length of the text including appendices and bibliography will be no more than 7000 words.

4. The originals should be double spaced. The first page of the manuscript should contain the following information: (1) the title; (2) the name and the institutional affiliation of the author(s); (3) an abstract of no more than 125 words; (4) JEL codes and keywords; (5) the postal and e-mail address of the corresponding author.

5. Sections will be numbered in sequence with arabic numerals. Footnotes will be numbered correlatively and will appear at the foot of the corresponding page. Mathematical formulae will be numbered on the right margin of the page in sequence. Bibliographical references will appear at the end of the paper under the heading "References" in alphabetical order of authors. Each reference will have to include in this order the following terms of references: author(s), publishing date (with an a, b or c in case there are several references to the same author(s) and year), title of the article or book, name of the journal in italics, number of the issue and pages.

6. If tables and graphs are necessary, they may be included directly in the text or alternatively presented altogether and duly numbered at the end of the paper, before the bibliography.

7. In any case, a floppy disk will be enclosed in Word format. Whenever the document provides tables and/or graphs, they must be contained in separate files. Furthermore, if graphs are drawn from tables within the Excell package, these must be included in the floppy disk and duly identified.

Together with the original copy of the working paper a brief two-page summary highlighting the main policy implications derived from the research is also requested.

ÚLTIMOS PAPELES DE TRABAJO EDITADOS POR EL INSTITUTO DE ESTUDIOS FISCALES

2004

1/04 Una propuesta para la regulación de precios en el sector del agua: el caso español.
Autores: M.ª Ángeles García Valiñas y Manuel Antonio Muñiz Pérez.

2/04 Eficiencia en educación secundaria e *inputs* no controlables: sensibilidad de los resultados ante modelos alternativos.
Autores: José Manuel Cordero Ferrera, Francisco Pedraja Chaparro y Javier Salinas Jiménez.

3/04 Los efectos de la política fiscal sobre el ahorro privado: evidencia para la OCDE.
Autores: Montserrat Ferre Carracedo, Agustín García García y Julián Ramajo Hernández.

4/04 ¿Qué ha sucedido con la estabilidad del empleo en España? Un análisis desagregado con datos de la EPA: 1987-2003.
Autores: José María Arranz y Carlos García-Serrano.

5/04 La seguridad del empleo en España: evidencia con datos de la EPA (1987-2003).
Autores: José María Arranz y Carlos García-Serrano.

6/04 La ley de Wagner: un análisis sintético.
Autor: Manuel Jaén García.

7/04 La vivienda y la reforma fiscal de 1998: un ejercicio de simulación.
Autor: Miguel Ángel López García.

8/04 Modelo dual de IRPF y equidad: un nuevo enfoque teórico y su aplicación al caso español.
Autor: Fidel Picos Sánchez.

9/04 Public expenditure dynamics in Spain: a simplified model of its determinants.
Autores: Manuel Jaén García y Luis Palma Martos.

10/04 Simulación sobre los hogares españoles de la reforma del IRPF de 2003. Efectos sobre la oferta laboral, recaudación, distribución y bienestar.
Autores: Juan Manuel Castañer Carrasco, Desiderio Romero Jordán y José Félix Sanz Sanz.

11/04 Financiación de las Haciendas regionales españolas y experiencia comparada.
Autor: David Cantarero Prieto.

12/04 Multidimensional indices of housing deprivation with application to Spain.
Autores: Luis Ayala y Carolina Navarro.

13/04 Multiple ocurrence of welfare recipiency: determinants and policy implications.
Autores: Luis Ayala y Magdalena Rodríguez.

14/04 Imposición efectiva sobre las rentas laborales en la reforma del impuesto sobre la renta personal (IRPF) de 2003 en España.
Autoras: María Pazos Morán y Teresa Pérez Barrasa.

15/04 Factores determinantes de la distribución personal de la renta: un estudio empírico a partir del PHOGUE.
Autores: Marta Pascual y José María Sarabia.

16/04 Política familiar, imposición efectiva e incentivos al trabajo en la reforma de la imposición sobre la renta personal (IRPF) de 2003 en España.
Autoras: María Pazos Morán y Teresa Pérez Barrasa.

17/04 Efectos del déficit público: evidencia empírica mediante un modelo de panel dinámico para los países de la Unión Europea.
Autor: César Pérez López.

18/04 Inequality, poverty and mobility: Choosing income or consumption as welfare indicators.
Autores: Carlos Gradín, Olga Cantó y Coral del Río.

19/04 Tendencias internacionales en la financiación del gasto sanitario.
Autora: Rosa María Urbanos Garrido.

20/04 El ejercicio de la capacidad normativa de las CCAA en los tributos cedidos: una primera evaluación a través de los tipos impositivos efectivos en el IRPF.
Autores: José María Durán y Alejandro Esteller.

21/04 Explaining. budgetary indiscipline: evidence from spanish municipalities.
Autores: Ignacio Lago-Peñas y Santiago Lago-Peñas.

22/04 Local governmets' asymmetric reactions to grants: looking for the reasons.
Autor: Santiago Lago-Peñas.

23/04 Un pacto de estabilidad para el control del endeudamiento autonómico.
Autor: Roberto Fernández Llera

24/04 Una medida de la calidad del producto de la atención primaria aplicable a los análisis DEA de eficiencia.
Autora: Mariola Pinillos García.

25/04 Distribución de la renta, crecimiento y política fiscal.
Autor: Miguel Ángel Galindo Martín.

26/04 Políticas de inspección óptimas y cumplimiento fiscal.
Autores: Inés Macho Stadler y David Pérez Castrillo.

27/04 ¿Por qué ahorra la gente en planes de pensiones individuales?
Autores: Félix Domínguez Barrero y Julio López-Laborda.

28/04 La reforma del Impuesto sobre Actividades Económicas: una valoración con microdatos de la ciudad de Zaragoza.
Autores: Julio López-Laborda, M.ª Carmen Trueba Cortés y Anabel Zárate Marco.

29/04 Is an inequality-neutral flat tax reform really neutral?
Autores: Juan Prieto-Rodríguez, Juan Gabriel Rodríguez y Rafael Salas.

30/04 El equilibrio presupuestario: las restricciones sobre el déficit.
Autora: Belén Fernández Castro.

2005

1/05 Efectividad de la política de cooperación en innovación: evidencia empírica española.
Autores:Joost Heijs, Liliana Herrera, Mikel Buesa, Javier Sáiz Briones y Patricia Valadez.

2/05 A probabilistic nonparametric estimator.
Autores: Juan Gabriel Rodríguez y Rafael Salas.

3/05 Efectos redistributivos del sistema de pensiones de la seguridad social y factores determinantes de la elección de la edad de jubilación. Un análisis por comunidades autónomas.
Autores: Alfonso Utrilla de la Hoz y Yolanda Ubago Martínez.

4/05 La relación entre los niveles de precios y los niveles de renta y productividad en los países de la zona euro: implicaciones de la convergencia real sobre los diferenciales de inflación.
Autora: Ana R. Martínez Cañete.

5/05 La Reforma de la Regulación en el contexto autonómico.
Autor: Jaime Vallés Giménez.

6/05 Desigualdad y bienestar en la distribución intraterritorial de la renta, 1973-2000.
Autores: Luis Ayala Cañón, Antonio Jurado Málaga y Francisco Pedraja Chaparro.

7/05 Precios inmobiliarios, renta y tipos de interés en España.
Autor: Miguel Ángel López García.

8/05 Un análisis con microdatos de la normativa de control del endeudamiento local.
Autores: Jaime Vallés Giménez, Pedro Pascual Arzoz y Fermín Cabasés Hita.

9/05 Macroeconomics effects of an indirect taxation reform under imperfect competition.
Autor: Ramón J. Torregrosa.

10/05 Análisis de incidencia del gasto público en educación superior: nuevas aproximaciones.
Autora: María Gil Izquierdo.

11/05 Feminización de la pobreza: un análisis dinámico.
Autora: María Martínez Izquierdo.

12/05 Efectos del impuesto sobre las ventas minoristas de determinados hidrocarburos en la economía extremeña: un análisis mediante modelos de equilibrio general aplicado.
Autores: Francisco Javier de Miguel Vélez, Manuel Alejandro Cardenete Flores y Jesús Pérez Mayo.

13/05 La tarifa lineal de Pareto en el contexto de la reforma del IRPF.
Autores: Luis José Imedio Olmedo, Encarnación Macarena Parrado Gallardo y María Dolores Sarrión Gavilán.

14/05 Modelling tax decentralisation and regional growth.
Autores: Ramiro Gil-Serrate y Julio López-Laborda.

15/05 Interactions inequality-polarization: characterization results.
Autores: Juan Prieto-Rodríguez, Juan Gabriel Rodríguez y Rafael Salas.

16/05 Políticas de competencia impositiva y crecimiento: el caso irlandés.
Autores: Santiago Díaz de Sarralde, Carlos Garcimartín y Luis Rivas.

17/05 Optimal provision of public inputs in a second-best scenario.
Autores: Diego Martínez López y A. Jesús Sánchez Fuentes.

18/05 Nuevas estimaciones del pleno empleo de las regiones españolas.
Autores: Javier Capó Parrilla y Francisco Gómez García.

19/05 US deficit sustainability revisited: a multiple structural change approach.
Autores: Óscar Bajo-Rubio. Carmen Díaz-Roldán y Vicente Esteve.

20/05 Aproximación a los pesos de calidad de vida de los "Años de Vida Ajustados por Calidad" mediante el estado de salud autopercibido.
Autores: Anna García-Altés, Jaime Pinilla y Salvador Peiró.

21/05 Redistribución y progresividad en el Impuesto sobre Sucesiones y Donaciones: una aplicación al caso de Aragón.
Autor: Miguel Ángel Barberán Lahuerta.

22/05 Estimación de los rendimientos y la depreciación del capital humano para las regiones del sur de España.
Autora: Inés P. Murillo.

23/05 El doble dividendo de la imposición ambiental. Una puesta al día.
Autor: Miguel Enrique Rodríguez Méndez.

24/05 Testing for long-run purchasing power parity in the post bretton woods era: evidence from old and new tests.
Autor: Julián Ramajo Hernández y Montserrat Ferré Cariacedo.

25/05 Análisis de los factores determinantes de las desigualdades internacionales en las emisiones de CO_2 *per cápita* aplicando el enfoque distributivo: una metodología de descomposición por factores de Kaya.
Autores: Juan Antonio Duro Moreno y Emilio Padilla Rosa.

26/05 Planificación fiscal con el impuesto dual sobre la renta.
Autores: Félix Domínguez Barrero y Julio López Laborda.

27/05 El coste recaudatorio de las reducciones por aportaciones a planes de pensiones y las deducciones por inversión en vivienda en el IRPF 2002.
Autores: Carmen Marcos García, Alfredo Moreno Sáez, Teresa Pérez Barrasa y César Pérez López.

28/05 La muestra de declarantes IEF-AEAT 2002 y la simulación de reformas fiscales: descripción y aplicación práctica.
Autores: Alfredo Moreno, Fidel Picos, Santiago Díaz de Sarralde, María Antiqueira y Lucía Torrejón.

2006

1/06 Capital gains taxation and progressivity.
Autor: Julio López Laborda.

2/06 Pigou's dividend *versus* Ramsey's dividend in the double dividend literature.
Autores: Eduardo L. Giménez y Miguel Rodríguez.

3/06 Assessing tax reforms. Critical comments and proposal: the level and distance effects.
Autores: Santiago Díaz de Sarralde Míguez y Jesús Ruiz-Huerta Carbonell.

4/06 Incidencia y tipos efectivos del impuesto sobre el patrimonio e impuesto sobre sucesiones y donaciones.
Autora: Laura de Pablos Escobar.

5/06 Descentralización fiscal y crecimiento económico en las regiones españolas.
Autores: Patricio Pérez González y David Cantarero Prieto.

6/06 Efectos de la corrupción sobre la productividad: un estudio empírico para los países de la OCDE.
Autores: Javier Salinas Jiménez y M.ª del Mar Salinas Jiménez.

7/06 Simulación de las implicaciones del equilibrio presupuestario sobre la política de inversión de las comunidades autónomas.
Autores: Jaime Vallés Giménez y Anabel Zárate Marco.

8/06 The composition of public spending and the nationalization of party sistems in western Europe.
Autores: Ignacio Lago-Peñas y Santiago Lago.Peñas.

9/06 Factores explicativos de la actividad reguladora de las Comunidades Autónomas (1989-2001).
Autores: Julio López Laborda y Jaime Vallés Giménez.

10/06 Disciplina credititicia de las Comunidades Autónomas.
Autor: Roberto Fernández Llera.

11/06 Are the tax mix and the fiscal pressure converging in the European Union?.
Autor: Francisco J. Delgado Rivero.

12/06 Redistribución, inequidad vertical y horizontal en el impuesto sobre la renta de las personas físicas (1982-1998).
Autora: Irene Perrote.

13/06 Análisis económico del rendimiento en la prueba de conocimientos y destrezas imprescindibles de la Comunidad de Madrid.
Autores: David Trillo del Pozo, Marta Pérez Garrido y José Marcos Crespo.

14/06 Análisis de los procesos privatizadores de empresas públicas en el ámbito internacional. Motivaciones: moda política *versus* necesidad económica.
Autores: Almudena Guarnido Rueda, Manuel Jaén García e Ignacio Amate Fortes.

15/06 Privatización y liberalización del sector telefónico español.
Autores: Almudena Guarnido Rueda, Manuel Jaén García e Ignacio Amate Fortes.

16/06 Un análisis taxonómico de las políticas para PYME en Europa: objetivos, instrumentos y empresas beneficiarias.
Autor: Antonio Fonfría Mesa.

17/06 Modelo de red de cooperación en los parques tecnológicos: un estudio comparado.
Autora: Beatriz González Vázquez.

18/06 Explorando la demanda de carburantes de los hogares españoles: un análisis de sensibilidad.
Autores: Santiago Álvarez García, Marta Jorge García-Inés y Desiderio Romero Jordán.

19/06 Cross-country income mobility comparisons under panel attrition: the relevance of weighting schemes.
Autores: Luis Ayala, Carolina Navarro y Mercedes Sastre.

20/06 Financiación Autonómica: algunos escenarios de reforma de los espacios fiscales.
Autores: Ana Herrero Alcalde, Santiago Díaz de Sarralde, Javier Loscos Fernández, María Antiqueira y José Manuel Tránchez.

21/06 Child nutrition and multiple equilibria in the human capital transition function.
Autores: Berta Rivera, Luis Currais y Paolo Rungo.

22/06 Actitudes de los españoles hacia la hacienda pública.
Autor: José Luis Sáez Lozano.

23/06 Progresividad y redistribución a través del IRPF español: un análisis de bienestar social para el periodo 1982-1998.
Autores: Jorge Onrubia Fernández, María del Carmen Rodado Ruiz, Santiago Díaz de Sarralde y César Pérez López.

24/06 Análisis descriptivo del gasto sanitario español: evolución, desglose, comparativa internacional y relación con la renta.
Autor: Manuel García Goñi.

25/06 El tratamiento de las fuentes de renta en el IRPF y su influencia en la desigualdad y la redistribución.
Autores: Luis Ayala Cañón, Jorge Onrubia Fernández y María del Carmen Rodado Ruiz.

26/06 La reforma del IRPF de 2007: una evaluación de sus efectos.
Autores: Santiago Díaz de Sarralde Míguez, Fidel Picos Sánchez, Alfredo Moreno Sáez, Lucía Torrejón Sanz y María Antiqueira Pérez.

27/06 Proyección del cuadro macroeconómico y de las cuentas de los sectores institucionales mediante un modelo de equilibrio.
Autores: Ana María Abad, Ángel Cuevas y Enrique M. Quilis.

28/06 Análisis de la propuesta del tesoro Británico “Fiscal Stabilisation and EMU” y de sus implicaciones para la política económica en la Unión Europea.
Autor: Juan E. Castañeda Fernández.

29/06 Choosing to be different (or not): personal income taxes at the subnational level in Canada and Spain.
Autores: Violeta Ruiz Almendral y François Vaillancourt.

30/06 A projection model of the contributory pension expenditure of the Spanish social security system: 2004-2050.
Autores: Joan Gil, Miguel Ángel Lopez-García, Jorge Onrubia, Concepció Patxot y Guadalupe Souto.

2007

1/07 Efectos macroeconómicos de las políticas fiscales en la UE.
Autores: Oriol Roca Sagalés y Alfredo M. Pereira.

2/07 Deficit sustainability and inflation in EMU: an analysis from the fiscal theory of the price level.
Autores: Oscar Bajo Rubio, Carmen Díaz Roldán y Vicente Esteve.

3/07 Contraste empírico del modelo monetario de tipos de cambio: cointegración y ajuste no lineal.
Autor: Julián Ramajo Hernández.

4/07 An empirical analysis of capital taxation: equity *vs*. tax compiance.
Autores: José M.ª Durán Cabré y Alejandro Esteller Moré.

5/07 Education and health in the OECD: a macroeconomic approach.
Autoras: Cecilia Albert y María A. Davia.