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The role of education in health system performance

A propos World Health Report 2000

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Abstract

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I investigate the role of education on health, using country level data and the production frontier framework suggested by the World Health Organization to assess performances of health care systems.

I find that the role of human capital is much smaller than what appears in the WHO frontier model, and the relationship exhibits diminishing return in the observed range. Taking into account the non-linearity in this relationship generates a different ranking of countries according to the efficiency of their health care system. This suggests that the method currently used by the WHO indeed favours health care systems operating in countries which underinvested in education in the past.

The relationship between education and health changes around an average value of 8 years of education per individual: above that level, the return of years of education in health is zero.

Keywords: Human capital, Rate of return, Economic impact, Efficiency

JEL Classification: I18

1. Introduction

This study is about the role of education in the production of health; namely, are the returns of education on health increasing, constant or diminishing?

This question of returns has not been investigated very often in the literature, but the publication by the World Health Organization in 2000 (in its World Health Report for 2000, WHR00 from now on) of a production frontier of health at the aggregate country level has opened an interesting avenue.

The production frontier is used here as a powerful tool to investigate the shape of the relationship between education and health; the study was prompted by a critical appraisal of the surprising logical consequences of the relationship as it was estimated by the WHO, namely that countries would do much better, health-wise, to withdraw any Dollar away from their health care systems and to put the money made available in the education system.

To overcome these weaknesses of the estimation as it was performed, I investigate the issue of heterogeneity: I suspect that education plays differently on health below and above a given threshold of education level, and I re-estimate two production frontiers, first among countries below the threshold, then among countries above it.

The main aim of the present study is to build upon the production frontier analysis suggested in WHR00 to provide empirical insight on the effect of education on health. This highly debated issue in health economics has prompted empirical work aimed mainly at proving or disproving the causal effect of education on health, but much less on the return of a supplementary year of education on the health of the individual (Grossman and Kaestner, 1997). The present analysis of aggregated data can provide a first hint on this issue. I use the broad methodological frame described in WHR00, production frontier analysis of population health, to investigate the return of education on health at various levels of education.

To do this, I have to further investigate the methodological issues involved in the estimation of the performance of national health care systems as carried out by WHR00. Much has been done already to assess and improve the frame proposed in WHR00 (notably by Gravelle et al. 2002, Hollingsworth and Wildman, 2003 and Greene 2004) and the aim here is only to make the case for a more cautious use of the human capital variable in the assessment of performance of a national health care system.

The paper is organized as follows: a second section states our knowledge on the relationship between education and health and the shape of the relationship (literature review). I then briefly describe the method used in WHR00 to assess performance of health care systems (section 3.1) and the specific role of human capital at the aggregated level: section 3.2 makes explicit why we cannot be content with the relationship between education and health as it is estimated in WHR00. A fourth section presents the method and data used to re-estimate the performance of national health care systems and the specific role of human capital. Results are detailed and commented in a fifth section. A last section briefly summarizes and concludes.

2. **The role of human capital in the production of health: what do we know?**

Two strands of literature investigate the relationship between education and health.

The first one, the only one referred to in WHR00, is the so-called demographic transition literature, a strand of writings addressing the issue of education and population (fertility, and mortality) in low-income countries or in western societies of the past (Caldwell, 1993). According to this literature, more education means more opportunities for women, smaller families and more attention paid to individual achievement among children, including survival. In such a context, "more" education means from illiteracy to literacy, or from no schooling to a few years of schooling. This literature typically does not investigate the marginal impact of education on health at higher levels of education (say from primary to secondary school).

The strand of literature concerned with the return of education on health at high levels of schooling stems from Grossman's seminal paper on health capital (Grossman, 1972)[1]. This literature aims at assessing the true causal impact of education on health, controlling for a possible endogeneity effect as well as for a possible heterogeneity effect.

Endogeneity would result from the fact that individuals with different health endowments might choose different education strategies; therefore, omitting to control for this bias (by introducing initial health in the equation for instance) would result in over-estimating the relationship between education and future health.

Heterogeneity means that, if a common latent (non observable) variable such as the individual's time discount rate influences both choices in health investment (smoking, preventative visits to physicians or nurses) and education choices, then, once again, the statistical relationship at the individual level would overestimate the true causal impact of education on health. Controlling for heterogeneity is much more complex than controlling for endogeneity and most of the empirical literature is about controls and their impact.

As a result, the form of the relationship (linear, convex or concave) has not been extensively studied.

In 1976, Grossman suggested that, contrary to income, education continues to influence health even at high level of inputs, but such a statement is absent from the most recent review proposed by Grossman and Kaestner (1997) or Grossman (2000).

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[1] As Pedersen (2002) has pointed out, implications of the health capital model on the production frontier of health differ from those of the health transition theory. According to Grossman, education can influence health through three different pathways: more educated individuals make better use of health care inputs, are more apt at choosing inputs that are good for health, and are more interested in being in good health than less educated ones. Among those pathways, only the third one would be compatible with the additive model estimated in WHR00, the two first ones would imply that a better educated population is more productive at using a given level of expenditures to reach a level of health. This would in turn entail a covariance approach (or multi-level estimation) where the frontier changes across countries (for an example of such an estimation of health care systems' efficiency, see Or et al., 2004).

Grossman and Kaestner (1997) convincingly establish that, even after controlling for heterogeneity and endogeneity, there exists a positive and significant impact of education on self-assessed health on average, when comparing U.S residents, but also that it is much more difficult to show such an impact on mortality.

Among the very rare studies investigating the form of the relationship at the individual level, it is worth mentioning that all (but, again, it is a small sample) find a non linear, rather concave, relationship.

Duleep 1986, on the 1973 Exact Match Sample (matching persons in the March 1973 American CPS with their Social Security records and tracing their mortality through 1977), and controlling for self assessed health and disability status prior to 1973 (to control endogeneity), finds a non-linear effect of schooling on mortality: those with no or not much education, as well as those with some high school or 1 to 3 years of college have higher mortality risk than college graduates do, but high school graduates (12 years of schooling) have lower mortality than do those with some college.

Similarly, Ross and Mirowsky (1999), in a study published after the Grossman and Kaestner review, find that the crude correlation (all other things varying) indicates a non linear relationship, with decreasing return of education on health. Using the simulation from Gilleskie and Harrison (1998), table 6, it can be shown that the gain in self assessed health (percentage in good or excellent health) from additional years of education decreases with the initial level: every additional year of schooling between 8 and 11 increases the proportion by 2.3 percentage points for men and 3.7 for women, the 12th year increases it by 2.4 and 3.5, every year between 12 and 16 by 2.1 and 2.5, and between 16 and 18 by 1.8 and 2.1.

Last, Curtin and Nelson (1997), in a study of the rate of return to education in developing countries advocating subsidies beyond the very first levels of schooling find a decline in the rate of return of maternal education on infants' neonatal mortality after six years of schooling.

Besides measures of the effect of schooling on health, a few studies aim at explaining how schooling affects health. Three plausible pathways are suggested (Kaestner and Grossman, 1997): education enhances productivity in the use of health care to produce health (technical efficiency), education improves the ability to process health-related information (allocative efficiency, in the sense that the implicit price of inputs are changed), and education raises concern for health (changes in preferences). Better knowledge of these causal pathways could shed light on the likely profile of the relationship between years of schooling and health.

Pauly (1980) shows that high school drop-outs in the U.S. in 1970 were more subject to supplier manipulation of their demand for health care than college graduates hence were less technically efficient in their production of health.

Studies on the allocative efficiency pathway are not conclusive.

Farrell and Fuchs (1982), testing the third pathway between education and health (more educated individuals value health more), focus on the impact of health on smoking when the decision to start smoking is usually taken, around the age of 17. They observe a significant negative relationship between schooling and smoking, but this difference does not increase between the ages of 17 and 24: future drop-outs are already more likely to smoke than future students, and the odd-ratio is the same. They conclude that a latent characteristic of individuals influence both their decision to smoke and to study and they suggest time discount (preference for present) could be that underlying trait. This prompted a controversy and studies to test whether the relationship between education and health was an artifact resulting from a non observable heterogeneity across individuals. Berger and Leigh (1989), using a two stage least squares methodology where the number of years of schooling is predicted by instruments (assumed to be not correlated with time preference), reject the hidden variable hypothesis. However, their choice of instruments can be criticized: they use parents' schooling and ancestry to identify schooling, while Becker and Mulligan (1997) offer evidence that time preference is culturally transmitted from parents to children[2]. More important for our purpose, they estimate a purely linear relationship between (instrumented) schooling and health, therefore failing to address directly the observation in Farrell and Fuchs that differences in preferences for health are already determined at age 17. Last, Hunt-McCool and Bishop (1998) present evidence that individual heterogeneity (not linked to time preference) explain the relationship between schooling and mental health.

Hence, not only is the quasi-constant rate of return of education on health questionable in its consequences, it is not confirmed in the empirical literature based on individual data. This finding is also contingent to choices in the specification of the production frontier.

3. The production frontier of health and the role of education according to the WHO:

3.1 The production frontier of health in WHR00:

The last chapter of WHR00 attempts at measuring the performance of health care systems in all 191 member states in a way that is comparable across countries, therefore allowing to rank national systems in a league table (a summarized account of the health system performance assessment frame is provided in the appendix 1 below).

The concept of performance is what economists usually call technical efficiency (Kumbhakar and Lovell, 2000): how much is produced relative to what could be achieved given the amount of resources used.

For a given health care system, "i", efficiency is $\frac{Y_i}{Y_i^{\max}}$. In WHR00 the output Y can be comprised of two different things: a health outcome, disability adjusted life expectancy (DALE, the life expectancy at birth, minus the portions of years of life "lost" due to

[2] They suggest that education can increase the ability to take future benefits and harms into account when making current decision, but also provide evidence that parental wealth is the

impairment or disability when lived in a less than perfect health state), or a composite outcome of DALE, inequality in health, responsiveness and inequality in responsiveness, and equity in financing.

The composite outcome as it was in WHR00 has been heavily criticized on two justified grounds: most of the 191 countries couldn't provide data on inequality of health, responsiveness or financing and the composite index was therefore imputed rather than measured, casting doubt on the significance of the efficiency scores of the majority of the health care systems; second, the same weights were used for all 191 countries, implying that all countries would make the same trade-offs between life expectancy and responsiveness or equity, independent of their current level of life expectancy (or equity). Since the present analysis focuses on the link between education and health, rather than education and the health care system, I will be content to use DALE, the first and simpler outcome[3].

Therefore, efficiency is defined in the present study as $\frac{DALE_i}{DALE_i^{\max}}$; the WHO further refines the definition to acknowledge the fact that, even in the absence of any health care system, something is produced in terms of DALE (a proportion of individuals survive their birth), and they standardize efficiency as $\frac{DALE_i - DALE_{\min}}{DALE_i^{\max} - DALE_{\min}}$. This latter refinement is only a matter of scale and should not alter the relative performance of health care systems.

What really determines the way efficiency is estimated is the way the maximum feasible output is calculated (the well known concept of the production frontier) or what is

main determinant of patience.

[3] DALE itself is not exempt from criticism: as it was measured in 2000 it was a mix of epidemiological knowledge (on the prevalence of diseases) and expert guesstimates (of the relative values of years of life lived with different conditions), relying on implicit assumptions on the link between disease and the prevalence of disability (Williams, 1999, Nord, 2002).

achievable given a level of inputs when there is no waste. There are many admissible ways of determining a production frontier for a given output hence the set of national efficiencies is conditional on the method. Even among the family of stochastic frontiers where the frontier is derived from the actual scatter-plot of inputs and output level of observed national health care systems several different methods and specifications can be found.

WHR00 made use of repeated observations (the same variables were observed every year from 1993 to 1997 on the same set of countries) to estimate a fixed effect production frontier (or within estimator). On the set of inputs X and output DALE of 191 countries observed at five different points in time, the following equation is estimated:

$$DALE_{i,t} = A + B.X_{i,t} + u_i + v_{i,t} \ ,$$

The frontier is given in WHR00 by $DALE_i^{\max} = B.X_{i,t} + (A + \max_i(u_i))$

Besides choosing an estimation method, the other main issue is the set of variables(X) to be included in the equation, or the factors of production of aggregate health. In WHR00 and HSPA03, the WHO argues for a very limited set of variables, namely expenditures on health care at the country level, number of years of education (as a proxy for human capital) and its squared value. A detailed account of the reasons for such a choice and the criticisms it has prompted is given in appendix 2.

3.1 The role of human capital on health in WHR00 and its unexpected consequences on public policy

The main focus of this paper is on the relationship between health and the only factor controlled for in the WHO study, namely the average number of years of education of the adult population. In particular, I aim to improve the production frontier estimations produced by the WHR00.

WHR00 estimates the following production frontier using a within (fixed-effect) estimator, and a translog functional specification:

$$\mathbf{Log(DALE_{max,i}) =}$$

$$\mathbf{0.00885 \times Log(EXP_i) + 0.06301 \times Log(EDU_i) + 0.0217 \times [Log(EDUi)]^2 +}$$

$$\mathbf{(3.81252 + 0.21441)}$$

In the panel of 191 countries examined by WHR00, EXP ranges from $20 (in the poorest African countries) to $3,724 in the USA, and EDU from 0 to 12 years.

The following graph illustrates the role of human capital in such a production frontier:

Figure 1

Figure 1 shows that, even at levels too high to be actually observed, human capital is described as having a highly positive rate of return on health. For example, raising the average number of years of education by 0.5 years from an initial of 8.5 allows a country which spends $1,500 per capita for medical care to increase its disability adjusted life expectancy by 0.7 year (from 75.6 to 76.3). On the other hand, increasing the medical expenditure by 33% from 1,500 to 2,000 per capita and per year in a country with an average number of years of education of 8 years would allow that fictional country to increase its maximum feasible DALE by 0.2 year only.

Such a production frontier entails two consequences: first, as pointed out by Hill (2001) “a country [rather its health care system] that has invested heavily in education in the past will be penalized relative to one that has not”. More accurately, the health care system of such a country will be penalized (deemed inefficient) if, and only if, the estimated production frontier is not the true one; if the true rate of return of education on health is indeed smaller than what is estimated in WHR00, for instance at higher levels of education, then countries such as Canada, Sweden, or the U.K. that have invested heavily in education in the past (OECD, 2000, Barro and Lee, 2000) will, as a result, see their health care system’s efficiency underestimated whereas countries such as France, Italy or Spain, that have invested less heavily in education in the past (OECD, 2000, Barro and Lee, 2000) will, as a result, see their health care system's efficiency overestimated in WHR00. The present analysis was partially prompted by the fact that these (relatively) low educated countries were doing very well in WHR00 (respectively ranked 4th, 3rd and 6th), when Canada ranked 35th, Sweden 21st and the U.K. 24th.

Some very simple use of the production frontier, as estimated by WHR00, show that much of the differences in efficiency among rich countries stem in fact from differences in education levels. For instance, neutralizing differences in that variable, Japan becomes more efficient than France, and Australia and Sweden reach the same level. Canada, the Netherlands, and Switzerland fall behind by 2 percentage points only and for the other countries, it reduces the difference with France by between half and two thirds (for details on these results and the method used, see appendix 2).

Second, if that production frontier is the true one, one might wonder why Governments continue to pour money into their health care system. Auster et al. (1969) reached such a conclusion based on their findings that the respective elasticities of mortality across states in the U.S. to medical expenditures and years of education were -0.1 and -0.2 and an estimation that, in 1960, raising education (number of years of schooling) by 1% cost 1.5 of what was needed to raise medical expenditure by 1%. Today, investing in education should be even more efficient, at least in rich countries, where spending in medical care has increased much more than spending in education (or even than education).

I use back of the envelope calculations to estimate the impact on health of switching funds from health care to education, assuming the WHR00's frontier is the true one. In France, public spending on education is 6.1% of GDP, and 15 cohorts are educated. Therefore, increasing the average number of years of education by 1 year on the whole population would cost 6.1*(80/15), assuming 80 living cohorts of the same size (this is conservative since it overestimates the spending necessary to increase human capital). We can then calculate how much years of education on average a Government would buy by switching 1% of what it spends on medical care, assuming WHR00 has correctly estimated the return of education on health; moreover, since education is a capital, switching funds toward education has an accruing effect on health. Such simple calculations show that switching 1% of medical expenditures toward education in France would first decrease DALE by 0.003 year, but DALE would be greater than the initial value by 0.002 in year 2, and the gain after 10 years would be 0.035 years. Switching 10% would entail a loss of 0.028 years of DALE in first year, but a gain in the second year (+0.013) and an overall gain after 10 years of 0.34 years of DALE. To gain 1 year of DALE after 10 years, the French Government should cut 33% of the budget on health care and switch it to education. Of more concern, a cut of 67% would still yield benefit (if switched to education): the first year with only one third of expenditures on medical care would decrease DALE by almost half a year, but the accrual in human capital would cancel it out after three years and there would still be a gain (of 1.86 years) after 10 years.

Judged by its consequences, the production frontier of health using health care and human capital as it is estimated by WHR00 doesn't seem credible. The remaining of the paper builds upon the broad methodological frame and tries to improve the estimation of the relationship between education and health, investigating heterogeneity and the potential for diminishing returns.

4. Re-specifying the production frontier – data an methods

4.1 Previous literature:

Kathuria and Sankhar (2005) apply the WHR00 method to measure the efficiency of health care systems of the States of India. In their first step only public health inputs are used to determine the frontier, the output being infant mortality rate; other determinants are introduced in a second step, to explain efficiency (once again, assumed constant for each state over the period of panel observation, namely 1986-1997). Surprisingly, literacy rate is never significant in this second step; the only significant factor of efficiency is whether families have access to a lavatory or not.

As developed below, Gravelle et al (2002) recommend a between rather than a within estimator, due mainly to a lack of variance over repeated observations for a same country. Interestingly, their between estimator (using the same data as WHR00, but pooling data for all years on a same country) shows a strongly declining return of education on health (due to a significant negative coefficient on the squared value of years of education): increasing education from 4 to 5 years increases DALE by 4.7%, but one more year of education from 8 to 9 increases DALE by 2.2% only. As a result, switching budget from health care to education now indicates (with this new production frontier) that switching 1% of the health care budget to education would yield a decrease of 0.054 years of DALE in first year and a decline of 0.008 after 10 years. Switching 10% would entail a loss by more than half a year in first year, and still a loss 0.12 years of DALE in the 10^{th} year. If the between estimator is correct, one can understand why Governments keep on spending in medical care in order to produce health.

Hollingsworth and Wildman (2003) raise the heterogeneity issue: even using a within estimator, the production frontier among OECD countries exhibits diminishing returns of education on health in the range of observed values. Increasing education from 4 to 5 years raises DALE by 5.9% but one more year of education from 8 to 9 increases DALE by 2.7% only among this reduced set of 30 rich countries. Interestingly, the coefficient for squared number of years of education is negative among OECD countries and positive among non OECD countries. Since OECD countries also are characterized by a much higher level of education (8.93 years on average versus 5.30) there are good reasons to suspect this heterogeneity simply reflects a decreasing return of education on health beyond a threshold.

Hollingsworth and Wildman produce different production frontiers for the sets of OECD and non OECD countries, and Greene (2004) confirms that income per capita is a strong factor of heterogeneity in the way health is produced. However, as shown in Hollingsworth and Wildman, since there are only 30 OECD countries, production frontiers estimated on a set restricted to these countries only are not robust. They even conclude that, among

OECD countries, expenditure and education don't explain much of health, but this could be due to lack of power.

Contrary to Hollingsworth and Wildman, Or (2000) finds a highly statistically significant constant return of human capital on health (she uses potential years of life lost as the outcome measure rather than DALE) among OECD countries. However, as she points out, her measure of human capital (the share of white collars in the workforce) is rather a proxy for both education and working conditions than for education only. Moreover, she doesn't allow any quadratic form for the effect of the proxy on health.

4.2 Present study:

Following Hollingsworth and Wildman (2004), I try to re-estimate two sets of production frontiers; however, instead of separating two sets of countries using an external threshold (being an OECD member) I use education as a way of increasing homogeneity: I suspect that education plays differently on health below and above a given threshold, and I re-estimate the production frontiers first among countries below the threshold, then among countries above it.

The data used in WHR00 have not been made available to the public; Pedersen (2001) pointed out that the discussion paper #7, supposed to provide and detail these data has never been posted on the WHO site, and it has not been either since. I tried in 2001-02 to obtain the data directly from the WHO but was not successful. Hence, I was not able to replicate, as in Gravelle et al. (2002), or Hollingsworth and Wildman (2003), the estimation of the production frontier using exactly the same data as WHR00.

I use instead the data published in WHR00, namely DALE for each country in 1997, and health care expenditures in international (PPP) dollars, in 1997 as well. I add the average number of years of education in the population aged 15 and over in 1995 as published by

Barro and Lee (2000, table #3)[4]. In choosing the population age 15 and over as the reference population (rather than the population age 25 and over, also available in Barro and Lee's data sets), I use the same indicator as WHR00 (see HSPA, page 687). Note that this indicator is better suited to developing countries than to developed countries where a large fraction of individuals age 15 to 25 are still out of the labour force.

Barro and Lee provide data for 112 countries only in 1995 (they gathered data on 142 countries for at least one year between 1960 and 2000), 111 of which are in the WHR00 panel (Taiwan is not a member state of the WHO). They use censuses and UNESCO data to estimate the average number of years of schooling in the population. As they point out, this captures quantity of education rather than quality, and, on the subset of countries for which the average number of years of education and students' scores are known, correlation between these two measures is weak (at 0.38); I use this indicator of human capital, although it is far from perfect, to preserve comparability with WHR00 and because it is known on many more countries than all other indicators (students scores are known for a smaller subset of 39 countries).

Descriptive statistics are provided in table 1 below (and detailed data are in table 5).

Table 1 here

I estimate the production frontier and test for heterogeneity on these 111 countries for which I have data on disability adjusted life expectancy, health care expenditures in $PPP, and average years of education in the population age 15 and over; the two first measures are for 1997, the third one for 1995.

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[4] Here is another puzzle about the data used in WHR00: Barro and Lee (2000) have produced the most complete set of data on the stock of education in populations of the world, but they have limited themselves to quinquennial measurements, whereas WHR00 uses yearly measurements (from 1993 to 1997).

Since I couldn't use repeated observations, but had only one observation per country, fixed or random effects estimations were not an alternative. Among stochastic frontier estimates, the composed error model is the natural choice with such data. In order to decompose the error term, I use a "normal half-normal" hypothesis (the purely random term is normal, and the efficiency term follows a half-normal non positive distribution) following Kumbhakar and Lovell, (2000). They show that in most of cases imposing a more flexible constraint on the distribution of the error term (such as truncated distributions) add computation difficulties but does not yield substantially different estimates.

The present choice of method is certainly constrained by the data at hand, and good panel data would be better than a cross-section. However, as Gravelle et al. (2002) showed the data used in WHR00 are not really panel data (almost all the variation in the data is between rather than within countries), and therefore recommend using composed error model (at least in the family of stochastic frontier estimates).

In the composed error model, the following equation is estimated:

$DALE_i = A + B.X_i + u_i + v_i$ where u is the efficiency component in the error term of the regression, constrained to be nonnegative, and v is the random component in the error term. The sum (u+v) is skewed, indicating potential inefficiency. For each unit, technical inefficiency is given by $TE_i = E(\exp(-u_i)|\varepsilon_i)$ (Kumbhakar and Lovell, 2000).

Since I suspect the impact of education on health to be different at different levels of the input, I test for a standard mis-specification known as parameter inconstancy (Kennedy, 2003). I use a straightforward procedure, suggested in Kennedy (2003), to determine two "regimes" in the quadratic relationship between education and health: in the first regime, observed on lower values of years of education, the coefficients for education and its squared value are expected to be both positive or to yield strongly positive returns in its range of values for education. In the second regime, observed above the cut-off point for the number of years of education, the coefficient for the squared value is expected to be negative and return of education on health declines rapidly. The procedure is as follows: first, I split the population of 111 countries into two subsets, one comprised of countries with values for EDU (the average number of years of education in the population age 15 and over) below a threshold and one comprised of countries with values of the same variable above the threshold. I then vary the threshold and pick the cut-off point as the value for the threshold that minimizes the sum of SSR (sum of squared residuals) in both equations. The cut-off value is therefore the value that separates the data into two regimes in order to better fit a piece-wise linear relationship between the output on one hand (disability adjusted life expectancy) and the inputs on the other hand (health care expenditures, education and its squared value).

I then use a Chow test to control that the two regimes thus identified are significantly different, in other words, that the coefficients estimated below and above the cut-off points really are different.

There exist more sophisticated procedures to find such non linearities or changes in the value of a parameter in a linear relationship, e.g. non-parametric estimates. I chose to rely on simpler approaches for two reasons though: first, with only 111 observations in the sample, non parametric approaches wouldn't work; second, I use the specified relationship to estimate a production frontier and must therefore keep it reasonably simple.

Once the cut-off point is known two production frontiers are estimated following both a composed error model (normal, half-normal hypothesis, using STATA 8.0). The result is two league tables of countries according to efficiency: one table for countries with high level of education and one table for countries with low level of education.

5 Results

Since I use a slightly different data set, I start by comparing my estimates with those of previous studies. Gravelle et al (2002) provide a stochastic production frontier, estimated on all 191 countries, using a between (rather than fixed effect) model. I use a between model, on 111 countries only and using different data for education.

Table 2 here

Table 2 confirms that my estimates are in the range of those based on the same assumptions (between model) but on a slightly different data set found in prior studies.

I start with identifying the cut-off point. I searched for such a cut-off point in a range that would split the data set into two subsets of reasonable size (not below 30), hence between 4.09 and 7.25. Table 3 provides the SSRs obtained for various thresholds used to split to population of 111 countries into two subsets, one with values for education below the threshold, and the other subset above the threshold. Table 3 provides SSRs for threshold values between 5.0 and 6.8 only, other values being much higher.

Table 3 here

According to table 3, 5.8 years of education seems to be a reasonable cut-off point between two regimes of relationship between education and health: below 5.8, we expect stronger return of education on health; above 5.8 the coefficients of the quadratic relationship are different from those estimated in the low education regime and yield a more rapidly decreasing rate of return of education on health.

The Chow test confirms that coefficients differ below and above the threshold of 5.8, with a Fisher (4,103) equal to 6.45 and a significance level smaller than 0.1%.

Contrary to the measure of heterogeneity as performed in Hollingsworth and Wildman (2003) (OECD versus non OECD), the relationship between health and its determinants is not too badly fitted in the present study even among the subset of high education countries (R2 = 38%), whereas expenditures and education didn’t explain much among OECD countries. As detailed below (table 4), the set of high education countries include most of OECD countries, but also non OECD countries, indicating that heterogeneity and inconstancy in parameters might prompt from the level of education input rather than from differences in income per capita[5].

Clearly, 5.8 is the best cut-off from a linear model fitting perspective but any value between 5.5 and 6.0 could have been picked as the cut-off. In other words, the results suggest that after six years of education (the beginning of a secondary level in many countries, around the age of 12), there is a discontinuous change in the relationship between education and health.

The results of the test provide evidence on heterogeneity in terms of education levels in the WHR00 model and fix that potential heterogeneity by identifying a cut-off point and two regimes in the relationship between education, expenditure and health. So, the first result of that study is the information on the value of a cut-off point and the two regimes in explaining the return of education on health at various levels.

Using this cut-off point, I then estimate the stochastic production frontiers for the two groups (high and low education countries), as well as the technical efficiency indices associated to it.

Table 4 here

Table 4 indicates that, in both subsets, the coefficient for the squared value of education is negative[6].

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[5] Almost all OECD are in the high education regime, except for Turkey, Portugal and Luxembourg, the latter having no information available for 1995. 32 non OECD countries also are in this high education regime.

[6] Whereas it was positive among non OECD countries according to Hollingsworth and Wildman (2003)

It can be seen also from table 4 that the impact of education on the maximum attainable level of health differs in both subsets. In low education countries, adding one year of education at the 5.8 level adds 1.02 years of disability adjusted life expectancy and the marginal impact of education on health becomes negative above approximately 20 years of education, well above the observed range. In high education countries, increasing the education level one year from 5.8 to 6.8, adds 1.06 years to DALE, (instead of 1.02), but the rate of returns decreases steadily toward 0 and is 0 for 8.48 years or Ln(education) = 2.78/1.30. If this production frontier is correct, there is no gain in population health in investing in education above 9 years.

These results based on aggregated data are consistent with the rare individual level studies showing stabilization or even a decrease in health between those having completed high school and those with superior education.

Following Gravelle et al. (2002) estimation: switching 1% of the health care budget to education would yield a decrease of 0.029 years of DALE in first year and a decline of 0.006 after 10 years. Switching 10% would entail a loss by 0.30 year in first year, and still a loss 0.14 years of DALE in the 10th year.

Table 4 also indicates that, among high education countries, the frontier is almost deterministic, with a very small variance for the pure random part of the error term (and consequently, a very high value for the ratio of the inefficiency variance to the random variance).

As shown in table 5, technical efficiencies calculated using this new production frontier yield a different league (or rather two different league tables) of health care systems according to efficiency. Countries with “rational” systems (where explicit schemes are aimed at rendering the whole system more efficient in the very meaning of the WHO) such as New Zealand, Australia, and Canada tend to do much better in that new league, where human capital plays a smaller role at high levels. The U.S. is also better treated under this production function. Norway and Sweden also improve their ranking (from 8th to 1st and from 10th to 5th, respectively). Other countries with a much better ranking according to this production frontier are Croatia, Guyana, China, Sri Lanka, and Cuba.

Austria, the Netherlands, Ireland, France, and Denmark are among the countries doing less well under the new production frontier, together with Uruguay and Argentina.

This alternative league table, where human capital plays a much smaller role among high-education countries, seems therefore more realistic (it gives a fairer account of the true endeavour of health care systems) than the one found in WHR00. However, it is not exempt from the criticisms addressed to the production frontier in WHR00, namely specification choices of the set of X variables (health care expenditures, education and its squared values). Therefore, it is only a marginal improvement, and further evidence of diminishing returns of education on health, but certainly not the optimal production frontier of health at the aggregate level.

Even if this study is not aimed at fixing other specification issues raised in the literature on the WHO 2000 report, most importantly the absence of income per capita or of the inequality in the distribution of income (Greene, 2004), I ran a linear regression (ordinary least squares) of DALE with income per capita (in international $, value for 1997, source: World Bank – www.devdata.worldbank.org/query/default.htm) as an additional independent variable (besides expenditures par capita on health care, years of education and its squared value). This can be seen as a robustness check.

There are 106 countries with non missing values. The coefficient on expenditure turns out to be non significant anymore and the coefficient on the log of income is strongly positive (+0.204); coefficients on education are not much affected by the introduction of income per capita: the coefficient on log of years of education diminishes slightly (from 0.245 to 0.172) and the coefficient on the squared value remains constant. Performing the Chow test on the coefficients for income (GDP per capita), education and its squared value yields the same conclusion that there are two regimes in the relationship between education and health at the aggregate level: the Fisher statistic for the test of any difference in the value of the coefficients for education and its squared value between the two groups of countries (those with less than 5.8 years of education and those with more) is 7.89 (probability smaller than 0.1%) and for any difference in the value of the coefficients for income, education, and its squared value the Fisher statistic is 6.03 (probability smaller than 0.1%). Moreover, qualitative effects are the same when income is substituted for health care expenditure in the equation. Therefore, this study confirms previous conclusions by Hollingsworth and Wildman (2003), and Greene (2004) regarding the respective roles of income and health care expenditure in the production frontier of health, but also points that the relationship between education and health is not affected by the choice of the variable for the 'wealth' (income or expenditure) of countries' health care systems.

6 Conclusions

Using data at the country level and a production frontier framework built upon that suggested by the WHO in WHR00, I show that the impact of education on health (disability adjusted life expectancy) follows two different regimes; among countries with a low level of education (below 5.8 years on average) the elasticity of health to education declines from 0.15 in a country with 4 years of education on average (if that country has a DALE of 60, increasing education by one year on average in the whole population would increase DALE by 2.3 years) to 0.11 in a country with 6 years of education on average (starting from a DALE of 60, the impact of increasing education by one year would only 1.1 years of DALE). Among countries with a high level of education, it doesn't pay (in health) to increase education above 8 years per individual on average in the population. This finding is certainly to be discussed and re-estimated with other data, among which individual level data focusing on the functional relationship between schooling and health rather than on the mere significance of the effect, but it suggests that the impact of schooling on health is smaller when the individual has received 8 years of schooling.

The second indication from this study is that the evaluation of efficiency of health care at the national level using country level data and modeling health care systems as producers of population health requires thorough investigation of the specification of the production frontier, and of the role of human capital on health. Every economist will agree that education is a determinant of health that is not controlled by the health care system and must be, for these reasons, included in the production frontier. However, the functional form used to include it in the estimation seems to influence the estimated values and countries ranking. If any policy recommendation must be drawn from such a league table, it is important that the rankings actually reflect differences in efficiency rather than specification errors.

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Appendix 1: a brief account of the health system performance assessment by the WHO:

In its world health report for the year 2000**,** the World Health Organization (WHO) launched an estimation of the efficiency (called performance in the initial report) of national health care systems among its 191 member countries (WHO, 2000). Efficiency is measured as the ratio of what is achieved to what should have been achieved given the amount of resources available, or the production frontier of health.

This endeavor has been criticized on many grounds and from various perspectives. Some objected the very idea of ranking all systems on a single scale, irrespective of the local objectives and preferences of societies (Navarro, 2001) or the constraints they face (Coyne and Hilsenrath, 2002). Williams (2001) stressed the lack of policy relevance of the whole exercise, arguing that policy makers are not faced with absolute objectives (producing the health of the population) but rather incremental choices (choosing one treatment over another, given the current level of achievement).

Even when the general aim was agreed upon, choices of methods were seen as arbitrary and even based on an implicit normative conception of health and health care. Some criticized the preeminence given to medical services over other (deemed more important) determinants of health such as prevention, income, inequalities, or social capital in the measurement of performance by the WHO (Navarro, 2002, Robbins, 2001, Almeida et al. 2001). Others made more specific objections on the way some dimensions of what is produced by a health care system is measured (Braveman et al., 2001 on equity or Williams 2001 on health status and the composite index of achievement). Almost all reviewers of the WHR00 pointed out the paucity and unreliability of data on which each country achievement and efficiency was assessed. Last, a few articles criticized the econometric approach of the WHR00, focusing mainly on specification issues (Pedersen, 2002, Gravelle et al. 2002, Hollingsworth and Wildman, 2003, Greene, 2004). All evidenced the lack of robustness of results (efficiency levels and rankings) to choices of econometric tools.

To address these criticisms the WHO has set up a scientific peer review group in 2001 (SPRG), and edited in 2003 a book, called Health System Performance Assessment (from now on, HSPA03) comprised of the SPRG's answers and complementary analyses in response to these criticisms (WHO, 2003). To summarize this large and rich volume in a few words, the WHO has acknowledged most of the criticisms targeted toward data quality but has remained adamant on methodological issues. As a result, should the health system performance assessment league table be reiterated (it was supposed to be in 2002 and every other year from then on), it would rely on much better quality data, but would still use the same methods and specifications.

Appendix 2: choice of X variables in the production frontier in WHR00:

WHR00 opted for the following rationale: include all resources directly attributed to the health care system as well as factors contributing to health and beyond the reach of the health care system (from now on the latter will be referred to as "controlling factors").

Ideally, the set of resources directly attributed to the health care system would include the density of physicians, the average cost of a physician's visit, the density of hospital beds, and expenditures on drugs but, for reason of data availability, WHR00 was content with total health care expenditure in each country. Hence, efficiency is the ratio of actual outcome (DALE) to the amount of outcome that could be expected with the same level of expenditure on health care[7]. As a result, no insight can be provided on allocative efficiency of a country's health care system (choosing the wrong mix of inputs given their relative prices).

Among the set of controlling factors, one would expect to find income per capita, the average human capital available in the population, climatic environment, epidemiologic environment of the country etc. However, the only other explanatory variable X in WHR00 estimations is education, more precisely, the number of years of education on average in the population aged 25 and over of each country.

Much has been written about the limited number of explanatory variables controlled for in WHR00 estimations, a list that boils down to the average number of years of education (and its squared value).

The WHO team argue that climatic and epidemiologic environments are not beyond reach of the public health care system: they state, convincingly, that the health care system can be held responsible for (not) preventing smoking, drinking or violence in the population, and, less convincingly (see Jamison and Sandbu, 2001), that the prevalence of tropical conditions or the spread of epidemics such as AIDS should be taken into account by the health care system when it allocates resources. Therefore, these variables are not included in the estimations of performance of the health care system in WHR00, but are used, in HSPA03, in a second step to explain countries' inefficiencies[8].

The exclusion of income per capita as a relevant controlling factor pointed as a major problem for WHO estimations (e.g. Pedersen, 2002). While WHR00 accepted the role of income per capita as a potential determinant of health it was argued that the inclusion of income (measured as GDP per capita) would produce problems of multicollinearity in the estimations. In HSPA03, it is suggested that part of the correlation between income and health stems from increased access to medical care due to higher income. The residuals of the regression of income per capita on health care expenditures and education were entered in the equation explaining DALE, rather than income per capita itself, and were found to be non significant. Gravelle et al. (2002) show however that the pure effect of health care expenditure (entering the residual of a regression of health care expenditure on income in the equation explaining health, controlling for income and education) is not significant either. They conclude that WHR00 has made an arbitrary choice in choosing expenditure rather than income per capita[9].

The exclusion of income inequality (briefly mentioned in HSPA03) as a potential determinant of health did not get much attention in the literature even though it can be considered as an important factor determining health status beyond the reach of the health

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[7] Expenditures are measured in international dollars (using the Purchasing Power Parity index)

[8] Pedersen (2002) points out that such a two step procedure is inconsistent since it assumes that residuals are identically distributed in the first step then vary systematically with explanatory variables in the second step. The standard procedure would be to include all factors in the same step.

[9] Singling out health care expenditures as the sole input raises other issues, among which the fact that using current health expenditure as a factor of current life expectancy the chosen model does not recognize the important time lags that exist in producing health outcomes (SRPG, 2002, Grignon, 2001). The WHO team addresses this issue in the HSPA volume (WHO, 2003, page 701) in that they suggest using incidence DALE (or HALE, Health Adjusted Life Expectancy as the terminology has evolved in 2003) instead of prevalence DALE as their measure of output.

care sector. WHR00 and HSPA03 do not provide any argument (theoretical or econometric) for this choice. Using the same data as WHR00, and adding the GINI index of income distributions, Greene (2004) shows that inequality of income is a strong and significant determinant of average health in a country.

Appendix 3: simulations of the impact of education on performance (comparative static).

Using the estimated parameters of the production frontier, we can calculate the performance of fictitious countries. Creating countries with values for DALE and EXP similar to the French ones and attributing to these fictitious countries values for EDU chosen among those of other rich countries (Canada, Denmark, Finland, Japan, New Zealand, Norway, Sweden, the United-Kingdom, the USA, as well as some Southern European countries) allows one to assess the impact of human capital on the performance of the health care system assuming the WHR00's production frontier is the true one. Such an exercise can be called simulation in that it creates virtual realities, even though it has nothing to do with what statisticians called simulations, or the use of Monte Carlo replications of a random phenomenon (I thank an anonymous referee for having pointed this ambiguity out in a previous version of the text).

How does it work? If one knows all the values used by WHR00 (including DALEmin), the logic is straightforward and goes without saying. However, as mentioned by Petersen (2001), the key Discussion Paper #7 in the HSPA series, which is supposed to provide all the data used by WHR00 has never been posted on the WHO website (I made a request to get the data, but was not able to get it). Hence, I had to deduce DALEmin from the other published data. For a given country, DALEmin is given by:

$$\mathbf{DALE_{min\ i} = (DALE_i - PERF_i \times E(DALE_{max} \mid EXP_i, EDU_i))/(1-PERF_i)}.$$

EDU has not been published either, therefore I used the data provided by Barro andLee (2000) and was able to infer values for DALEmin in an reasonable range (between 28 and 47, life expectancy was around 50 in 1913 in France, according to Bideau et al. 1988) for 30 countries, but not for Norway (1.5), Portugal (51.1), and Spain (65.7). Leaving these countries aside, and based on such calculated DALEmin, it appears that a country similar to France but with the human capital of Australia would have an efficiency smaller by 13.6 percentage points than that of France, if the WHR00 frontier were true.

Among countries penalized by their human capital level are found the U.S. (12.6 percentage points), New Zealand (12.4) and South Korea (10.1). Scandinavian countries are found just behind, in a category where human capital decreases performance by 10.3 to 8.4 percentage points.

Another way to describe the impact of human capital on performance, such as it is estimated in WHR00 is to measure the difference between the fictitious country (local EDU but French EXP and DALE) and the actual local country. It shows that human capital explains all the difference between France and Japan, Australia and Sweden, almost all the difference between Canada, the Netherlands and Switzerland. Neutralizing EDU reduces the difference between France and the U.K, Austria and Belgium to 3 percentage points of efficiency (instead of, respectively, 9.1, 13.0 and 9.6), between France and Finland, Germany and Ireland by 6 points (instead of 14.5, 13.8 and 11.5), between France and the U.S. by 7 points instead of 20.0 and between France and New Zealand by 8 points instead of 20.8.

These simulations show that EDU explains much of the difference in performance between France and comparable countries.

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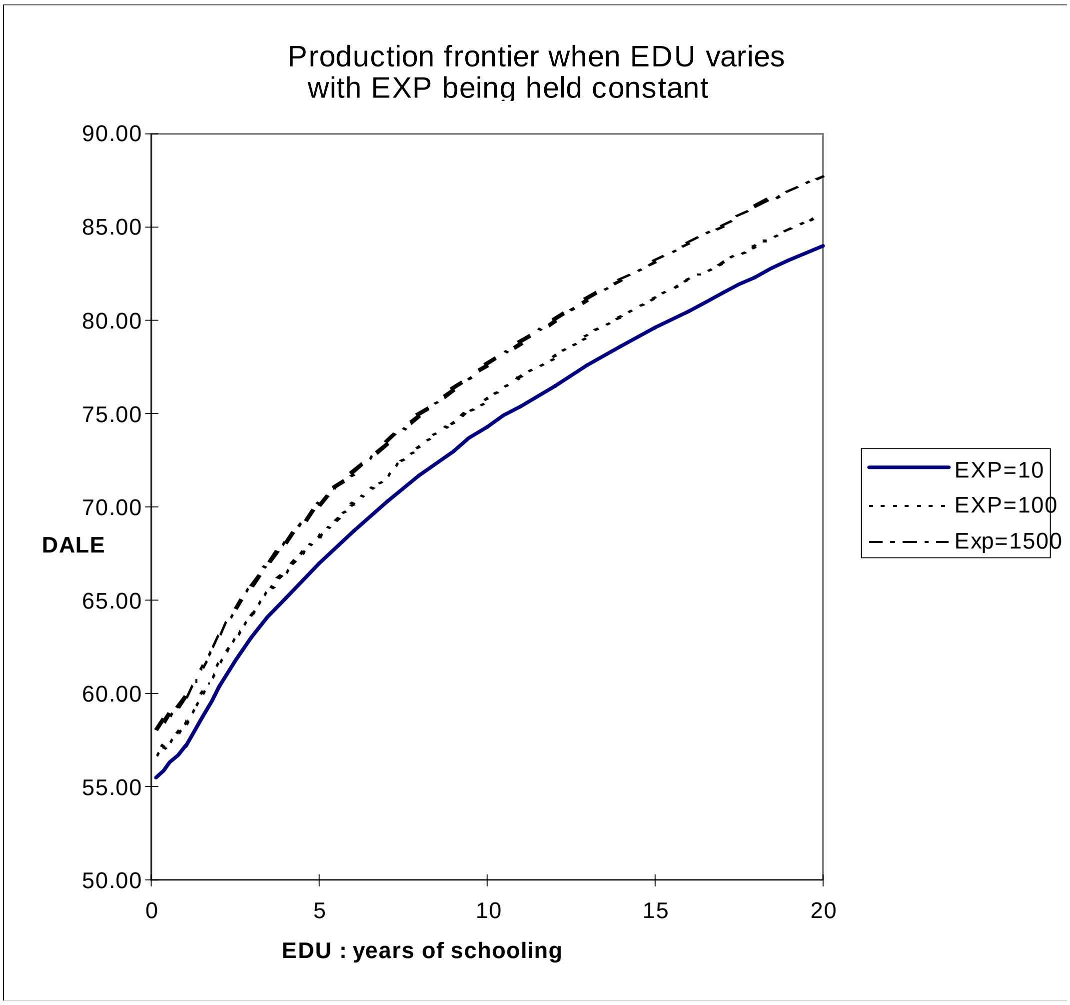
Figure 1:



Production frontier when EDU varies with EXP being held constant
90.00
85.00
80.00
75.00
70.00
65.00
60.00
55.00
50.00
DALE
0
5
10
15
20
EDU : years of schooling
EXP=10
EXP=100
Exp=1500

Table 1: descriptive statistics

	DALE 1997	HCX per capita 1997	Years of EDU 1995	GDP per capita 1997
Average all countries (N=191)	56.8	442.4	6.0	7385.4
Average EDU non missing (N=111)	57.3	553.6	6.0	8783.6
Average high EDU (N=57)	66.1	945.1	8.3	13898.8
Average low EDU (N=54)	48.1	140.3	3.6	3054.6
		$PPP	(Barro and Lee)	$PPP (World Bank)

Table 2: coefficients of a stochastic production frontier, composed error model, normal, half-normal, using WHR00 data (Gravelle et al, 2002) or a mix of WHR00 and Barro and Lee (2000) data (this study)

Coefficient	Gravelle et al. 2002 (data are WHR00, pooled, 141 countries used in the estimate)	This study (data are mixed WHR00 and Barro and Lee)
Intercept	+ 3.233	+ 3.125
Expenditures	+ 0.080	+ 0.109
Education	+ 0.240	+ 0.245
Education, squared	- 0.012	- 0.036
R2	0.69	0.68

Table 3: values of sum of squares of residuals in two equations of DALE on EXPENDITURES and EDU and EDU squared, each subset of countries being determined according to a threshold value for EDU

Threshold value (in years of education)	Numbers of countries below	SSR subset below threshold	SSR subset above threshold	Sum of SSRs
5.0	42	0.871	1.324	2.195
5.1	43	0.879	1.216	2.095
5.2	46	1.153	1.020	2.173
5.3	46	1.153	1.020	2.173
5.4	47	1.154	1.014	2.168
5.5	51	1.364	0.735	2.099
5.6	51	1.364	0.735	2.099
5.7	52	1.425	0.635	2.060
5.8	**54**	**1.428**	**0.604**	**2.032**
5.9	55	1.701	0.513	2.214
6.0	57	1.767	0.276	2.043
6.1	61	1.993	0.056	2.049
6.2	63	2.143	0.054	2.197
6.3	63	2.143	0.054	2.197
6.4	63	2.143	0.054	2.197
6.5	66	2.250	0.048	2.298
6.6	66	2.250	0.048	2.298

6.7	67	2.255	0.048	2.303
6.8	68	2.256	0.048	2.304

Table 4: values of coefficients estimated on both subsets of countries for the production frontiers:

Coefficient	Low education countries (below 5.8) N=54	High education countries (above 5.8) N=57
Intercept	+ 3.35	+ 1.09
Expenditure	+ 0.10	+ 0.04
Education	+ 0.29	+ 2.78
Education, squared	- 0.05	- 0.65
Sigma v (random term)	0.028	0.000
Sigma u (efficiency term)	0.276	0.138

Data and table 5 (efficiencies and ranks):

Country	DALE	HCX (per capita, in PPP)	Years of EDU (Barro and Lee 1995)	GDP per capita 1997 PPP$ Source: WB	TE EDU smaller than 5.8 //	Rank among countries EDU smaller than 5.8	Technical Efficiency, Frontier estimation restricted to countries with EDU greater than 5.8 // Corrected Error Model, Normal - Half Normal	Rank among countries EDU greater than 5.8	Rank in WHR00 among countries with EDU GT 5.8	Difference
Norway	71.7	1708	11.7	31737.13			1.000	1	8	7
Cuba	68.4	109	7.54				1.000	2	20	18
Spain	72.8	1211	6.83	17097.24			1.000	3	3	0
Croatia	67.0	410	6.06	7775.68			1.000	4	27	23
Sweden	73.0	1943	11.23	21064.48			0.999	5	10	5
Canada	72.0	1836	11.39	23731.08			0.992	6	19	13
Australia	73.2	1601	10.67	23275.15			0.992	7	21	14
Italy	72.7	1824	6.85	22402.58			0.984	8	1	-7
China	62.3	74	6.11	2997.31			0.984	9	28	19
Japan	74.5	1759	9.23	24498.57			0.980	10	4	-6
Singapore	69.3	750	6.72	19939.05			0.973	11	6	-5
Greece	72.5	964	8.32	14195.05			0.972	12	5	-7
Sri Lanka	62.8	77	6.45	2948.35			0.969	13	32	19

New Zealand	69.2	1393	11.49	18035.99	0.965	14	38	24
France	73.1	2125	7.42	22193.71	0.965	15	2	-13
Paraguay	63.0	206	6.1	4708.81	0.961	16	26	10
United States of America	70.0	3724	11.89	30483.03	0.957	17	36	19
Switzerland	72.5	2644	10.31	26194.41	0.957	18	14	-4
United Kingdom	71.7	1193	9.09	21661.19	0.955	19	13	-6
Chile	68.6	581	7.25	8502.83	0.953	20	12	-8
Slovenia	68.4	996	6.84	13954.79	0.946	21	29	8
Cyprus	69.8	731	8.91	14230.79	0.945	22	11	-11
Venezuela, Bolivarian Republic of	65.0	298	6.69	5973.89	0.945	23	17	-6
Netherlands	72.0	1911	9.12	23438.9	0.943	24	9	-15
Belgium	71.6	1738	9.1	23255.23	0.941	25	16	-9
Guyana	60.2	130	6	4040.11	0.941	26	48	22
Austria	71.6	1960	8.05	24230.1	0.938	27	7	-20
Kuwait	63.2	605	5.96	15380.26	0.938	28	34	6
Finland	70.5	1539	9.65	21304.34	0.936	29	24	-5
Israel	70.4	1402	9.45	18080.68	0.935	30	22	-8
Ecuador	61.0	186	6.14	3250.84	0.931	31	45	14
Germany	70.4	2365	10.03	23289.23	0.928	32	23	-9
Czech Republic	68.0	640	9.33	12646.11	0.928	33	39	6
Iceland	70.8	1757	8.48	24293.94	0.928	34	15	-19
Ireland	69.6	1200	9.08	21540.8	0.927	35	18	-17

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Poland	66.2	392	9.64	8345.58			0.923	36	43	7
Mexico	65.0	421	6.96	7703.2			0.922	37	30	-7
Uruguay	67.0	849	7.31	8568.14			0.917	38	25	-13
Bulgaria	64.4	193	9.26	5189.41			0.916	39	44	5
Malaysia	61.4	202	6.49	8292.8			0.914	40	40	0
Denmark	69.4	1940	9.39	25979.5 6			0.911	41	31	-10
Trinidad and Tobago	64.6	325	7.44	7162.67			0.911	42	37	-5
Slovakia	66.6	574	9.09	10016.5 4			0.910	43	42	-1
Panama	66.0	449	8.36	5392.46			0.909	44	33	-11
Thailand	60.2	327	6.08	6397.77			0.905	45	47	2
Romania	62.3	136	9.42	5743			0.899	46	51	5
Republic of Korea	65.0	862	10.56	13425.7 8			0.898	47	50	3
Argentina	66.7	823	8.46	12015.5 5			0.898	48	35	-13
Jordan	60.0	178	6.47	3790.45			0.898	49	46	-3
Hungary	64.1	372	8.83	10388.1 4			0.888	50	49	-1
Barbados	65.0	814	8.34	13353.2 9			0.876	51	41	-10
Russian Federation	61.3	251	9.77	6132.26			0.869	52	55	3
Philippines	58.9	100	7.88	3738.37			0.858	53	54	1
Peru	59.4	246	7.31	4567.22			0.849	54	52	-2
Fiji	59.4	214	8.08	4633.64			0.841	55	53	-2
South Africa	39.8	396	6.03	9063.68			0.596	56	56	0
Botswana	32.3	219	5.86	6082.18			0.500	57	57	0
Indonesia	59.7	56	4.55	3148.66	0.984	1				
Nepal	49.5	41	2.01	1189.18	0.982	2				
Jamaica	67.3	212	5.02	3461.2	0.977	3				
Gambia	48.3	52	1.95	1507.8	0.966	4				

Algeria	61.6	122	4.83	4846.16	0.963	5
Pakistan	55.9	71	3.92	1748.68	0.953	6
Guinea-Bissau	37.2	54	0.78	983.38	0.952	7
Honduras	61.1	156	4.5	2482.64	0.947	8
Dominican Republic	62.5	202	4.66	4958.4	0.940	9
Guatemala	54.3	87	3.25	3620.48	0.939	10
Myanmar	51.6	78	2.64		0.938	11
Bangladesh	49.9	70	2.41	1338.14	0.935	12
Turkey	62.9	231	5.12	5886.62	0.922	13
Syrian Arab Republic	58.8	109	5.48	3145.27	0.920	14
Egypt	58.5	118	4.98	3047.14	0.919	15
Nicaragua	58.1	150	4.09	2953.19	0.918	16
El Salvador	61.5	228	4.7	4281.34	0.915	17
Tunisia	61.4	239	4.53	5316.44	0.913	19
Iraq	55.3	110	3.74		0.913	18
Iran, Islamic Republic of	60.5	200	4.73	5348.78	0.911	20
Mali	33.1	34	0.76	701.25	0.896	21
Costa Rica	66.7	489	5.77	7111.32	0.895	22
Sudan	43.0	43	1.93	1395.5	0.887	23
Mauritius	62.7	288	5.79	8179.66	0.886	24
India	53.2	84	4.52	2055.76	0.876	25
Portugal	69.3	1060	5.47	14807.55	0.870	26
Afghanistan	37.7	28	1.48		0.864	27
Bahrain	64.4	539	5.5	14352.49	0.862	28
Papua New Guinea	47.0	77	2.58	2413.92	0.861	29
Colombia	62.9	507	4.96	6176.4	0.859	31

Benin	42.2	39	2.14	874.33	0.859	30
Senegal	44.6	71	2.39	1303.36	0.836	32
Brazil	59.1	428	4.45	6859.48	0.833	33
Ghana	45.5	45	3.75	1735.4	0.821	34
Mozambique	34.4	50	1.03	714.16	0.820	35
Haiti	43.8	55	2.83	1675	0.815	36
Bolivia	53.3	153	5.31	2247.52	0.811	37
Togo	40.7	34	3.15	1687.72	0.778	38
Niger	29.1	27	0.93	733.43	0.760	39
Democratic Republic of the Congo	36.3	22	2.89	773.47	0.736	40
Uganda	32.7	44	3.37	1078.06	0.729	41
Central African Republic	36.0	34	2.45	1052.18	0.724	42
Congo	45.1	101	5.12	916.04	0.719	43
United Republic of Tanzania	36.0	36	2.68	471.23	0.706	44
Liberia	34.0	33	2.29		0.695	45
Kenya	39.3	58	4.01	1007.59	0.686	46
Rwanda	32.8	35	2.36	927.85	0.662	47
Lesotho	36.9	100	4.06	2084.41	0.610	48
Cameroon	42.2	86	3.37	1672.22	0.604	49
Swaziland	38.1	118	5.63	3922.49	0.592	50
Malawi	29.4	49	2.7	557.75	0.560	51
Sierra Leone	25.9	31	2.27	492.73	0.534	52
Zimbabwe	32.9	130	5.19	2725.08	0.513	53
Zambia	30.3	64	5.42	762.5	0.504	54
Albania	60.0	63		2654.72		
Andorra	72.3	1216				
Angola	38.0	47		1718.41		

Armenia	66.7	152	1839.12
Azerbaijan	63.7	48	1816.05
Bahamas	59.1	1230	14798.6 9
Belarus	61.7	253	3831.14
Bhutan	51.8	82	
Bosnia and Herzegovina	64.9	145	4575.09
Burkina Faso	35.5	37	949.12
Cambodia	45.7	73	1424.29
Cape Verde	57.6	60	3875.75
Chad	39.4	35	848.15
Comoros	46.8	47	1640.14
Cook Islands	63.4	345	
Côte d'Ivoire	42.8	57	1557.89
Democratic People's Republic of Korea	52.3	39	
Djibouti	37.9	48	1934.7
Equatorial Guinea	44.1	89	3561.94
Eritrea	37.7	24	850.37
Ethiopia	33.5	20	628.4
Gabon	47.8	196	6314.59
Georgia	66.3	94	1646.17
Grenada	65.5	298	5650.43
Guinea	37.8	52	1809.53
Kazakhstan	56.4	127	3602.34
Kiribati	55.3	152	
Kyrgyzstan	56.3	66	1351.57
Lao People's Democratic Republic	46.1	53	1335.24

Latvia	62.2	246	6051.61
Lebanon	60.6	563	4148.18
Lithuania	64.1	273	7453.33
Luxembourg	71.1	1985	39677.65
Madagascar	36.6	18	760.88
Maldives	53.9	248	
Malta	70.5	755	14645.05
Marshall Islands	56.8	238	
Micronesia, Federated States of	59.6	234	
Monaco	72.4	1799	
Mongolia	53.8	69	1470.09
Morocco	59.1	159	3234.79
Nauru	52.5	602	
Nigeria	38.3	35	804.34
Niue	61.6	92	
Oman	63.0	334	11664.97
Palau	59.0	559	
Qatar	63.5	1105	
Republic of Moldova	61.5	133	1357.33
Saint Kitts and Nevis	61.6	489	10626.59
Saint Lucia	65.0	218	5196.71
Saint Vincent and the Grenadines	66.4	210	4634.35
Samoa	60.5	108	4421.06
San Marino	72.3	1301	
Sao Tome and Principe	53.5	45	
Saudi Arabia	64.5	332	11921.9

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Somalia	36.4	11	
Suriname	62.7	257	
Tajikistan	57.3	94	656.7
The former Yugoslav Republic of Macedonia	63.7	141	5650.24
Tonga	62.9	257	5083.93
Turkmenistan	54.3	90	2265.12
Tuvalu	57.4	59	
Ukraine	63.0	128	3628.82
Uzbekistan	60.2	109	1328.46
Viet Nam	58.2	65	1696.58
Yugoslavia	66.1	127	
Antigua and Barbuda	65.8	598	9132.62
Belize	60.9	212	4652.87
Brunei Darussalam	64.4	857	
Burundi	34.6	26	585.54
Dominica	69.8	286	4984.48
Estonia	63.1	346	8373.18
Libyan Arab Jamahiriya	59.3	221	
Mauritania	41.4	73	1601.82
Namibia	35.6	312	5697.61
Seychelles	59.3	470	
Solomon Islands	54.9	83	2277.75
United Arab Emirates	65.4	816	20372.8 5
Vanuatu	52.8	85	3131.24
Yemen	49.7	33	739.26