INVESTIGATING THE ROLE OF HEALTH: IS IT REALLY AN INTANGIBLE RESOURCE FOR ECONOMIC GROWTH?

by

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In this study I investigate the empirical evidence of health factor influence on economic growth in different country groups. A particular attention is paid to the research of health peculiarities in the countries with transition economies. Based on the PCA method I construct four different health indices including eight health factors that could proxy for health. Extending production function model of economic growth by constructed health indices I examine the influence of health factor on the real output. The main finding is that under majority of specifications health indices were found to be positive and significant. The influence of health on productivity growth in transition countries does not differ much from the health influence on productivity in the other countries groups. Under stochastic frontier estimation approach, in terms of coefficients the health influence on output was also found to be positive and significant. The main findings provide the grounds to claim that health is an important factor for the output growth, and the governments should consider for the nexus between health and productivity when deciding for different policy implications.
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<tr>
<td>IV</td>
<td>Instrumental Variable</td>
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<tr>
<td>Immunization DPT</td>
<td>Immunization from Diphtheria, Pertussis, Tetanus</td>
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<td>CIS</td>
<td>Commonwealth of Independent States</td>
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<td>EU</td>
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<td>GDP</td>
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<td>Gross National Income</td>
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<td>PCA</td>
<td>Principal Component Analysis</td>
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<td>ROW</td>
<td>Rest of the World</td>
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Chapter 1

INTRODUCTION

The idea that a healthy person is likely to be more productive, more able to be educated and more effective than one with poor health is not a new one. Moreover, the most recent research provides a clear evidence of economic benefits of better health. It has already been investigated that healthy people get better jobs and are able to earn more than unhealthy people do (Bliss and Stern, 1970; Ross and Mirovsky, 1995). This means that general health improvements, given the same level of combination of skills, physical capital and technological knowledge, should increase a country’s productivity, which in its own turn is an important factor of a country’s economic growth (Howitt, 2005).

In modern economic theory two approaches are applied for investigating the influence of health on productivity at both micro- and macro- levels. The first type of research is concentrated at the level of households and individuals, investigating the interdependence between people’s health and their productivity and income. The second one is a comparison of economic performance of different countries over time, using proxy indicators for health such as life expectancy, total fertility rate and GDP. I am going to focus my research on the second one. Motivation for investigating this question is that in transition countries there is no such a strong correlation between education and productivity, as large amount of population even with higher education show low income and productivity, in this case health might better explain human capital and be significant for explaining growth. The second reason is that for now there are no empirical studies on the impact of health capital on economic growth in CIS countries considering for peculiarities in determinants of economic growth and health systems, including such factors as structural economical changes, CO₂ pollutions, immunizations, quality of political institutions, physicians per 1000 people, increase in tobacco and alcohol consumption due to stress of uncertainty etc.
While doing my research I am going to apply two approaches.

Considering for the estimation of health influence on economic growth proposed by Bloom (2001) I’ll try to model the proxy determinants of economic growth with the emphasis on variables that approximate health. The novelty of my research at this step will be that for modeling health index I will apply the Principle Component Analysis that will allow constructing a health index considering for eight different factors that could possibly proxy for health. In order to compare the influence of health on productivity in transition countries versus the other countries groups the model specification including dummy variables for transition countries are estimated.

In most cases it is difficult to sort out the nature of the relationship between health and income. If income is very low, health suffers, sometimes to the point of death and vice versa, a person in a very poor health may have no capacity to create wealth. The same trend can be observed on the level of countries, wealthy countries are always found to be healthier than poor ones, and of course the poor countries are both less healthy and as a result less productive. At this point it is difficult to determine what initially causes what, and as a result the problem of endogeneity arises. Finding of an appropriate instrumental variable can allow for a possible solution to this problem.

The second approach will consider for the importance of health factor in explaining the efficiency in production function for the countries in transition vs the ROW countries classified by income. I am going to estimate the stochastic frontier of the production function of different countries at the first step without health variable, and at the next step considering for the health variables. This will give the evidence, how important health can be in terms of explaining the inefficiencies.

This paper will consist of several parts.

The next chapter is literature review of the papers already written on the subject and general conclusions found for most countries investigated, including those in transition.
In the third chapter the data description is be presented with short variables description and summary statistics on each of the variables, which are included in the empirical model.

In the fourth chapter the methodology is analyzed. The main description of the model, advantages and disadvantages of both applied in the estimation part methods.

The fourth chapter is dedicated to empirical estimations on the basis of model. The results received are analyzed and compared to the expected; basically in this part I check for the hypothesis on the importance of health factor in economic growth of countries with transition economies.

In the conclusive chapter the results obtained are discussed, possible policy implementations are provided, and of course questions of interest for future investigations in this area are formulated.
LITERATURE REVIEW

Nowadays the idea of health as one of the most important factors in human capital is quite spread in the scientific world. The identity of being “healthy is successful” or “health is wealth” is a key one in cultures of most countries. No doubt that health is important on both individual and overall nation's levels. In a global survey prepared for the Millennium Summit of the United Nations a good health was ranked as the number one desire of men and women around the world. For any individual health is an important asset for personal development and future prosperity. It is the basis of the capacity to learn at school, of the ability to grow intellectually and physically; moreover it’s one of the cornerstones of an individual economic productivity. The health of the population is determined by the health of separated households or individuals, so in the long run this fact makes possible to treat health as the inevitable factor for economic development at the scale of whole nation. The same logic can be applied in case of alternative approach – economic costs of being ill. Sickness decreases the annual income of the society, diminishes the lifetime income of the individuals, and causes the slow downs in economic growth, which expressed in money equivalent, could be equated to the hundreds of billions of US dollars (Gwatkin, 2000).

Taking into consideration the multidirectional influence of health, the literature devoted to this topic can be classified into two basic directions micro-oriented, which considers health impact at the individual and household level, and macro-oriented which estimates the contribution of health on the economy overall.

The studies devoted to the economic impact of health at the individual (micro) level usually consider such questions as the impact of health on wages, earnings, the amount of hours worked, labor force participation, personal education, early retirement and labor supply and the importance of physiology in earnings and wages. The key questions of the
Macro effects are aggregated effect of the abovementioned factors on the country level in terms of GDP or the GDP growth rate. This research is mostly concentrated on the macro level questions, particularly I apply the principle component analysis in order to model the health index, including different health factors that can influence the health on the country level and then investigate the influence of constructed health index on economic growth of different countries groups with particular analysis of the Eastern Europe transition countries.

The interest to the relationship between health and economic growth is not a new one in the literature, but the new wave of discussion in considerable extent was raised by The World Bank report on health 1993 (World Bank 1993). The studies in this area can be examined in two aspects: including either theoretical and empirical analysis or just empirical one.

**Papers Considering both Theoretical and Empirical Research**

In a theoretical basis, Grossman (1972) developed the model that set health capital formation as a capital good, which was able to produce domestic goods and to earn money. His model assumes health as initial endowment, depreciating with age and growing with investment in health. The basic conclusions of the model are that the productive nature of health is when a good state of health allows for a more effective performance in the job and study. He considered demand for medical services and main determinants of health capital accumulation to be determined by wages, age and level of education.

The Nobel laureate Robert Fogel was among the pioneers in developing models that included health capital specifically. Fogel (1994) examined the contribution of health improvement to the economic development of several countries over one or two centuries. His investigations gave an explanation to the relationship between body size and food supply and showed it to be critical for long-term labor productivity (Report of the Commission on Macroeconomics and Health, WHO, 2001). Fogel states that increase in the amount of calories available for work over the past 200 years in Europe
have been importantly boosted by the increased availability of calories in the diet, as well as by advances in public health and medical technologies, which in its own case resulted in huge productivity growth (Fogel, 1994).

Sorkin (1977) was the first one to conclude that health in terms of reduction in mortality had a significant effect on economic growth at the beginning of the 20th century. Sorkin separated the influence of health on the economy in developing and developed countries. He found that improvement of health status of the developed countries population would have insignificant influence on economic growth, while in developing countries the expected result is vice versa.

The majority studies that examine the effect of health on economic growth widely use theoretical framework that underlies the specification of the conditional convergence model developed by Barro and Sala-i-Martin (1995). Common empirical estimation based on this theoretical framework focuses on the cross-section of countries. The standard approach is to regress the rate of growth income per capita on the initial level of health, which is typically proxied by life expectancy or adult survival rate. The possible problem that can arise underlies in the idea that countries can be very different in income level, so to control for the initial level of income and for some other factors that could possibly influence steady state income levels different authors include various policy variables such as institutions (Knack and Keefer(1995)), measure of openness to trade, which in its own turn also depends on country-specific market institutions (Sachs and Warner (1995)), measure of ethno-linguistic fractionalization (Easterly and Levine (1997), variables that control for geographical factors that possibly influence the productivity and trading opportunities (Gallup, Sachs et al.) etc.

Hamoudi and Sachs (1999); Bloom and Canning (2000); Bloom, Canning and Graham (2003) consider different ways through which health improvements can influence the pace of income growth influencing the changes on worker productivity, labor market participation, investments in human capital, saving, population and age structure. Empirical approach peculiar to the previously considered papers for studying the health impact on economic growth is based on above mentioned Barro and Sala-i-
Martin theoretical framework. All these studies differ in terms of functional forms, data definitions and configurations, country samples, time trends etc., but important is the fact that the results of these papers in terms of parameter estimates of life expectancy and age structure on economic growth are quite comparable.

Also following Barro and Sala-i-Martin theoretical framework Bloom, Canning and Sevilla (2001) extend production function model of economic growth in order to account for to fundamental components of human capital from the point of view of microeconomics such as work experience and health. In previous works health in form of life expectancy was widely used in many cross country regressions, and in most papers it was found to have significant and positive effect on economic growth, but before it was not clearly indicated whether health directly influences growth or it is just a proxy for the other possible missing factors. To test for the existence of a true effect of health on labor productivity and to estimate its strength Bloom et al include health and experience in a well specified production function. The variable experience, along with political institutions and geography function is included to avoid the problem of overestimation of contribution of health variable. In result the authors found that “a one year improvement in population’s life expectancy contributes to a 4 per cent increase in output”, when experience and experience squared were found to be insignificant. The other aspect of the model used is that it “considers for the efficiency with which the inputs are used”, by other words it considers for the total factor productivity, estimating it under assumption that steady state TFP levels are the same in every country. In my research I would estimate a production function model of economic growth, keeping the specification as close as possible to that of Bloom, Canning and Sevilla (2001) in order to facilitate the comparison between estimates obtained in my model to the result obtained by the authors. To improve the model instead of life expectancy as a proxy for health I will construct a health index including 8 different factors which influence health both on the individual and country level and aggregated could be considered as a more efficient proxy for health. To consider for the efficiency with which the different country groups use their inputs I would apply the other different from the Bloom et al (2001) method, in particular Simor and Wilson (2005) efficiency estimation. Applying the Simor and Wilson (2005) method to the same specified production function I would estimate how much of
the inefficiency of the production frontier of different country groups can be explained in terms of health. The second approach allows alternatively estimate the influence of health factor on countries’ growth productivity, which can also be considered as advantage. Along with considering on health index and applying the alternative estimation approach I would also consider peculiarly for the transition countries in terms of including dummy for this particular group. The interest to this particular country group is motivated by to reasons: 1) the research of health factor on productivity growth considering for this counties group has not been done yet and is not considered in above mentioned paper, this fact can be explained by poor data availability because of historical and political peculiarities of these countries; 2) education in the Eastern Europe transition countries do not correlate so much with income as it does in other countries of the world, which can be explained by the fact that higher education was free of charge and available almost for everybody, and now there are many people who have higher education and do not have job or have low level of income.

Bhargava et al. (2001) applied different approaches to modeling the proximate determinants of economic growth with emphasis on variables that approximate health of the population. They developed an analytical framework within which issues of human development, capital formation, and demographic transition can be discussed. The models developed include stochastic properties of GDP series and consider for data limitations. For investigation of stochastic properties of the GDP series from Penn World Table and World Development Indicators the authors applied fixed effect framework and dynamic random effects models. Average growth rates at 5 years intervals were modeled via using model similar to Barro (1997) but allowing for some simultaneity and interactions between dependent variables. The results in estimated models showed that in spite of the rough approximation of individual’s health in national averages there is significant effect of adult survival rate on economic growth for low-income countries. A novelty of the paper was in the ability of authors to estimate the threshold point beyond which adult surviving rate had negligible effect on growth rates; confidence intervals estimated for the net impact of adult surviving rate on economic growth proved the asymmetries for poor and rich countries. The main drawback of given research rather unevenly available data for poor, middle and high income countries. Analyses
based on more complicated and precise data sets would allow sharper insights into the influence of health on economic growth.

Bloom and Canning (2005) “compare the size of macroeconomic estimates of the effect of health on worker productivity with the microeconomic estimates of the effect of health on wages. The authors estimated that one percentage point increase in adult survival rates increases labor productivity approximately by 2.8 per cent. The results obtain go along with the results received by Weil (2001), which basically are that health factor is strongly significant for the explanation in the cross-country differences of the income level per worker. Bloom and Canning conclude that judging by the estimation results, there is a strong evidence of larger role for health than for education.

Empirical Papers

Early empirical research of the impact of health on economic growth belongs to Malenbaum (1970). He investigated how the influence of health factor on output could be larger compared with other economic and social variables. To get the result he used a step wise regression equation with macroeconomic data of poor countries, where independent variable was agriculture output and dependent variables were social, economic and health data.

Mankiw et al. (1992) enlarged the Solow growth model by adding human capital as a determinant variable for economic growth. They showed that the augmented Solow model provides an excellent description of the cross-country data. Improved model explains 80% of the international variation in income per capita. The estimated influences of physical capital accumulation, population growth and human capital accumulation confirm the model's prediction.

Following a Ramsey scheme, Barro (1996) developed a growth model, which included physical capital inputs determined by health capital, level of education and the number of worked hours. The result of the first order condition demonstrated the diminishing marginal returns to investment in health and found out that “increase in health indicators raises the incentives to invest in education and raise in health capital
lowers the rate of depreciation of health" (Aguayo-Rico et al., 2005). In particular, Barro received a significantly positive effect of health (measured by life expectancy) on economic growth, and the size of effect appeared to be bigger than the effect of education. But in this case he noted the problem of reverse causality. “Better health tends to enhance economic growth in various ways. At the same time, economic advance encourages further accumulation of health capital”

Based on the idea that people in rich countries are on average healthier than people in poor countries, Weil (2005) evaluates the extent to which these gaps in health can help explain the income gaps. The problem of endogeneity of health variable almost excludes the possibility of using aggregated data for estimation of structural effect of health on income. Besides, Weil applies a kind of novelty in estimation approach; basically he takes “microeconomics estimates of the health effect based on individual outcomes for constructing macroeconomic estimates of the proximate effect of health on GDP per capita” or by other words he uses microeconomic results for answering macroeconomic question of the magnitude in income variation among countries could be explained by health. The effect of health on income estimated via such methodology is quite large and significant. So, using the adult survival rate for man as one of possible measures for health, Weil found that 22.6% of log GDP variance per worker is explained by health, and which is more important that decresing of health gaps among poor, middle and high developed countries would decrease the variance of log GDP by 36.6%. Such a result again verified the thought that health is one of the central determinants of income variation. The drawback of methodology is that it gives an opportunity to estimate only proximate effect of health. Moreover there exist a number of indirect channels through which health influences country-level output, that are not envisaged by the model (Weil, 2005).

The majorities of the authors investigating the problem base their research mostly on the data of poor African and high-developed European countries. For now there is relatively small number of the researches concerning the influence of health on and macro-economical level of countries in transition, despite there are some considering the micro-level.
Papers Including Transition Countries

Ivaschenko et al. (2002) tried to investigate the returns to health in the Ukrainian labor market. For getting more precise estimation, the author tested three different models: influence of health on wages; impact of health on labor supply, dependence of health on economic and social factors. The estimation results showed that health status had a significant effect on earnings in a way that a 1 per cent improvement in individual’s health on average increases the labor income by 1.1 and 1 percentage points for men and women respectively. Moreover, the authors found that the effect of health on labor income depends mostly on the type of job performed. The results of the paper are important not only for Ukraine but also for the countries of the former Soviet Union, as the labor market of these countries has very much in common with Ukrainian one.

Nazarova (2003) analyzed the individual behavior in respect of one’s health. The results of the research showed that there is no strong dependency between income and self reported health level. Health is mostly affected by structural indicators of social and economic inequality. In a way that smoking, alcohol consumption, body mass and lifestyle on average are much less significant than job of a person, income and residence characteristics.

Tapilina (2004) conducts a quantitative and qualitative analysis of the dependence between health and income in Russia. The results obtained are quite controversial. She found both straight and inverse dependency between various health indicators and different economic statuses. The deviations on the following factors were investigated: objective economic status, age, number of years of education, frequency of alcohol and coffee consumption, overweight, environmental pollution. The strong evidence of relationship between health status and education level was not found.

As it can be concluded from the literature mentioned above, for the case of countries with transition economies there is quite much space to investigate. There are almost no researches that investigate the influence of health factor on aggregated macroeconomic level. That’s why the main goal of this paper is to determine some
special features of the health factor construct a health index and then estimate the influence of health index on economic growth applying two different approaches. The next section will further proceed with data and methodology description.
Chapter 3

DATA DESCRIPTION

For the purpose of empirical estimation of health factor influence on economic growth I construct a panel of 135 countries observed yearly from 1988 to 2003. As both stages of estimation are based on the Cobb-Douglas function I will need data on nations’ output, labor, physical capital and human capital consisting of health and education variables. Output data (GDP) are obtained from the WDI 2005 (World Development Indicators) by multiplying real per capita GDP measured in 2000 international PPP dollars by national total population.

Total population and labor force are taken from the database of International Labour Organization. Following the definition of International Labour Organization total labor force “comprises people who supply labor for the production of goods and services during a specified period. It includes both the employed and the unemployed. While national practices vary in the treatment of such groups as the armed forces and seasonal or part-time workers, in general the labor force includes the armed forces, the unemployed and first-time job-seekers, but excludes homemakers and other unpaid caregivers and workers in the informal sector”.

Proxy for capital stock for each time period is constructed applying the perpetual inventory method. The initial level of capital stock is calculated basing on the gross fixed capital formation, which is the same as gross domestic fixed investment in terms of SNA terminology of 1968. Gross fixed capital formation is taken as a proxy for the value of the first observed investment level. To calculate the initial level of capital stock, I apply the following formula:

1 Summers and Heston, (1991) methodology
\[ K_0 = \frac{I_0}{(\xi + \phi)} \]

where

- \( I_0 \) is the value of the first observed investment level,
- \( \xi \) is calculated as the average geometric growth rate of the investment series,
- \( \phi \) – the depreciation rate, which is assumed to be 0.07 following Summers and Heston (1991) methodology for all countries observed.

The average growth rate over \( n \) periods is calculated as

\[
r = \left( \prod_{t=1}^{n} r_t \right)^{\frac{1}{n}} - 1,
\]

where \( r_t = \frac{I_t}{I_{t-1}} \) is calculated for each country. Similar to the exponential growth rate, it does not take into account intermediate values of the series.

To calculate the stocks of capital in each following period the formula

\[
K_T = (1 - \phi)^T * K_0 + \sum_{t=0}^{T} I_t * (1 - \phi)^{T-t}
\]

is used for any \( t \) in the sample.

Human capital would be proxied in terms of education and health. The life expectancy, total fertility rate (births per woman), death rate crude (per 1000 people), birth rate crude(per 1000 people), immunization DPT (% of children under 12 months), immunization of measles (% of children under 12 months), physicians (per 1000 of people), CO₂ emissions (kt per 1000 people) variables are taken from the WDI 2005 and via application of principle component analysis will be used for constructing a health index, which in its own turn will be taken as the proxy for health. For education literacy
rate, adult total (% of population ages 15 and above) will be included. For quality of political institutions two variables will be considered, trade (% of GDP) and listed domestic companies, total. The intuition behind this variables is that the higher their value the better the quality of political institutions. So that if the country has good institutions it would definitely have more trade partnership. Listed domestic companies follow the same intuition.

All the data series mentioned would be used in the estimation of the health influence on economic growth of different groups of countries. Besides, as it was previously mentioned in my research I am going to pay special attention to the transition countries of the NIS group as the problem of health influence in this particular group has not been studied yet.

To estimate empirically the influence of health factor on economic growth in this particular group I am going to use the yearly data of 24 NIS countries from which 15 are former CIS countries (Belarus, Moldova, Russia, Ukraine, Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan, Estonia, Latvia and Lithuania) and other 9 countries which belonged to the socialist camp (Czech Republic, Slovakia, Poland, Hungary, Slovenia, Croatia, Albania, Bulgaria, Romania) for the period 1988-2003. Considering the problems data on transition countries usually suffers from, I'll try to use along with WDI 2005 huge and publicly available databases like “Health for All” (HFA) from World Health Organization and TransMONEE database from UNISEF. The advantage of HFA is that it contains detailed data on different socioeconomic indicators for most countries in transition, but the drawback is that for some of the countries of post USSR the data especially on some macroeconomic indicators is evidently overestimated. To double-check the reliability of the source I'll use TransMONEE database, which contains quite reliable data for macroeconomic indicators. Some data like GDP per capita, and life expectancy as it was previously mentioned would be taken from the WDI 2005.

Specifically for Ukraine Derzhkomstat (State Committee of Statistics) and the Ministry of Health statistical yearbooks are very helpful source of information, and
inspite their reliability for some series is a bit questionable they can serve as a benchmark for double-checking. For some problems connected with the transition processes in countries mentioned there are some gaps in data for 1989-1991 years, which if not random could result in unbalanced panel and possible estimation biases. One of the solutions of that kind of a problem could be including smaller number of observations or trial of some other proxies.

The empirical analysis will involve different variables that will proxy determinants of economic growth with particular interest to health proxy determinants. The idea is to construct several health indexes that would help to find optimal proxy for health particularly and determine their influence on economic growth of the countries that belong to the different groups, with particular interest to those in transition.

In the Appendix to this paper there are tables, which are basically the gist of my empirical part of the paper. One table contains the variables I am going to use in my empirical part of paper with short description and links to the sources mentioned. The other includes summary statistics, basically mean and standard deviation on each of the variables that would be included in model estimation.
METHODOLOGY

In this chapter I will try to analyze theoretical setup of the methods, which I use for the empirical estimation of the influence of health factor on economic growth. At the very first stage, I am going to construct a health index, which would consider for different factors that directly or indirectly influence the health on personal and overall country level. Constructing of such index could lead to the multicollinearity problem and as a result future inconsistent OLS estimators. To control for this problem I apply Principle Component Analysis (PCA), that allows concurrently considering for different factors and avoiding possible multicollinearity problem.

PCA is a non-parametric method of extracting relevant information from confusing datasets. In most cases it provides a roadmap for how to reduce a complex data set to a lower dimension one. Basically, this method implies that “a set of correlated variables would be transformed into the set of uncorrelated variables, which are ordered by reducing variability. The uncorrelated variables are linear combinations of the original variables and the last of these variables can be deleted with the minimum loss of real data.” The other advantage of the method is that it reduces the dimensionality of a data set while retaining maximum possible information. The method implies that the first principle component is the combination of variables explains the greatest amount of variation. The second defines the next largest amount of information. Theoretically, it can be as many principle components as there are variables. For calculating the Principle Components several algorithms can be applied. As the purpose of my research is other that the PCA method investigation, I simply will apply the algorithm proposed by the statistical package STATA. 8.2.

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2 Shlens, J. Tutorial on Principal Component Analysis: Derivation, Discussion and Singular Value Decomposition, Princeton, March 2003
Based on the health indexes obtained by PCA implication and on methodology proposed by Bloom (2001) I investigate the existence of the effect of health on labor productivity and measure its strength in a way of including health in a well-specified production function. In next steps of estimation I'll follow the method proposed by Bloom et al. (2001).

1) “Construct an aggregate production function, which will include a multidimensional human capital”, or by other words the variable, which would be expressed in 2 dimensions: education and health, where health would be proxied by a constructed health index and schooling by literacy rate as a percentage of literate population aged above 15.

2) Estimate all the parameters of the production function using panel data for transition countries for a period from 1989 till 2003 and find measure of the relative contribution of each of the inputs to economic growth.

The interesting fact is that most of the studies connected with growth theory are mostly cross-sectional not panel studies, though in my research I am going to use panel data. This could be explained by 2 reasons:

One of the novelties of this research is that I am going to investigate health influence on economic growth of countries with economies in transition. The novelty is good, but the problem is in the number of time periods. For today it’s about 16 or even 14, which is not enough for estimation long-run growth. The most optimistic number is 27, but this is also unreal number from the point of accessibility view. We have immediately to exclude Bosnia-Herzegovina, Macedonia and Yugoslavia from the sample as all these countries went through several years of civil war, so their health indicators would be very much disfigured.

The other problem, which may arise, is a lack of degrees of freedom. In this case again possible solution is a cross section for a huge sample of countries, where transition countries would be included via special dummy. In case data is available “panel data models at close to business cycle frequences”. 7-10 years panel datasets model can be
very good at solving the problems of endogeneity and omitted variables in case good instrumental variables would be found. So, considering for the previously mentioned reasons in this particular case panel data would produce more efficient estimators than the cross section model would do.

Assume world is a Cobb-Douglas, then the aggregate production function, which models output as the function of inputs will look like:

$$ Y = AK^\alpha L^\beta e^{\varphi_1S + \varphi_2 health\_index} $$  \hspace{1cm} (1)

where, $Y$ – Gross Domestic Product or output;

$A$ – stands for TFP;

$K$ – capital (to be calculated, method is still indefinite);

$L$ – labor force, proxied by population from 18-59 years old;

The last component stands for complicated human capital expressed in terms of education, $s$ – stands for years of schooling, health_index stands for health index, including different health variables from 4 main determinants of health defined by European Commission of Public Health: socioeconomic determinants, lifestyles, physical environment, health system. Considering for PCA applied for different health determinants along with applying it to the transition countries will be novelty to the methodology proposed by Bloom (2001).

To derive an equation for the log of output in country $i$ at time $t$ the next step would be taking logs of the aggregate production function:

$$ \ln Y_{it} = \ln A + \alpha \ln L_{it} + \beta \ln K_{it} + \eta_1 S + \eta_2 Health\_index + \epsilon_{it}, \hspace{1cm} (2) $$

where $\ln Y_{it}$, $\ln L_{it}$, $\ln K_{it}$ are the logs of output, labor and capital respectively, health_index and schooling would are not in log form because of assumed production function, $\epsilon_{it}$ - error term.
The regression obtained on equation (2) as it stands will be definitely suffering from reverse causality or endogeneity problem. While I am interested in measuring the contribution of health on output growth, output growth itself can cause the better health conditions and overall health improvement. For instance, the better the country performs in terms of growth, the larger investments can be done in improvement of people’s health. In statistical terms, reverse causality would cause correlation between “health” (independent variables) and the error term $\varepsilon_u$, which would result in the inconsistency of ordinary least square estimates of the coefficients.

For example, suppose the economy of some country $i$ is influenced by some positive shock $\varepsilon_u^i > 0$, that would increase the output, following the mechanism described above it will also influence health as an input variable. So observing increase in both parts of equation, the growth in output would be explained via growth in health input, when in reality the relationship could be exactly the opposite. To distinguish between the influence of health impact on economic growth or the effect of economic growth on health improvement the instrumental variable technique can be applied.

Based on the Wooldridge (2002) candidate for instrumental variable should satisfy two basic criteria. First, it should be correlated with the independent variables, in my case I am interested in health proxy index. Second, along with the previous restriction it should be uncorrelated with the error term $\varepsilon_u^i$.

First restriction implies that in case of existence of such an IV variable, any fluctuations in it would lead to fluctuations in independent variables. The second, in its own turn, controls for causality problem in a way that it does not allow influence of the error term on these fluctuations. In such a way “correlation between changes in output and the induced changes in the endogenous inputs can be interpreted as the casual effect of input increase on output increase, disentangled from reverse causality problem” Bloom (2001).
For preventing reverse causality problem in this particular estimation, I tried “marriages” as instrumental variable (marital status and health are strongly correlated (Fuchs V., 1997, p.30). The idea is that married people usually are healthier than unmarried or separated ones and during the period of crises or economic instability the number of divorces usually increases, while the number of marriages decreases. Applying for the case of transition countries, at the beginning of transition process I would assume decrease in marriages and increase in divorces, which would indirectly influence on health factors in general. From the figure 1 we could see that starting from the years of transition number of marriages in most post socialist countries sharply declines, when number of divorces (could be seen on the figure 2) vice versa tends to grow. Taking in consideration all the above-mentioned facts, marriages as an IV variable should satisfy at least first restriction.
Figure 1
Marriages in (1000s), 1989-2003

Source: TransMonee 2005

Figure 2
General Divorce Rate per 100 Marriages

Source: TransMonee 2005

In reality the idea with marriages as an IV variable was found invalid in case of transition countries, similar to Bloom (2001) I use lagged levels of health as valid IVs.
The next approach is based on the Simar (2005) stochastic frontier model. Following his methodology I estimate inefficiencies in production frontier of each country and clarify how much of this inefficiency could be explained by health factors. This method allows checking the assumption about the importance of health factor in different groups of countries along with the transition ones.

To simplify the estimation I’ll assume the same specification of the function as in the previous method.

For now in terms of method description, assume:

\[ Y_{it} = A(L)_i^\alpha (K)_i^\beta e^{s_i \text{Health\_index}} \]

Simar et al. (2005) applied the stochastic frontier estimation for the cross sectional data. Following their method I am going to use panel data, but hopefully there will be no much problems as STATA facilities gives opportunities to estimate frontier for panel data either.

For the ease of estimation we’ll turn the model in the log form:

\[ \ln Y_{it} = \ln A + \alpha \ln L_{it} + \beta \ln K_{it} + S_{it} + \text{Health\_index}_{it} + \varepsilon_{it}, \quad (2) \]

Based on Simar (2005) the error term is \( \varepsilon_{it} = v_i - u_i, i=1,\ldots,n \), where \( v \) – white noise and \( u \) – technical inefficiency:

The two-sided error term \( v \) is invariably assumed to be normally distributed, and \( u \) is assumed to be distributed half normal on the non-negative part of the real number line:

\[ v_i \xrightarrow{\text{id}} N(0, \sigma_v^2) \]

\[ u_i \xrightarrow{\text{id}} \mathbb{1} N(0, \sigma_u^2 \mathbb{1}) \]

(3)

(4)
Mean and variance of general residual term are:

\[ E(\varepsilon_i) = E(\varepsilon) = E(-u_i) - E(u) = -\sqrt{\frac{2}{\pi}} \sigma_u \]  

(5)

\[ V(u_i) = V(v_i - u_i) = V(v) + V(u) = \sigma_v^2 + \left(\frac{\pi - 2}{\pi}\right) \sigma_u^2 \]  

(6)

Distribution of the error term assuming between \( u \) and \( v \) is:

\[ f_\varepsilon(\varepsilon) = \frac{2}{\sigma} \phi\left(\frac{\varepsilon}{\sigma}\right) \left[1 - \Phi\left(\frac{\varepsilon \lambda}{\sigma}\right)\right] \quad -\infty \leq \varepsilon \leq +\infty. \]  

(7)

These were general estimation steps, now we’ll follow more applicable for this particular problem of investigation. Considering the distribution of an error term as in (10), we compose log-likelihood function, which will look like:

\[ \ln L(\lambda, \sigma^2 \mid \varepsilon_1, \ldots, \varepsilon_n) = \frac{n}{2} \ln\left(\frac{2}{\pi}\right) - \frac{n}{2} \ln(\sigma^2) - \frac{1}{2\sigma^2} \sum_{i=1}^{n} (\varepsilon_i)^2 + \sum_{i=1}^{n} \ln(1 - \Phi\left(\frac{\varepsilon_i \lambda}{\sigma}\right)) \]  

(8)

Changing factor parameters into the function in a way that

\[ \varepsilon_i = y_i - g(x_i), \quad i=1, \ldots, n \]  

will turn the function into

\[ \ln L(\beta, \lambda, \sigma^2 \mid x_1, \ldots, x_n; y_1, \ldots, y_n) = \frac{n}{2} \ln\left(\frac{2}{\pi}\right) - \frac{n}{2} \ln(\sigma^2) - \frac{1}{2\sigma^2} \sum_{i=1}^{n} (y_i - g(x_i))^2 + \sum_{i=1}^{n} \ln(1 - \Phi\left(\frac{y_i - g(x_i) \lambda}{\sigma}\right)) \]  

(9)
Then following the procedure we have to maximize (12) w.r.t. the function parameters \( \sigma^2, \lambda, \beta \).

\[
\frac{\partial}{\partial \sigma^2} \ln L(\beta, \lambda, \sigma^2 \mid \ldots) = -\frac{n}{2\sigma_{MLE}^2} + \frac{1}{2\sigma_{MLE}^2} \sum_{i=1}^{n} (y_i - g(x_i))^2 + \\
+ \frac{\lambda}{2\sigma_{MLE}^2} \sum_{i=1}^{n} \phi((y_i - g(x_i))\lambda_{MLE}\sigma_{MLE}^{-1}) (y_i - g(x_i)) = 0
\]

(10)

\[
\frac{\partial}{\partial \lambda} \ln L(\beta, \lambda, \sigma^2 \mid \ldots) = -
\]

\[
\frac{1}{\sigma_{MLE}} \sum_{i=1}^{n} \phi((y_i - g(x_i))\lambda_{MLE}\sigma_{MLE}^{-1}) (y_i - g(x_i)) = 0
\]

(11)

\[
\nabla_\beta \ln L(\beta, \lambda, \sigma^2 \mid \ldots) = \frac{1}{\sigma_{MLE}} \sum_{i=1}^{n} (y_i - g(x_i)) \cdot \nabla_\beta g(x_i) + \\
+ \frac{\lambda_{MLE}}{\sigma_{MLE}} \sum_{i=1}^{n} \phi((y_i - g(x_i))\lambda_{MLE}\sigma_{MLE}^{-1}) \nabla_\beta g(x_i) = 0
\]

(12)

After solving the system of K+2 equations (4 in the particular case) we'll get the MLE estimates \((\beta_{MLE}, \lambda_{MLE}, \sigma_{MLE}^2)\)

Then the expectation of expected individual inefficiency is

\[
E(u_i \mid \epsilon_i) \equiv \int_0^{\epsilon_i} f_{u \mid \epsilon}(u \mid \epsilon) du
\]

(13)

\[
f_{u \mid \epsilon}(u \mid \epsilon) \equiv \frac{f_{u \epsilon}(u, \epsilon)}{f_{\epsilon}(\epsilon)}
\]

(14)

Where the distribution is presented in a way:
The mean of the individual expected inefficiency is

\[ E(u \mid \varepsilon) \equiv \sigma \left[ \frac{\varepsilon \lambda}{\sigma} + \frac{\phi(\varepsilon \lambda / \sigma)}{1 - \Phi(\varepsilon \lambda / \sigma)} \right] \]  

\[ u \geq 0 \]  

To measure efficiency we have to obtain:

\[ E[\exp(-u_i)] \]  

But because we obtain expectations of \( u \), we can’t directly receive the Afriat measure, that is the problem arises which can be reflected by Jensen’s inequality that

\[ \exp(E(u_i)) \neq E[\exp(-u_i)], \]  

actually \( \exp(E(u_i)) \leq E[\exp(-u_i)] \)

But the problem is kind of solved by applying numerical methods – Taylor-expand the measure:

\[ E[\exp(-u_i)] \equiv 1 - \mu, \]  

In the next chapter will proceed with the empirical application of the method described above.
CHAPTER 5

EMPirical Estimations and Results

Based on methodology provided previously, in this chapter I will try empirically analyze the influence of health factors along with usual factors on the productivity of different countries proxied by real GDP. The estimated results will be based on the panel data for 135 countries representing different country groups for the period from 1988 till 2003.

Before starting the empirical testing of both previously described methods, I would like to stop on the health index construction, which was created by applying of the principle component analysis.

The main idea behind using PCA is to reduce the number of variables comprising the dataset while retaining the variability in the data. Simplifying, this method allows computing a compact and optimal description of the dataset while efficiently reducing multicollinearity.

The peculiarity of the health factor is that health itself cannot be exactly determined, for now there is no one unique definition of health. This fact creates the situation when it is difficult to find appropriate proxy for health factor. Based on the data available, I take the variables such as birth rate (per 1000 people), CO$_2$ emissions, death rate (per 1000 people), fertility rate (births per woman), immunization DPT (% of children under 12 months), immunization of measles (% of children under 12 months), life expectancy at birth (total years), number of physicians (per 1000 people), which all can be a proxy for health on the country level. Combining these variables I construct 4 different health indexes, based on the number of observations for each variable. The logic is to construct an index which would capture both the appropriate proxy for health and a maximum possible number of observations. The health indices are constructed in a way that each following index includes fewer observations than the previous one, but a larger amount
Applying the PCA method in STATA I got the following linear combination of constructed health indexes.

\[
\text{Health}_1 = 0.63920i_D \text{PT} + 0.62806i_{\text{mzls}} + 0.44381CO_z \\
\text{Health}_2 = 0.54001i_D \text{PT} + 0.50172i_{\text{mzls}} + 0.35678CO_z - 0.49753b_r \text{ate} \\
- 0.28606d_r \text{ate} \\
\text{Health}_3 = 0.39667i_D \text{PT} + 0.34660i_{\text{mzls}} + 0.29689CO_z - 0.43314b_r \text{ate} \\
- 0.25598d_r \text{ate} - 0.43562f_r \text{ate} + 0.43668f_exp \\
\text{Health}_4 = 0.38443i_D \text{PT} + 0.30807i_{\text{mzls}} + 0.28300CO_z - 0.43885b_r \text{ate} \\
- 0.09433d_r \text{ate} - 0.43768f_r \text{ate} + 0.40750f_exp + 0.34367phy s
\]

From the results obtained, it can be seen that the sign of the components of four constructed health indexes coincides. Thus the number of immunizations of both DPT and measles has positive influence on health, the higher is the immunization the healthier should be people. CO2 emissions per 1000 people also have the positive sign, the possible explanation of such sign is that the more developed countries have more developed industries and higher CO2 emission per thousand people, this allows for safer technologies and improved healthcare systems, birth rate and fertility rate both have negative influence on health, this can be explained by the fact that in poor countries the birth rate and fertility rate are high, but GDP per capita is very small, so that many people are not able to receive appropriate health care, death rate was found to have negative influence on health index, by other words the more people die in the country the worse is the health care system and health factor overall, life expectancy positively influence on health, so that healthier people usually live longer, physicians per 1000 of people also has positive influence, as more physicians per 1000 people correlates with appropriate health care treatment, the idea is that the more doctors the healthier people should be.

As health is quite an abstract notion, the obtained health indices are difficult to interpret from the economic point of view. In order to make it easier I turn the index into the percentage scale. First, I calculate the mean, minimum and maximum value for each health index, then using the ratio of difference between health index and its
minimum value and difference between maximum and minimum value I calculate the health index for each country in percentage points.

\[
Health_{\text{index\_scaled}}(\%) = \frac{Health_{\text{index}} - \min(Health_{\text{index}})}{\max(Health_{\text{index}}) - \min(Health_{\text{index}})}
\]

Now the country with the highest health index has 100% of health, and with minimum health index 0 %. Of course in reality it is impossible for a country to have absolute health or not to have health at all, but this scaling of health helps us to compare the relative health values in different countries.

At the next step I sort the countries of the sample according to the income groups divided by World Bank Atlas method (low income, $765 or less GDP per capita; lower middle income, $766- $3,035 GDP per capita; upper middle income, $3,036- $9,385 GDP per capita; and high income, $9,386 or more GDP per capita). Then I find the mean value of each health index for the low-income countries, lower middle income countries, upper middle income countries and high income countries. In the diagrams below we can see the relationship between health indices and different income level countries.

Figure 3.

From the results presented in the chart, we can see that the countries that have the lowest GDP per capita on average have lower health index, the countries with higher
income have higher health index. Based on the results obtained I can conclude that high income countries have health index on 37.97% higher than the lower income countries.
The health index presented in the chart shows the similar trend, so that it is higher in high income countries and lower in the lower income ones. The high income countries have health index 45.85% higher than the low income ones. Comparing this gap with the previous result, we can see that the gap increases when more health factors are included in the index.

From the results obtained in chart 3, we can see that when we additionally consider for life expectancy and fertility rate the share of health between countries do not differ much. Health index follows the same trend as two previous health indices.
Health index includes 8 different factors that can proxy for health. Again, we can see that the richest countries are much better off in terms of health than the poorest ones. Consideration for more factors increases the gap between the high-income countries and lower-income countries up to 65.76 percentage points.

Of course, this procedure does not allow us to make any conclusions concerning the model estimation. Still, we can see the intuition behind the idea of relationship between the health indices and output. Really, the overall tendency is evident, wealthier countries on average are better off in terms of health than the poor ones. Then the question arises whether the countries which have better health on average are more productive, or rich countries are able to improve their health factor because of higher income. This is the question that in later estimations will arise as endogeneity problem, which would be considered in his chapter below.

On the further steps following Bloom(2001) methodology I will estimate the model, including all the indexes constructed, and then check which of them and under which assumptions performs better.

First of all, before starting the model estimation I have to check pooled least squares vs panel data estimation. The usual way to test this is F-test for common intercepts. The null hypothesis of the test is that the efficient estimators are obtained by
pooled least square estimation. If the p-value is zero and the hypothesis is rejected then unbiased estimators would be obtained with panel data estimation.

**Fixed vs Random-Effects Estimation**

The following step will be to test whether the model is appropriately specified and chose which of the estimation methods would be more precise. Basically, on this stage I test fixed effects model vs random effects model. The main difference between two estimation procedures is in group specific effects, we have to determine whether \( \alpha's \) represent \( N \) fixed unknown parameters or they are drawn from the population of randomly distributed intercepts and in this case can be treated as the part of the error term. This procedure is usually tested by Hausman test. If the null hypothesis is rejected then the fixed effect estimation should be used. (Wooldridge, 2002)

In some cases when applying Hausman test the differences between random effects and fixed effect estimates can be particularly small and it is possible to get statistical rejection of the random effect. The opposite case is when the differences between the fixed effects and random effects are large due to large standard errors, in this case the Hausman statistic fails to reject. Following the Wooldridge we should consider for random effect estimates. Unfortunately these particular cases can suffer from Type II error. While estimating different specifications of my empirical model, I chose fixed versus random effect estimations based on the criteria described above. Most of the estimated specifications were found to be under fixed effect estimation assumption.

After estimating either fixed or random effects model, the results obtained cannot be very much trusted unless the model is tested for the autocorrelation and heteroskedasticity. Only after implementation of these both tests the results of the model can be interpreted.

**Checking for the autocorrelation problems**:

In case of autocorrelation problems the estimators remain unbiased and consistent despite no longer efficient. The inefficiency of estimators means that t statistics and F statistics tests cannot be trusted any more. To check for autocorrelation I
used usual for panel data xtreg operator, which offers a within estimator for a fixed effect model and the Baltagi-Wu GLS estimator of the random effects model. The advantage of this operator is that it can accommodate unbalanced panel whose observations are unequally spaced over time. Both of the approaches offer Durbin-Watson estimator of $\rho$ by default. Using this estimator I calculated d-statistics for each specification of the model using the formula $d = 2(1 - \hat{\rho})$, then from the Durbin-Watson d-statistic table took the critical values of $d_l$ and $d_u$. Then following the decision rule given in Table 12.5 (Gujarati, D. 1995, p. 423) checked for the autocorrelation problem. In majority of the estimation of the different model specifications the hypothesis of “no positive autocorrelation” was rejected, which means both that received coefficients, despite consistent and unbiased, cannot be considered efficient, and standard errors cannot be trusted.

Checking for the heteroskedasticity problems:

As the analysis is based on the panel data, which includes small, medium and large-sized countries sampled together the heteroskedasticity problem can be intuitively expected. Heteroscedasticity means that estimators are no longer of minimum variance or inefficient, however it does not destroy the unbiasedness and consistency properties. To test for the heteroskedasticity problem I use standard Breusch-Pagan test, where zero hypothesis is constant variance or homoscedastic residuals. In majority cases the $H_0$ was rejected, which means that most specifications suffer from the heteroskedasticity problem. As a remedy for the problem, robust operator estimation was applied. The finally obtained estimation output after the robust operator procedure can be interpreted as the most efficient, unbiased and consistent.

The results obtained are presented in four different tables each including four different estimations of Cobb-Douglas function specifications considering for human capital presented in methodology part in equation (1). Each regression is estimated with the help of statistical package STATA 8.2. The estimation output is obtained based on the 3-step procedure described above by adding a new variable for each specification. I consider for different specifications in order to compare the difference in model
estimation in both cases including and excluding health variable along with some other variables such as trade (% of GDP) and listed domestic companies which could capture for good governance and institutional quality. To compare the influence of education and health factors on productivity in transition countries versus other countries time dummies for literacy rate and health index for transition countries were included.

Table 1

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<td>Yes</td>
<td>No</td>
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</table>

Model specification presented in column (1.1) of table (4.1) includes only capital, labor and literacy rate (a proxy for schooling) as inputs. The estimated coefficients are 0.68 for capital, 0.46 for labor and -0.008 for literacy rate. Despite the sum of labor and capital coefficients is close to one, which is appropriate under constant returns to scales technology assumption, the shares of capital and labor are not consistent with theory, as
shares of capital and labor in national income according to (Mankiw, 1994) should be one-third and two-thirds respectively. The estimate of literacy rate coefficient was found negative, which contradicts the results obtained in previous studies, as mostly it was found positive and significant, so that Barro and Lee found it 9.1 percent, Bloom et al. (2001) as 8.5 percent. This can be explained by not a very good proxy used for schooling, in most papers which consider the influence of human capital on economic growth schooling is taken from Barro and Lee (2000). I didn’t use their data for schooling because it was available only up to 1995, when I am interested in data up to 2003. In terms of goodness of fit I obtained $R^2 = 0.8592$, which means that the model fits the data well, moreover as the estimates obtained are based on fixed effect procedure $R^2$ within can be considered as an ordinary $R^2$.

The F statistic is a test that the coefficients near the regressors are all jointly zero, in all the models specification we rejected this hypothesis, so (1.1) model specification along with the rest ones is a significant model.

Adding health_index1 in column (1.2) improves results in terms of shares between capital and labor, so that under this specification capital is 0.27 and labor is 0.78. In sum they add approximately to one which is good, as it satisfies CRS assumption. The estimated schooling coefficient again is found to be negative and significant at 5% level. Health index1 was found to be positive and significant under 5% significance level, so that improvement in one unit of health index would increase the output by 1.4 percentage points. The $R^2$ obtained is equal to 0.8112, which is a bit less than in previous regression, but still is reasonably high.

In the next columns (1.3) and (1.4) the trade as a percentage of GDP and listed domestic companies variables are added. These variables were included in order to capture some other effects which could possibly influence the results of health_index estimation when omitted. Both variables included could be treated as a proxy for quality of political institutions. I would stop on the (1.4) specification model, as it included both added variables trade and listed domestic companies, when (1.3) considers only trade. Under this specification I received literacy rate positive and statistically insignificant,
while all the rest of the estimated coefficients are positive and statistically significant. As it was already mentioned health_index1 has positive and significant influence on productivity, so that one unit improvement in health index would increase the output by 1.8%. This result is a bit larger than the result we got under previous specification. The influence of trade and listed domestic companies despite is statistically significant with p-value (0.000), is very negligible in terms of coefficients values, so are not worth interpreting from the economic standpoint. Under (1.4) model specification the number of observations decreased almost twice, this could bring negative results in terms of degrees of freedom decrease. Such sharp decrease in observations can be explained by the poor data availability on included new variables trade and listed domestic companies. The $R^2$ of the model is 0.8468, which is quite high.

In model specification (1.5) along with all the factors included in (1.4) dummy variable for literacy rate and dummy variable for health index in transition countries are estimated. I included dummy variables for transition countries in order to see whether the influence of health and schooling differs in transition countries vs the other countries groups. Both literacy rate and dummy for literacy rate are statistically significant. The coefficient near the literacy rate dummy is negative -0.004, when the coefficient near the literacy rate variable, which stands for the rest countries groups is positive and is estimated to be nearly 0.003. Overall the influence of literacy rate on transition countries can be interpreted as with 1 per cent increase in literacy rate decreases the productivity growth by 0.001 per cent. This result may seem a bit strange at the first glance, but after considering the peculiarities of transition countries where for many years education was free of charge and many people with higher education are unemployed now, the estimated result could be taken as quite reasonable. As for the health index1 it was found positive for transition and rest non-transition countries, but in case of transition it was found to be statistically insignificant. This result can be interpreted in a way that health factor influence on productivity growth in transition countries do not differ from the health influence on productivity of the other countries groups. Capital and labor under this model specification are 0.18 and 0.68 respectively, this result does not coincide with the stylized shares of these inputs, but again their sum tends to 1, which is good in terms of CRS assumption. The other variables included in regression, such as trade and listed
domestic companies are also found to be positive and statistically significant. The $R^2$ coefficient of the model is 0.8582, which is good, in terms that model fits the data well.

Based on the LR test the most appropriate model specification is (1.4). In terms of output growth interpretation, if we increase the Health_index1 by one unit, the output will increase by 1.81 per cent, which in money equivalent is equal to 3746700.00 of current international $. This was calculated in terms of average GDP and Health index1 of the overall country sample.

In the next table 4.2 similar results with the Health_index2 are presented.

Table 2

<table>
<thead>
<tr>
<th>RHS variables</th>
<th>(2.1)</th>
<th>robust (2.2)</th>
<th>(2.3)</th>
<th>robust (2.4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital</td>
<td>0.3311***</td>
<td>0.3062</td>
<td>0.261***</td>
<td>0.1848</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Labor</td>
<td>0.6178***</td>
<td>0.8652</td>
<td>0.8952***</td>
<td>0.4207***</td>
</tr>
<tr>
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<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Schooling</td>
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<td>-0.0064</td>
<td>-0.0001</td>
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<tr>
<td></td>
<td>(0.026)</td>
<td>(0.057)</td>
<td>(0.128)</td>
<td>(0.225)</td>
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<td>Dummy_for_Schooling in</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>transition countries</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health_index2 in transition</td>
<td>0.279***</td>
<td>0.0176</td>
<td>0.0142</td>
<td>0.0779***</td>
</tr>
<tr>
<td>countries</td>
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<td>(0.060)</td>
<td>(0.093)</td>
<td>(0.048)</td>
</tr>
<tr>
<td>Dummy_for_Health_index2 in</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>transition countries</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trade(% of GDP)</td>
<td>5.72e-13***</td>
<td>5.72e-13</td>
<td>4.69e-13***</td>
<td>4.78e-13***</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.046)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>List of registered domestic</td>
<td>0.000673***</td>
<td>0.0001</td>
<td>0.0002***</td>
<td>0.0001</td>
</tr>
<tr>
<td>companies</td>
<td>(0.000)</td>
<td>(0.158)</td>
<td>(0.201)</td>
<td>(0.079)</td>
</tr>
<tr>
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<td>3.3911</td>
<td>4.551***</td>
<td>4.5511</td>
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<td>(0.000)</td>
<td>(0.020)</td>
<td>(0.000)</td>
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<td>N</td>
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<td>599</td>
<td>572</td>
<td>572</td>
</tr>
<tr>
<td>R2coefficient</td>
<td>0.8592</td>
<td>0.9972</td>
<td>0.9978</td>
<td>0.8793</td>
</tr>
</tbody>
</table>

Test vs Random:
- Fixed vs Random: f.e
- Autocorrelation test: r.e
- Heteroscedasticity test: Yes
As it was previously mentioned Health_index2 was constructed via application of principal component analysis. The main difference between Health_index1 and Health_index2 is that the last one considers along with Health_index1 variables also for the birth rate crude (per 1000 people) and death rate crude (per 1000 people). I didn’t include all the possible proxies for health at once in one index, as the data was sorted in a way that each following variable that I include in the index contains fewer observations than the previous one, so that the Health_index1 contains the least number of proxies, but the largest number in terms of observations, the Health_index4 vice versa includes the largest amount of proxies, but the number of observation for it drops significantly. This could be easily seen from the results presented in the following tables.

In all four columns of table 4.2 the coefficients near Health_index2 are positive, and in all but (2.2) specification model are statistically significant. In (2.2) specification model, when trade variable is additionally considered Health_index2 is statistically significant only at 12% level.

Overall the estimation output we got in table 4.2 doesn’t differ much from the results we obtained in previous table. In model specification (2.1) the capital is 0.33 labor is 0.62, which is good result from the both sides as stylized facts of capital and labor shares as of one third to two thirds, and from the other side that the coefficients sum very close to 1 which is good according to the CRS assumption. Both literacy rate and Health_index2 are statistically significant, however their influence on productivity is opposite. If literacy rate would increase by 1 percentage point the output will decrease by 0.6 percentage points, which means that influence of literacy rate on output growth is not very much economically significant. In case of Health_index2, if it increases by one unit, the output will increase by 2.8 percentage points. The estimated result is quite reasonable comparably to other papers which estimated health just by life expectancy; they got the coefficient 0.04 or 4 percentage points. The $R^2$ coefficient is 0.8592, which is reasonably high.

In (2.2) (2.3) columns we by turns estimate at first model including trade and then including both trade and listed domestic companies variables. I would stop on the
model specification (2.3) as it considers for both added variables. So the results in column (2.3) along with capital, labor, literacy rate and Health_index2 include trade and listed domestic companies. The coefficients close to 0.5 were found for both capital and labor, theoretically under condition that the technology exhibits CRS and perfectly competitive input markets, such case is possible. The coefficient of literacy rate is negative and strongly insignificant, when Health index2 is positive at 5 % significance level, and its value is quite big 0.079. In terms of interpretation it means that if the health_index2 would increase by one unit, the output would increase by 7.9 percentage point. This result is quite different in comparance to the 4% found in Bloom, Canning, Graham and Sevilla (2000), but this I quite logical as in my model health is different from the one they used as a proxy. Trade and listed domestic companies which are proxies for the quality of political institutions are both statistically significant. The $R^2$ of the model is rather high 0.8793.

Adding the dummy variables for literacy rate and Health_index3 for transition countries changes the results. Two variables standing for the quality of political institutions are statistically insignificant. As for the literacy rate the estimated results show that it has negative influence in transition countries as for the other countries it is positive. It means that overall the influence of literacy on output in transition countries would be less than in the rest country groups. Health_index2 vise versa is positive and significant both for index itself and for its dummy, so that for transition countries the coefficient would be equal to the sum of 0.11 and 0.39, which is 0.5. This result looks unrealistically large for the transition countries and cannot be unambiguously interpreted. Despite the high $R^2$ (0.9258) the (2.4) model specification to my mind cannot be considered a good one, as most of its estimates despite statistical significance do not contain much economic reasoning.

Based on the LR test model specification (2.1) should be chosen. Health_index2 under such model specification is equal 0.0279, which can be interpreted as if we change health_index1 by one unit the output will increase by 2.8 percentage points, in money equivalent it means that the output will grow by 5775300 current international $.
In the next table similar model specifications are considered, the only difference is in the health index, which for that particular case would consider for two more proxies that could influence health index such as fertility rate and life expectancy.

Table 3

Health Index3 Estimation Results:

<table>
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<tr>
<th>RHS variables</th>
<th>(3.1)</th>
<th>robust (3.2)</th>
<th>robust (3.3)</th>
<th>robust (3.4)</th>
<th>robust (3.4)</th>
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</thead>
<tbody>
<tr>
<td>Capital</td>
<td>0.2831***</td>
<td>0.2611</td>
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<td>0.2164</td>
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<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Labor</td>
<td>0.6967***</td>
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<td>-0.5664***</td>
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</tr>
<tr>
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<td>-0.0036</td>
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<td>transition countries</td>
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<td></td>
<td></td>
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</tr>
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<td>Health_index3</td>
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<td>transition countries</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Trade(% of GDP)</td>
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<td>5.73e-13</td>
<td>7.79e-13</td>
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<td>0.000392</td>
<td>0.0001</td>
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<td>f.e</td>
<td>f.e</td>
<td>f.e</td>
<td>f.e</td>
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<td>+autocorr</td>
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<td>Heteroscedasticity test:</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
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</table>

The results in column (3.1) of table 4.3 include capital, labor, literacy rate and Health_index3 as inputs. All the coefficients obtained under this model specification are statistically significant. The coefficient on capital is 0.28 and on labor 0.7, their shares sum to 1. Moreover they take the values that are close to their stylized factor shares of one third for capital and two thirds for labor. The schooling coefficient is significant only at 5 per cent significance level and its value is negative, Health_index3 vice versa is...
positive and significant. It's influence on output under this model specification can be interpreted as very high, so that one unit increase in Health_index3 will increase output by 25.8 percentage points. The $R^2$ of the model is 0.8813, which is good result in terms of fitting the model.

Adding the trade for the column (3.2) and both trade and listed domestic companies in column (3.3) changes the results. Under model specification (3.3) the capital has larger influence than under (3.2) and labor reciprocally has less, both this variable in sum are very close to one which is good in terms of CRS assumption. The capital is 0.31 and labor 0.57. The literacy rate coefficient is negative and statistically insignificant, such results contradicts to the results obtained in other empirical papers. This again evidence the fact that literacy rate as a proxy for schooling is not very much good. Health index3 is statistically significant with the value of 0.1556, which means that one unit increase in health index would lead to an output increase of 15.56 per cent. The trade and listed domestic companies, which stand for the quality of political institutions are both positive and statistically significant but their influence on the output growth is comparatively small.

Adding the dummy variables for literacy rate and Health_index3 for transition countries influences the results. The literacy rate coefficient changes the sign from negative to positive, but as under (3.4) specification model it is still statistically insignificant, we should consider for the coefficient near dummy, which negative, so overall literacy would be negative and insignificant just as under the previous (3.3) specification model. The shares of the capital and labor are 0.41 and 0.52 correspondingly, they do not respond to the stylized shares but still their sum is approximately equal to 1. Health_index3 vise versa is positive and significant both for index itself and for its dummy, so that for transition countries the coefficient would be equal to the sum of 0.86and 0.15, which is 1.01. This result is unrealistically large and economically doesn't have much sense. The list of domestic companies is also statistically insignificant under this model specification. The $R^2$ is very high 0.9258, which is good in terms fitting the data by the model.
Applying LR test we should choose (3.1) model specification. Under (3.1) specification model if we increase health_index3 by one unit, the productivity will grow by 15.56 percentage points, which in money equivalent means 32209200.00 current international $.

The next table considers for the Health_index4, which includes all previous proxies plus the variable physicians (per 1000 people). The estimation output with Health_index4 is presented in the next table 4.4.

Table 4.

Health Index4 Estimation Results:

<table>
<thead>
<tr>
<th>RHS variables</th>
<th>(4.1)</th>
<th>robust</th>
<th>(4.2)</th>
<th>robust</th>
<th>(4.3)</th>
<th>robust</th>
<th>(4.4)</th>
<th>robust</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital</td>
<td>.1963***</td>
<td>.3790</td>
<td>.1854***</td>
<td>.2991</td>
<td>.1615**</td>
<td>.0777</td>
<td>.2173***</td>
<td>.1047</td>
</tr>
<tr>
<td>(0.001)</td>
<td>(0.000)</td>
<td>(0.001)</td>
<td>(0.000)</td>
<td>(0.053)</td>
<td>(0.336)</td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.039)</td>
</tr>
<tr>
<td>Labor</td>
<td>.7996***</td>
<td>.5529</td>
<td>.7114***</td>
<td>.6128</td>
<td>.7197***</td>
<td>.7329</td>
<td>.7123***</td>
<td>.8890516</td>
</tr>
<tr>
<td>(0.000)</td>
<td>(0.026)</td>
<td>(0.000)</td>
<td>(0.006)</td>
<td>(0.000)</td>
<td>(0.018)</td>
<td>(0.000)</td>
<td>(0.003)</td>
<td></td>
</tr>
<tr>
<td>Schooling</td>
<td>-.0063**</td>
<td>.0083</td>
<td>-.0026</td>
<td>.0046</td>
<td>.0025</td>
<td>.0025</td>
<td>.0083</td>
<td>.0211319</td>
</tr>
<tr>
<td>(0.129)</td>
<td>(0.368)</td>
<td>(0.529)</td>
<td>(0.593)</td>
<td>(0.635)</td>
<td>(0.059)</td>
<td>(0.047)</td>
<td>(0.079)</td>
<td></td>
</tr>
<tr>
<td>Dummy_for_Schooling in transition</td>
<td>-</td>
<td>0.01216***</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>.0964052</td>
<td>(0.238)</td>
</tr>
<tr>
<td>countries</td>
<td>(0.000)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health_index4</td>
<td>.2394***</td>
<td>.0229</td>
<td>.1849***</td>
<td>.0224</td>
<td>.1143**</td>
<td>.0081</td>
<td>.1935**</td>
<td>.0200019</td>
</tr>
<tr>
<td>(0.000)</td>
<td>(0.329)</td>
<td>(0.000)</td>
<td>(0.322)</td>
<td>(0.018)</td>
<td>(0.685)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.249)</td>
</tr>
<tr>
<td>Dummy_for_Health_index4 in transition</td>
<td>.2665</td>
<td>.1465359</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>countries</td>
<td>(0.147)</td>
<td>(0.110)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trade(%) of GDP</td>
<td>1.64e-12</td>
<td>4.74e-12</td>
<td>1.13e-12</td>
<td>5.22e-13</td>
<td>4.04e-13</td>
<td>4.04e-13</td>
<td>5.59e-13</td>
<td></td>
</tr>
<tr>
<td>(*** (0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td></td>
</tr>
<tr>
<td>List of registered domestic companies</td>
<td>.0008***</td>
<td>.0002</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>(0.003)</td>
<td>(0.034)</td>
<td>(0.000)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0.000)</td>
<td>(0.057)</td>
<td>(0.000)</td>
<td>(0.013)</td>
<td>(0.000)</td>
<td>(0.018)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.077)</td>
</tr>
<tr>
<td>N</td>
<td>301</td>
<td>301</td>
<td>293</td>
<td>293</td>
<td>185</td>
<td>185</td>
<td>185</td>
<td>185</td>
</tr>
<tr>
<td>R2coefficient</td>
<td>0.8539</td>
<td>0.9974</td>
<td>0.8691</td>
<td>0.9979</td>
<td>0.8668</td>
<td>0.9989</td>
<td>0.9212</td>
<td></td>
</tr>
<tr>
<td>Test on CRS</td>
<td>f.e</td>
<td>f.e</td>
<td>r.e</td>
<td>r.e</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed vs Random:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Autocorrelation test:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>rho_dw</td>
<td>.81735215</td>
<td>.79357178</td>
<td>.8515724</td>
<td>.9421897</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d_calculated</td>
<td>.365296</td>
<td>.412856</td>
<td>.293686</td>
<td>.19156</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d_lower</td>
<td>1.633</td>
<td>1.623</td>
<td>1.613</td>
<td>1.592</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d_upper</td>
<td>1.715</td>
<td>1.725</td>
<td>1.735</td>
<td>1.757</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decision:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heteroscedasticity test:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

43
The results of column (4.1) include capital, labor, literacy rate and Health_index4 as inputs. As in previous regressions all the obtained coefficients except for literacy rate are statistically significant. The coefficients of capital and labor are 0.2 and 0.8 correspondingly. The sum of the coefficients is 1, exactly what we expect under CRS technology. The shares of capital and labor do not take values that are close to their stylized factor shares. Health_index4 has positive and significant value, if the health index3 changes by one unit the output would increase by 23.9 percentage points. The results obtained under this specification can be judged as good in terms of $R^2$-coefficient, despite the number of observation in comparison with the similar model in previous table significantly decreased.

The model specifications (4.2) and (4.3) consider for quality of political institutions factors, which accordingly with the previous tables are proxied by trade and listed domestic companies. As (4.3) specification considers for both factors I would stop on the interpretation of this particular model. The coefficient of literacy rate is positive and statistically insignificant, the health index4 can be considered significant only at 5 per cent significance level. The value of health_index4 is quite big, so that one unit increase in health index4 would increase the output by 11.4 percentage points. The coefficient of capital is significant at 10 per cent significance level. The capital and labour coefficients under (4.3) specification of the model also approximately sum to one, but as under the majority specifications their shares do not coincide with the stylized factor shares. Trade and listed domestic companies are both statistically significant and positively influence on productivity. The $R^2$ square of the model is rather high0.8668.

Adding dummy for literacy rate in transition countries changes its sign from the positive to negative one, but overall effect of literacy rate on other country groups would be negative after summation, as the coefficient near dummy is much higher than the coefficient near literacy rate itself. Overall our proxy for schooling in terms of literacy rates would have negative influence on productivity growth. Dummy for Health_index4 for transition countries is both positive and significant, which after summation will give the result that health is more important in terms of economic growth for the transition countries vs rest country groups. Thus I obtained that one unit of health_index4
improvement would benefit in output increase by 46 percentage points. As for the quality of political institutions both the trade variable and listed domestic companies were found to be insignificant under this model specification. The $R^2$ coefficient of the model is extremely high 0.9212, which means that given specification of the model fits the data well.

Overall the picture that emerges from the all above analysed tables is that in the majority of specifications health variables were found to be positive and significant. The coefficients of capital and labour summed to one, though their shares where not very much close to the stylized fact. The institutional variables that were taken as a proxy for the quality of institutional environment were found statistically significant, though in majority their value is extremely small. Possibly, this problem can be explained in terms of scale, so that the difference in listed domestic companies in big countries versus small can be rather large. All the specifications proved to have autocorrelation and heteroskedasticity problems, which make the estimated results inefficient and standard errors not reliable. To control for the heteroskedasticity problem the robust regressions were run. The results obtained in robustness check in some specifications were significantly different from those obtained in fixed/random effect estimations. This fact can be partially explained with the endogeneity problem.

Statistically speaking, endogeneity creates a correlation between the independent variables and the error term that makes the coefficients in equation inconsistent. To control for this problem I assume lagged variables of health indices and literacy rate as valid IVs. I decided not to include the results on the IV estimation for all the specifications, only those that consider all the variables of interest. The estimated results are presented in the table 4.5

Table 5. Instrumental Variables Estimations Output

<table>
<thead>
<tr>
<th>RHS variables</th>
<th>(1.5)</th>
<th>(IV_1.5)</th>
<th>(2.4)</th>
<th>(IV_2.4)</th>
<th>(3.4)</th>
<th>(IV_3.4)</th>
<th>(4.4)</th>
<th>(IV_4.4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital</td>
<td>.1789***</td>
<td>.1591</td>
<td>.4107***</td>
<td>.2267</td>
<td>.4107***</td>
<td>.0806</td>
<td>.2171***</td>
<td>.0778</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.488)</td>
</tr>
<tr>
<td>Labor</td>
<td>.6783***</td>
<td>.8412</td>
<td>.5204***</td>
<td>1.3361</td>
<td>.5204***</td>
<td>1.491</td>
<td>.7133***</td>
<td>1.6257</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.657)</td>
</tr>
<tr>
<td>Schooling</td>
<td>.0034***</td>
<td>-.0029</td>
<td>.0038</td>
<td>-.0022</td>
<td>.0038</td>
<td>.0125</td>
<td>.0083</td>
<td>.0125</td>
</tr>
</tbody>
</table>
From the results presented in the table above I can conclude that taking lagged variables of health indices as instrumental variables change the coefficients. Under the (IV_2.4), (IV_3.4) and (IV_4.4) the coefficients near health variable turned to negative, just opposite to the expected. In IV specifications the R² is very low, which means that the model fits the data not appropriately and the obtained results cannot be very much trusted. On this step, the evident thing is that model needs further check for the robustness.

In the second part of my empirical investigation I will estimate the stochastic frontier, considering for health as a explanatory variable for the efficiency terms.

The second approach is based on estimation of the stochastic frontier, considering for health as an explanatory variable of the inefficiency terms. As it was previously mentioned in methodology part the disturbance term in a stochastic frontier model is assumed to have two components. One component is assumed to have a symmetric distribution, the other is assumed to have strictly non-negative distribution. Non-negative component is known also as inefficiency term. A fundamental assumption of our country analysis is that potentially each country produces less than it might due to a degree of inefficiency.

Assume the country has the production function as in (6):
\[ y_u = K^\alpha L^\beta H \varepsilon_u, \]

where \( \varepsilon_u \) is the level of efficiency for country \( i \) at time \( t \). \( \varepsilon_u \) can be in the range \((0,1]\). If \( \varepsilon_u = 1 \), the country produces its optimal output appropriately using all its factors, \( \varepsilon_u < 0 \) means that the country is not appropriately using most of its inputs. As we assume that output is strictly positive, the term \( \varepsilon_u \) of technical efficiency has also to be strictly positive. Generally, technical efficiency term shows the difference between actual and potential output values.

At first I estimate the model given in without health and schooling indicators

\[
\ln Y_u = \ln A + \alpha \ln L_u + \beta \ln K_u + \varepsilon_u, \alpha + \beta = 1
\]

(basically production frontier, excluding human capital):

where \( \alpha + \beta = 1 \), restriction implied for having constant returns to scales.

At the next step I estimate the same model including previously constructed health indices. This will be “stochastic frontier function” considering for health variable;

\[
\ln Y_u = \ln A + \alpha \ln L_u + \beta \ln K_u + H_u + S_u + \varepsilon_u, \alpha + \beta = 1
\]

Then, based on the output of these two specifications I estimate technical efficiency for each health index separately. Such approach will help to determine the influence of health factor on output in terms of efficiency.
Table 6. Technical Efficiency Estimation Output

<table>
<thead>
<tr>
<th>RHS variables</th>
<th>(0)</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital</td>
<td>.7526</td>
<td>.2796</td>
<td>.4486</td>
<td>.2854</td>
<td>.4238</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Labor</td>
<td>.1607</td>
<td>.6801</td>
<td>.6443</td>
<td>.6682</td>
<td>.5409</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Literacy Rate</td>
<td>-.0011</td>
<td>.0007</td>
<td>-.0238</td>
<td>.0049</td>
<td>.0033</td>
</tr>
<tr>
<td></td>
<td>(0.424)</td>
<td>(0.671)</td>
<td>(0.000)</td>
<td>(0.032)</td>
<td>(0.308)</td>
</tr>
<tr>
<td>Health_index1</td>
<td>.0176</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health_index2</td>
<td>-.0682</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health_index3</td>
<td></td>
<td>.0568</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.000)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health_index4</td>
<td></td>
<td></td>
<td></td>
<td>.0567</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.012)</td>
<td></td>
</tr>
<tr>
<td>constant</td>
<td>3.6017</td>
<td>8.0429</td>
<td>5.4879</td>
<td>7.6353</td>
<td>6.0194</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>N</td>
<td>1368</td>
<td>1162</td>
<td>589</td>
<td>425</td>
<td>301</td>
</tr>
<tr>
<td>Technical efficiency</td>
<td>.6131</td>
<td>.2952</td>
<td>.4888</td>
<td>.3664</td>
<td>.4391</td>
</tr>
</tbody>
</table>

From the results presented in the table 4.6 follows that in the model specifications (1-4), when we consider for four different health indices the technical efficiency is lower than in the (0) specification model which excludes health variable, moreover, in each model technical efficiency varies. Based on such results we cannot predict the influence of health on output in terms of efficiency, the only possible conclusion we can make is that health factor influences the efficiency. In case the estimated technical efficiencies were all approximately equal when including other variables would witness the fact that these variables do not influence the efficiency or by other words are not an omitted variables.

The estimated variety in technical efficiencies could be partially explained by a significant gap between minimum and maximum values of health indices, and also possible correlation between output and health actor.
In terms of coefficients this method also proved that in 3 out of 4 model specifications health has positive and significant influence on output growth. As a result of estimation I got that the change of the health index by one unit will increase the output by 1.57 percentage points \((0.0176-0.0682+0.0568+0.0567)\times0.25\). Such result does not differ much from the results got in the previous methods. The capital and labor coefficients in (1) and (3) specifications have the shares close to their stylized facts, and under all the considered specifications their sum is approximately equal to 1, which is good under assumption of constant returns to scales. Overall, based on the results got from the stochastic frontier estimation it is inappropriate to judge about the influence of health on the technical efficiencies, from the other side the results in terms of coefficients can be interpreted so that health indexes proved to have positive and significant value on output growth.
Chapter 6

CONCLUSIONS

The main purpose of this study has been to investigate the empirical evidence of health factor influence on economic growth. A specific question guiding the research was to find the peculiarities of health impact on transition economies countries.

Based on the Principle Component Analysis I constructed four different health indices including different health factors that could proxy for health. To make the estimated result more comprehensive the estimated output was scaled to the percentage equivalent, so that it would be possible to receive relative estimates of health. Sorting the countries by income, showed the result that wealthier countries along with high income present high values of health indices, when the countries whose income is low also do not perform very well in terms of health. Such result indicates correlation and gives the intuition on understanding health-wealth nexus between different countries groups.

Following Bloom et al (2001) I examined the influence of constructed health indices on the real output. The main finding is that under majority of specifications health indices were found to be positive and significant, so that on average one unit improvement in health index would increase the output by 1.8%. In case of transition countries versus the rest countries groups the coefficient near literacy rate was found negative, when the coefficient near the literacy rate variable, which stands for the rest countries groups was found positive. As for the health index its influence on productivity growth in transition countries do not differ from the health influence on productivity of the other countries groups. The negative influence of education of the literacy rate on productivity in case of transition countries can be explained by the fact that in post-Soviet countries secondary education was compulsory and free of charge, so that in these group of countries unlike in the rest countries group education doesn't necessarily mean better job or higher standard of living. The institutional variables that
were taken as a proxy for the quality of institutional environment were found statistically significant, though they are not easy to interpret economically as for both variables the proxies were taken in the absolute values, so that listed domestic companies are the number of listed domestic companies in the country, and trade was taken just as absolute trade.

To control for the endogeneity problem I use lagged variables of health indices and literacy rate as valid IVs. The results obtained via IV estimation approach, except for the health_index1, were found opposite to the expected. At this point the conclusion is that the only results we can trust in terms of robustness are obtained with the health_index1 model specifications.

Under stochastic frontier estimation approach, in terms of coefficients the health influence on output (except for the health_index2) was also found to be positive and significant. In terms of efficiency the change in technical efficiency varied in all specifications when health_index was considered. It means that though we cannot make definite conclusion whether considering for health decrease or increase the efficiency, the overall conclusion is that it influences the efficiency and health indexes cannot be considered as omitted variables of the model.

In my model under different specifications I considered the health influence on output only through labor productivity, but improvements of health may increase output also through capital accumulation. In further research it would be appropriate to consider this approach also. The other interesting question for further research can be not only how health influences output, but also how health itself can be determined. In my research I assumed that for different country groups it is influenced by the same set of channels, the peculiarities of different countries health factor formation would be interesting to consider.

Based on results obtained I think that the following policy implications would be appropriate. At first, it is necessary for the governments to consider for the nexus between the health factor and output growth, so that the policies geared to increasing expenditures for health care will be in the long-run effective in terms of increasing
productivity, income and wealth. It follows that government policies aimed directly at improving health should be emphasized and funded. The other important issue is that just an increase in health expenditures will not necessarily result in higher levels of population health. As it was previously mentioned health has a multifaceted nature and itself can be influenced by different factors. This suggest the demand for a complex approach from different policies traditionally considered outside the borders of health policy that indirectly can influence the population health. For example, labour market policy, education policy, parentel and child-care policy. In case of transition countries labor market policy can have a remarkable effect on the productivity growth, which based on Becker (2004) can be explained by the fact that in the transition countries work-related injuries and illnesses are a major source of productivity losses.
BIBLIOGRAPHY


Gwatkin, Davidson R. Health Inequalities and he Health of the Poor:
What Do We Know? What can We Do?


Macroeconomic and health: Investing in health for economic development.


Global Integration”, Brooking Papers on Economic Activities, pp. 111-118


### APPENDIX A

**Variables List**

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Short Description</th>
<th>STATA coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country Name</td>
<td>country name</td>
<td>c_name</td>
</tr>
<tr>
<td>Year</td>
<td>year</td>
<td>year</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross Domestic Product, PPP (current international $)</td>
<td>Y</td>
</tr>
<tr>
<td>Real Capital</td>
<td>capital calculated by perpetual method</td>
<td>K</td>
</tr>
<tr>
<td>Labour Force</td>
<td>comprises people who supply labor for the production of goods and services during a specified period, includes both the employed and the unemployed</td>
<td>L</td>
</tr>
<tr>
<td>Birth Rate</td>
<td>birth rate, crude (per 1000 people)</td>
<td>b_rate</td>
</tr>
<tr>
<td>CO₂ emissions</td>
<td>CO₂ emissions (kt) per 1000 people</td>
<td>CO2</td>
</tr>
<tr>
<td>Death Rate</td>
<td>death rate, crude (per 1000 people)</td>
<td>d_rate</td>
</tr>
<tr>
<td>Fertility Rate</td>
<td>fertility rate, total (births per woman)</td>
<td>f_rate</td>
</tr>
<tr>
<td>Health Expenditure</td>
<td>health expenditure, total (% of GDP)</td>
<td>h_exp</td>
</tr>
<tr>
<td>Hospital Beds per 1000 People</td>
<td>hospital beds per 1000 people</td>
<td>h_bed</td>
</tr>
<tr>
<td>Immunizations DPT</td>
<td>Immunizations from diphtheria, pertussis, tetanus (% of children under 12 months)</td>
<td>i_DPT</td>
</tr>
<tr>
<td>Immunizations measles</td>
<td>Immunizations from measles (% of children under 1 month)</td>
<td>i_mz1s</td>
</tr>
<tr>
<td>Life Expectancy</td>
<td>theoretical number of years a newborn will live if the age specific mortality rates in the year of birth are taken as constant</td>
<td>lfx_exp</td>
</tr>
<tr>
<td>Physicians per 1000 of people</td>
<td>physicians per 1000 of people</td>
<td>phys</td>
</tr>
<tr>
<td>Population Total</td>
<td>Population total</td>
<td>pop</td>
</tr>
<tr>
<td>Literacy Rate</td>
<td>literacy rate, adult total (% of people aged 15 and above)</td>
<td>lit_rate</td>
</tr>
<tr>
<td>Marriages (in 1000's)</td>
<td>marriages in 1000s of people</td>
<td>marr</td>
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<tr>
<td>Dummy for Transition Countries</td>
<td></td>
<td>dummy_t</td>
</tr>
<tr>
<td>Exports of Goods and Services</td>
<td>exports of goods and services (% of GDP)</td>
<td>exp_good</td>
</tr>
<tr>
<td>Listed Domestic Companies</td>
<td>listed domestic companies, total</td>
<td>listed_dom_comp</td>
</tr>
<tr>
<td>Trade</td>
<td>trade (% of GDP)</td>
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</tr>
<tr>
<td>Real GDP</td>
<td>GDP devided by deflator</td>
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</tr>
<tr>
<td>Real Capital</td>
<td>capital devided by deflator</td>
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<td>Real Trade</td>
<td>trade considered for deflator</td>
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Specifications of variables are not enlisted to the table.
## APPENDIX B

### Estimation Output

#### 1. SUMMARY STATISTICS

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<th>Variable</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Dev.</th>
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<th>Max</th>
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<td>55853.07</td>
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<td>7.73e+08</td>
</tr>
<tr>
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#### 2. HEALTH INDEX CONSTRUCTION, PCA METHOD

```
pca i_mzls i_DPT CO2_per_1000, factors(1)
```

(Principal components; 1 component retained)

<table>
<thead>
<tr>
<th>Component</th>
<th>Eigenvalue</th>
<th>Difference</th>
<th>Proportion</th>
<th>Cumulative</th>
</tr>
</thead>
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<tr>
<td>2</td>
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<td>0.60339</td>
<td>0.2378</td>
<td>0.9636</td>
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<tr>
<td>3</td>
<td>0.19934</td>
<td>.</td>
<td>0.0864</td>
<td>1.0000</td>
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</tbody>
</table>

**Variance explained:**
- PC 1: 72.58%
- PC 2: 23.78%
- PC 3: 9.06%

**Eigenvalues:**
- PC 1: 2.17738
- PC 2: 0.71328
- PC 3: 0.19934

**Variance explained:**
- PC 1: 72.58%
- PC 2: 23.78%
- PC 3: 9.06%

**Eigenvectors:**

<table>
<thead>
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<th>Variable</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
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<tbody>
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<td></td>
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<td>i_DPT</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>DPT</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CO2_per_1000 | 0.44381

score Health1
(based on unrotated principal components)
Scoring Coefficients
Variable | 1
-------------+----------
i_mzls | 0.62806
i_DPT | 0.63920
CO2_per_1000 | 0.44381

. gen logHealth1=log(Health1)
(1184 missing values generated)

. pca i_mzls i_DPT CO2_per_1000 d_rate b_rate, factors(1)
(obs=941)

(principal components; 1 component retained)
Component | Eigenvalue | Difference | Proportion | Cumulative
-------------+------------+------------+------------+------------
1 | 2.77082 | 1.81543 | 0.5542 | 0.5542
2 | 0.95538 | 0.25001 | 0.1911 | 0.7452
3 | 0.70537 | 0.32327 | 0.1411 | 0.8863
4 | 0.38210 | 0.19577 | 0.0764 | 0.9627
5 | 0.18633 | . | 0.0373 | 1.0000

Eigenvectors
Variable | 1
-------------+----------
i_mzls | 0.50172
i_DPT | 0.54001
CO2_per_1000 | 0.35678
d_rate | -0.28606
b_rate | -0.49753

score Health2
(based on unrotated principal components)
Scoring Coefficients
Variable | 1
-------------+----------
i_mzls | 0.50172
i_DPT | 0.54001
CO2_per_1000 | 0.35678
d_rate | -0.28606
b_rate | -0.49753

. gen logHealth2=log(Health2)
(1525 missing values generated)

. pca i_mzls i_DPT CO2_per_1000 d_rate b_rate f_rate, factors(1)
(obs=811)

(principal components; 1 component retained)
Component | Eigenvalue | Difference | Proportion | Cumulative
-------------+------------+------------+------------+------------
1 | 3.60776 | 2.67489 | 0.6013 | 0.6013
2 | 0.93287 | 0.22185 | 0.1555 | 0.7568
3 | 0.71102 | 0.16879 | 0.1185 | 0.8753
4 | 0.54224 | 0.34790 | 0.0904 | 0.9656
5 | 0.19433 | 0.18255 | 0.0324 | 0.9980
6 | 0.01178 | . | 0.0020 | 1.0000

Eigenvectors
Variable | 1
----------+------------------
i_mzls | -0.40740
i_DPT | -0.45453
CO2_per_1000 | -0.32203
d_rate | 0.25264
b_rate | 0.47779
f_rate | 0.48126

.score Health3
(based on unrotated principal components)
.Scoring Coefficients
Variable | 1
----------+------------------
i_mzls | -0.40740
i_DPT | -0.45453
CO2_per_1000 | -0.32203
d_rate | 0.25264
b_rate | 0.47779
f_rate | 0.48126

.log Health3=log(Health3)
1929 missing values generated.

.pca i_mzls i_DPT CO2_per_1000 d_rate b_rate f_rate lf_exp, factors(1)
(obs=720)
(principal components; 1 component retained)
Component | Eigenvalue | Difference | Proportion | Cumulative
----------+------------+------------+------------+------------
1 | 4.51541 | 3.59088 | 0.6451 | 0.6451
2 | 0.92453 | 0.12855 | 0.1321 | 0.7771
3 | 0.79598 | 0.29633 | 0.1137 | 0.8908
4 | 0.49965 | 0.31407 | 0.0714 | 0.9622
5 | 0.18558 | 0.05813 | 0.0098 | 0.9887
6 | 0.06849 | 0.05813 | 0.0098 | 0.9985
7 | 0.01036 | | 0.0015 | 1.0000

.Eigenvectors
Variable | 1
----------+------------------
i_mzls | 0.34660
i_DPT | 0.39667
CO2_per_1000 | 0.29689
d_rate | -0.25598
b_rate | -0.43314
f_rate | -0.43652
lf_exp | 0.43668

.score Health4
(based on unrotated principal components)
.Scoring Coefficients
Variable | 1
----------+------------------
i_mzls | 0.34660
i_DPT | 0.39667
CO2_per_1000 | 0.29689
d_rate | -0.25598
b_rate | -0.43314
f_rate | -0.43652
lf_exp | 0.43668

.log Health4=log(Health4)
. pca i_mzls i_DPT CO2_per_1000 d_rate b_rate f_rate lf_exp phys, factors(1)
(obs=536)

(principal components; 1 component retained)

<table>
<thead>
<tr>
<th>Component</th>
<th>Eigenvalue</th>
<th>Difference</th>
<th>Proportion</th>
<th>Cumulative</th>
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</thead>
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<td>0.46435</td>
<td>0.1651</td>
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<td>3</td>
<td>0.85650</td>
<td>0.22482</td>
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<td>0.8447</td>
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<td>4</td>
<td>0.63168</td>
<td>0.34697</td>
<td>0.0790</td>
<td>0.9237</td>
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<td>5</td>
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Eigenvectors

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.score Health5
(based on unrotated principal components)

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<td>b_rate</td>
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<td>f_rate</td>
<td>-0.43768</td>
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<tr>
<td>lf_exp</td>
<td>0.40750</td>
</tr>
<tr>
<td>phys</td>
<td>0.34367</td>
</tr>
</tbody>
</table>

.gen logHealth5=log(Health5)
(1814 missing values generated)

HEALTH 1

FIXED vs RANDOM effects:

.xtreg logY_real logK_real logL, fe

Fixed-effects (within) regression
Group variable (i): country

| R-sq:       | Number of obs =  2072 |
|---------------------------------------------------|
| within      | Number of groups = 132 |
| between     | Obs per group: min = 11 |
| overall     | avg = 15.7            |
| F(2,1938)   | max = 16              |

F(2,1938) = 2402.42
corr(u_i, Xb) = 0.3260                         Prob > F           =    0.0000  

-------------+----------------------------------------------------------------  
logY_real |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]  
-------------+----------------------------------------------------------------  
logK_real |   .7358576   .0110376    66.67   0.000     .7142107    .7575044  
logL |     5.738467  

-------------+----------------------------------------------------------------  
sigma_u |   .76204941  
sigma_e |   .24326983  
rho |   .9075164   (fraction of variance due to u_i)  

F test that all u_i=0:     F(131, 1938) =   106.78           Prob > F = 0.0000  

. est store fixed  
. xtreg logY_real logK_real logL, re  

Random-effects GLS regression                   Number of obs      =      2072  
Group variable (i): country                     Number of groups   =       132  
R-sq:  within  = 0.7109                         Obs per group: min =        11  
between = 0.8778                                        avg =      15.7  
overall = 0.8719                                        max =        16  
Random effects u_i ~ Gaussian                   Wald chi2(2)       =   5718.05  
corr(u_i, X)       = 0 (assumed)                Prob > chi2        =    0.0000  

-------------+----------------------------------------------------------------  
logY_real |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]  
-------------+----------------------------------------------------------------  
logK_real |   .7286296   .0107156    68.00   0.000     .7076274    .7496319  
logL |   .1889628   .0313834     6.02   0.000     .1274524    .2504731  
_cons |   3.1254888  

-------------+----------------------------------------------------------------  
sigma_u |   .6387431  
sigma_e |   .24326983  
rho |   .87332281   (fraction of variance due to u_i)  

F test that all u_i=0:     F(131, 1938) =   106.78           Prob > F = 0.0000  

. est store random  
. hausman fixed random  

---- Coefficients ----  
|   (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))  
|     fixed        random       Difference          S.E.  
-------------+----------------------------------------------------------------  
logK_real |   .7358576     .7286296        .0072279        .0026465  
logL |     5.738467  

-------------+----------------------------------------------------------------  
sigma_u |   .6387431  
sigma_e |   .24326983  
rho |   .87332281   (fraction of variance due to u_i)  

b = consistent under Ho and Ha; obtained from xtregr  
B = inconsistent under Ha, efficient under Ho; obtained from xtregr  
Test:  Ho:  difference in coefficients not systematic  
ch2(2) = (b-B)'[(V_b-V_B)^(-1)](b-B)  
        =   19.86  
Prob>ch2 =    0.0000  

Checking for autocorrelation:  
. xtregr logY_real logK_real logL, fe
FE (within) regression with AR(1) disturbances

Number of obs      =      1940
Group variable (i): country                     Number of groups   =       132
R-sq:  within  = 0.8918                         Obs per group: min =        10
between = 0.8815                                        avg =      14.7
overall = 0.8779                                        max =        15

corr(u_i, Xb)  = -0.1784                        Prob > F           =    0.0000
F(2,1806)          =   7445.71

|                 | Coef. | Std. Err. | t    | P>|t| | [95% Conf. Interval] |
|------------------|-------|-----------|------|------|-----------------------|
| logY_real        |       |           |      |      |                       |
| logK_real        | 0.6604| 0.0104    | 63.32| 0.000| [0.6399, 0.6808]      |
| logL             | 0.4309| 0.0238    | 18.07| 0.000| [0.3841, 0.4777]      |
| _cons            | 1.1283| 0.0799    | 14.11| 0.000| [0.9715, 1.2852]      |
| rho_ar           |       |           |      |      |                       |
| sigma_u          |       |           |      |      |                       |
| sigma_e          |       |           |      |      |                       |
| rho_fov          | 0.6613|           |      |     | (fraction of variance due to u_i) |

F test that all u_i=0:     F(131,1806) =    35.62            Prob > F = 0.0000

Checking for heteroskedasticity:
. xi: reg logY_real logK_real logL i(country)
  i:  operator invalid
  r(198);
. xi: reg logY_real logK_real logL i.country
i.country         _Icountry_1-135     (naturally coded; _Icountry_1 omitted)

<table>
<thead>
<tr>
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<tr>
<td>Model</td>
<td>7536.92228</td>
<td>133</td>
<td>56.685886</td>
<td>Prob &gt; F = 0.0000</td>
</tr>
<tr>
<td>Residual</td>
<td>114.691246</td>
<td>1938</td>
<td>0.05918020</td>
<td>R-squared = 0.9850</td>
</tr>
<tr>
<td>Total</td>
<td>7651.61353</td>
<td>2071</td>
<td>3.6946468</td>
<td>Root MSE = 0.24327</td>
</tr>
</tbody>
</table>

| logY_real        | Coef. | Std. Err. | t    | P>|t| | [95% Conf. Interval] |
|------------------|-------|-----------|------|------|-----------------------|
| logK_real        | 0.7359| 0.0111    | 66.67| 0.000| [0.7142, 0.7575]      |
| logL             | 0.0069| 0.0533    | 0.13 | 0.896| [-0.0975, 0.1115]     |
| _cons            | 5.2340| 0.7359    | 7.11 | 0.000| [3.7908, 6.6772]      |

. hettest
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
Ho: Constant variance
Variables: fitted values of logY_real

<table>
<thead>
<tr>
<th>chi2(1)</th>
<th>Prob &gt; chi2</th>
</tr>
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<tbody>
<tr>
<td>13.02</td>
<td>0.0003</td>
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</tbody>
</table>

Specification (2)
. xtreg logY_real logK_real logL lit_rate, fe
Fixed-effects (within) regression

|                | Coef.  | Std. Err. | t     | P>|t| | [95% Conf. Interval] |
|----------------|--------|-----------|-------|-----|----------------------|
| logY_real      |        |           |       |     |                      |
| logK_real      | .7515716 | .0128937  | 58.29 | 0.000 | .7262763 - .7768669  |
| logL           | .2422081 | .1122245  | 2.16  | 0.031 | .0999857 - .3844266  |
| lit_rate       | -.0135044 | .0036083 | -3.74 | 0.000 | -.0205833 - -.0064255 |
| _cons          | 2.71966  | 1.486045  | 1.83  | 0.067 | -.195722 - 5.635042  |
|                | sigma_u | .58246822 |      |     |                      |
|                | sigma_e | .24991197 |      |     |                      |
|                | rho     | .84453057 |      |     |                      |
|                | F(3,1266) | 1216.36   |      |     |                      |

F test that all u_i=0: F(98, 1266) = 63.05 Prob > F = 0.0000

Random-effects GLS regression

|                | Coef.  | Std. Err. | t     | P>|t| | [95% Conf. Interval] |
|----------------|--------|-----------|-------|-----|----------------------|
| logY_real      |        |           |       |     |                      |
| logK_real      | .7487218 | .0126701  | 59.09 | 0.000 | .7238888 - .7735547  |
| logL           | .2036281 | .0332821  | 6.12  | 0.000 | .1383963 - .2688598  |
| lit_rate       | -.0094102 | .001675  | -5.62 | 0.000 | -.012693 - -.0061274 |
| _cons          | 3.054944 | .4824019  | 6.33  | 0.000 | 2.094503 - 4.015384  |
|                | sigma_u | .53645245 |      |     |                      |
|                | sigma_e | .24991197 |      |     |                      |
|                | rho     | .82167517 |      |     |                      |
|                | Wald chi2(3) | 4469.78 |      |     |                      |

F(98, 1266) = 63.05 Prob > F = 0.0000
**Test:** Ho: difference in coefficients not systematic

\[ \chi_2(3) = (b-B)'[(V_b-V_B)^{-1}](b-B) \]

\[ = 13.73 \]

\[ \text{Prob} > \chi_2 = 0.0033 \]

Checking for autocorrelation:

.xtregar logY_real logK_real logL lit_rate, fe

### FE (within) regression with AR(1) disturbances

- Number of obs = 1269
- Number of groups = 97
- R-sq: within = 0.9048
- Obs per group: min = 8
- between = 0.8848
- avg = 13.1
- overall = 0.8827
- max = 14

\[ F(3,1169) = 3702.99 \]

\[ \text{corr}(u_i, Xb) = -0.3659 \]

\[ \text{Prob} > F = 0.0000 \]

| Coef. | Std. Err. | t | P>|t| | [95% Conf. Interval] |
|-------|-----------|---|------|---------------------|
| logY_real | .6797197 | .0120479 | 56.42 | 0.000 | .6560817 - .7033577 |
| logK_real | .6535281 | .0367391 | 17.48 | 0.000 | .6201805 - .6868757 |
| logL | .4555281 | .0367391 | 12.40 | 0.000 | .3834461 - .5276101 |
| lit_rate | -.0082887 | .0039238 | -2.11 | 0.035 | -.0159871 - -.0005903 |
| _cons | .8291125 | .0996757 | 8.32 | 0.000 | .6335491 - 1.024676 |

\[ \rho_{ar} = .66073021 \]

\[ \sigma_u = .64050327 \]

\[ \sigma_e = .15819567 \]

\[ \rho_{fov} = .94250499 \] (fraction of variance due to u_i)

**F test that all u_i=0:**

\[ F(96,1169) = 21.64 \]

\[ \text{Prob} > F = 0.0000 \]

Heteroskedasticity test:

\[ . xi: reg logY_real logK_real logL lit_rate i.country \]

<table>
<thead>
<tr>
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<tr>
<td>Model</td>
<td>4148.70638</td>
<td>101</td>
<td>41.076302</td>
<td>F(101, 1266) = 657.68</td>
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<tr>
<td>Residual</td>
<td>79.0628663</td>
<td>1266</td>
<td>0.062456999</td>
<td>R-squared = 0.9813</td>
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<tr>
<td>Total</td>
<td>4227.77561</td>
<td>1367</td>
<td>3.09274002</td>
<td>Root MSE = .24991</td>
</tr>
</tbody>
</table>

| Coef. | Std. Err. | t | P>|t| | [95% Conf. Interval] |
|-------|-----------|---|------|---------------------|
| logY_real | .6797197 | .0120479 | 56.42 | 0.000 | .6560817 - .7033577 |
| logK_real | .6535281 | .0367391 | 17.48 | 0.000 | .6201805 - .6868757 |
| logL | .4555281 | .0367391 | 12.40 | 0.000 | .3834461 - .5276101 |
| lit_rate | -.0082887 | .0039238 | -2.11 | 0.035 | -.0159871 - -.0005903 |
| _cons | .8291125 | .0996757 | 8.32 | 0.000 | .6335491 - 1.024676 |

\[ \rho_{ar} = .66073021 \]

\[ \sigma_u = .64050327 \]

\[ \sigma_e = .15819567 \]

\[ \rho_{fov} = .94250499 \] (fraction of variance due to u_i)

**F test that all u_i=0:**

\[ F(96,1169) = 21.64 \]

\[ \text{Prob} > F = 0.0000 \]

\[ . hettest \]

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

Ho: Constant variance

\[ \chi_2(3) = 0.0033 \]
Variables: fitted values of logY_real

\[ \chi^2(1) = 48.64 \]
\[ \text{Prob } \chi^2 = 0.0000 \]

**SPECIFICATION (1.3)**

```
. xtreg logY_real logK_real logL lit_rate Health1, fe
```

Fixed-effects (within) regression

- Number of obs = 1162
- Number of groups = 98
- R-sq: within = 0.6369
- Obs per group: min = 1
- between = 0.8105
- avg = 11.9
- overall = 0.8122
- max = 13
- F(4,1060) = 464.73
- corr(u_i, Xb) = -0.1197

| Coef. | Std. Err. | t | P>|t| | [95% Conf. Interval] |
|-------|-----------|---|-----|------------------|
| logK_real | 0.2683264 | 0.0144336 | 18.59 | 0.000 | 0.2400048 - 0.2966481 |
| logL | 0.7763202 | 0.0556094 | 13.96 | 0.000 | 0.6672032 - 0.8854372 |
| lit_rate | -0.0036434 | 0.0017311 | -2.10 | 0.036 | -0.0070402 - 0.0002466 |
| Health1 | 0.0136713 | 0.0059813 | 2.29 | 0.022 | 0.0019348 - 0.0254078 |
| _cons | 5.743598 | 0.7350961 | 7.81 | 0.000 | 4.301189 - 7.186007 |

| sigma_u | 0.75745549 |
| sigma_e | 0.09576529 |
| rho | 0.98426688 |

F test that all u_i=0: 
\[ F(97, 1060) = 375.04 \]
\[ \text{Prob } F = 0.0000 \]

```
. est store fixed
```

```
. xtreg logY_real logK_real logL lit_rate Health1, re
```

Random-effects GLS regression

- Number of obs = 1162
- Number of groups = 98
- R-sq: within = 0.6341
- Obs per group: min = 1
- between = 0.8515
- avg = 11.9
- overall = 0.8561
- max = 13
- Wald chi2(4) = 2479.86

| Coef. | Std. Err. | z | P>|z| | [95% Conf. Interval] |
|-------|-----------|---|-----|------------------|
| logK_real | 0.2843884 | 0.0143865 | 19.77 | 0.000 | 0.2561914 - 0.3125855 |
| logL | 0.6439886 | 0.0320994 | 20.07 | 0.000 | 0.5810945 - 0.7068828 |
| lit_rate | -0.0006434 | 0.0017311 | -0.36 | 0.713 | -0.0030393 - 0.0000357 |
| Health1 | 0.018646 | 0.005837 | 3.19 | 0.001 | 0.0072058 - 0.0300863 |
| _cons | 7.036821 | 0.4314304 | 16.31 | 0.000 | 6.191233 - 7.882409 |

| sigma_u | 0.58206861 |
| sigma_e | 0.09576529 |
| rho | 0.97364688 |

```
. est store random
```

65
. hausman fixed random

<table>
<thead>
<tr>
<th></th>
<th>(b)</th>
<th>(B)</th>
<th>(b-B)</th>
<th>sqrt(diag(V_b-V_B))</th>
</tr>
</thead>
<tbody>
<tr>
<td>logK_real</td>
<td>.2683264</td>
<td>.2843884</td>
<td>-.016062</td>
<td>.0011648</td>
</tr>
<tr>
<td>logL</td>
<td>.7763202</td>
<td>.6439886</td>
<td>.1323316</td>
<td>.0454167</td>
</tr>
<tr>
<td>lit_rate</td>
<td>-.0036434</td>
<td>.0006423</td>
<td>.0042857</td>
<td>.0012251</td>
</tr>
<tr>
<td>Health1</td>
<td>.0136713</td>
<td>.018646</td>
<td>-.0049748</td>
<td>.001306</td>
</tr>
</tbody>
</table>

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

\[ \chi^2(4) = (b-B)'[\text{Var}(b-B)]^{-1}(b-B) \]

\[ = -81.01 \]

chi2=0 ==> model fitted on these data fails to meet the asymptotic assumptions of the Hausman test; see suest for a generalized test

. xtregar logY_real logK_real logL lit_rate Health1,fe

FE (within) regression with AR(1) disturbances
Number of obs = 1064
Group variable (i): country
Number of groups = 96
R-sq: within = 0.0993
between = 0.7585
overall = 0.7572
F(4, 964) = 26.57
Prob > F = 0.0000

corr(u_i, Xb) = 0.3371

| logY_real | Coef. | Std. Err. | t     | P>|t| | 95% Conf. Interval |
|-----------|-------|-----------|-------|------|-------------------|
| logK_real | .02959 | .0122531  | 2.42  | 0.016| .0055477 .0536394 |
| logL      | .73229 | .0883338  | 8.29  | 0.000| .5589397 .050637  |
| lit_rate  | .00397 | .002239   | 1.77  | 0.077| -.0004236 .0083642|
| Health1   | .00689 | .0041013  | 1.68  | 0.093| -.0149428 .0011541|

rho_ar | .81896318
sigma_u | .9083395
rho_fov | .99638465

corr(u_i, Xb) = 0.3371

F test that all u_i=0: F(95, 964) = 51.38
Prob > F = 0.0000

. xi: reg logY_real logK_real logL lit_rate Health1 i.country

Source | SS | df | MS | Number of obs = 1162
-------|----|----|----|-------------------|
Model  | 3544.06466 | 101 | 35.0897491 | Prob > F = 0.0000
Residual | 9.722124957 | 1060 | .00917099 | Adj R-squared = 0.9973
Total | 3553.78591 | 1161 | 3.06096978 | Root MSE = .09577

| logY_real | Coef. | Std. Err. | t     | P>|t| | 95% Conf. Interval |
|-----------|-------|-----------|-------|------|-------------------|

66
logK_real | .2683264  .0144336   18.59   0.000   .2400048    .2966481  
logL | .7763202  .0556094    13.96   0.000   .6672032    .8854372 
lit_rate | -0.0036434  .0017311   -2.10   0.036  -.0070402   -.0002466  
Health1 | 0.0136713  .0059813     2.29   0.022   .0019348    .0254078  

_cons | 5.528464  .6702978     8.25   0.000   4.213202    6.843725

---

. hettest 
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity 
Ho: Constant variance 
Variables: fitted values of logY_real 
chi2(1)      =     6.10 
Prob > chi2  =   0.0135

SPECIFICATION – (1.4) 

. xtreg logY_real logK_real logL lit_rate Health1 trade_n_real ,fe 
Fixed-effects (within) regression 
Number of obs      =      1145 
Number of groups   =        97 
R-sq:  within  = 0.6889 
Obs per group: min =         1 
between = 0.7936 
avg =      11.8 
overall = 0.7967 
max =        13 
corr(u_i, Xb)  = -0.1710 
F(5,1043)          =    461.88 
Prob > F           =    0.0000 

logY_real |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval] 
-------------+---------------------------------------------------------------- 
logK_real |  .2239215   .0135064  16.58   0.000     .1974186    .2504243 
logL |  .8091172   .0511833  15.81   0.000     .7086831    .9095512 
lit_rate | -0.0050015  .0015843  -3.16   0.002    -.0081102   -.0018928  
Health1 |  .0119521   .0054480   2.19   0.028    .0012618    .0226423 
trade_n_real |  6.07e-13 5.01e-14  12.12   0.000     5.09e-13    7.05e-13 
_cons |  6.393211  .6770924  9.44   0.000     5.064593     7.72183  
-------------+---------------------------------------------------------------- 
sigma_u |   .80119465  
sigma_e    |   .08703122  
rho       |   .98833783  

F test that all u_i=0:     F(96, 1043) =   426.96            Prob > F = 0.0000 

. est store fixed 
. xtreg logY_real logK_real logL lit_rate Health1 trade_n_real ,re 
Random-effects GLS regression 
Number of obs      =      1145 
Number of groups   =        97 
R-sq:  within  = 0.6855 
Obs per group: min =         1 
between = 0.8400 
avg =      11.8 
overall = 0.8463 
max =        13 
corr(u_i, X) = 0 (assumed) 
Wald chi2(5) =   2235.67 
Prob > chi2  =   0.0000 

---
logY_real |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
logK_real |   .2404443   .0135704    17.72   0.000     .2138468    .2670418
logL |   .6643917   .0312736    21.24   0.000     .6030966    .7256867
lit_rate |  -.0004223   .0011575    -0.36   0.715    -.0026909    .0018464
Health1 |   .0171989    .005361     3.21   0.001     .0066916    .0277061
trade_n_real |   5.86e-13   5.10e-14    11.48   0.000     4.86e-13    6.86e-13
_cons |   7.846615   .4246708    18.48   0.000     7.014275    8.678954
-------------+----------------------------------------------------------------
sigma_u |  .58266034
sigma_e |  .08703122
rho |  .97817591   (fraction of variance due to u_i)

Note: the rank of the differenced variance matrix (4) does not equal the number of
coefficients being tested (5); be sure this is what you expect, or there
may be problems computing the test. Examine the output of your
estimators
for anything unexpected and possibly consider scaling your variables so
that the coefficients are on a similar scale.

---- Coefficients ----
|       (b)       (B)         (b-B)     sqrt(diag(V_b-V_B))
| fixed random Difference         S.E.
-------------+----------------------------------------------------------------
logK_real |   .2239215     .2404443       -.0165228               .
logL |   .8091722     .6643917        .1447255        .0405179
lit_rate |  -.0050015    -.0004223       -.0045792        .0010817
Health1 |   .0119521     .0171989       -.0052468        .0009699
trade_n_real |    6.07e-13     5.86e-13        2.09e-14               .
-------------+----------------------------------------------------------------

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test:  Ho: difference in coefficients not systematic
       chi2(4) = (b-B)'[(V_b-V_B)^(-1)](b-B)
       Prob>chi2 = 67.38
(V_b-V_B is not positive definite)

.xtregar logY_real logK_real logL lit_rate Health1 trade_n_real ,fe

FE (within) regression with AR(1) disturbances
Number of obs =      1048
Number of groups =        95
R-sq:  within = 0.1499  Obs per group: min =         3
       between = 0.7621     avg = 11.0
       overall = 0.7611     max =       12
F(5,948) = 33.44
Prob > F = 0.0000

corr(u_i, Xb) = 0.2461

-------------+---------------------------------------------
logY_real |   Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+---------------------------------------------
logK_real |   .0328243   .0123134     2.67   0.008     .0086596    .0569889

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<table>
<thead>
<tr>
<th></th>
<th>Coef.</th>
<th>Std. Err.</th>
<th>t</th>
<th>P&gt;</th>
<th>95% Conf. Interval</th>
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<tr>
<td>logl</td>
<td>0.7741337</td>
<td>0.0826125</td>
<td>9.37</td>
<td>0.00</td>
<td>0.6120092 - 0.9362583</td>
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<tr>
<td>lit_rate</td>
<td>0.0031016</td>
<td>0.0021849</td>
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<td>0.16</td>
<td>-0.0011861 - 0.0073894</td>
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<tr>
<td>Health1</td>
<td>-0.0069951</td>
<td>0.0041424</td>
<td>1.69</td>
<td>0.09</td>
<td>-0.0151245 - 0.0011343</td>
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<td>trade_n_real</td>
<td>2.746-13</td>
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<td>3.90</td>
<td>0.00</td>
<td>1.3e-13 - 4.16e-13</td>
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<tr>
<td>_cons</td>
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<td>0.2591606</td>
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<td>10.58021 - 11.5974</td>
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<p>| | | | | | |</p>
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<td></td>
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<td>sigma_u</td>
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<tr>
<td>sigma_e</td>
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<tr>
<td>rho_fov</td>
<td>0.99623757</td>
<td>(fraction of variance due to u_i)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

F test that all u_i=0: F(94,948) = 60.79 Prob > F = 0.0000

\[ \text{xi: reg logY_real logK_real logL lit_rate Health1 trade_n_real i.country} \]
\[ \text{i.country} \quad \text{Icountry}_1-135 \quad \text{(naturally coded; } \text{Icountry}_1 \text{ omitted)} \]

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<td>3528.48681</td>
<td>101</td>
<td>34.935513</td>
<td>Proc &gt; F = 0.0000</td>
</tr>
<tr>
<td>Residual</td>
<td>7.90013417</td>
<td>1043</td>
<td>0.007574434</td>
<td>R-squared = 0.9978</td>
</tr>
<tr>
<td>Total</td>
<td>3536.38695</td>
<td>1144</td>
<td>3.09124733</td>
<td>Root MSE = 0.08703</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>logY_real</th>
<th>Coef.</th>
<th>Std. Err.</th>
<th>t</th>
<th>P&gt;</th>
<th>95% Conf. Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>logK_real</td>
<td>0.2239215</td>
<td>0.0135064</td>
<td>16.58</td>
<td>0.00</td>
<td>0.1974186 - 0.2504243</td>
</tr>
<tr>
<td>logL</td>
<td>0.8091172</td>
<td>0.0511833</td>
<td>15.81</td>
<td>0.00</td>
<td>0.7086831 - 0.9095512</td>
</tr>
<tr>
<td>lit_rate</td>
<td>-0.0050015</td>
<td>0.0015843</td>
<td>-3.16</td>
<td>0.00</td>
<td>-0.0081102 - -0.0018928</td>
</tr>
<tr>
<td>Health1</td>
<td>0.0119521</td>
<td>0.005448</td>
<td>2.19</td>
<td>0.03</td>
<td>0.0012618 - 0.0226423</td>
</tr>
<tr>
<td>trade_n_real</td>
<td>6.07e-13</td>
<td>5.01e-14</td>
<td>12.12</td>
<td>0.00</td>
<td>5.09e-13 - 7.05e-13</td>
</tr>
<tr>
<td>_cons</td>
<td>6.216219</td>
<td>0.6169232</td>
<td>10.08</td>
<td>0.00</td>
<td>5.005667 - 7.426771</td>
</tr>
</tbody>
</table>

\[ \text{hettest} \]

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
Ho: Constant variance
Variables: fitted values of logY_real
\[ \chi2(1) = 52.04 \]
Prob > \chi2 = 0.0000

**SPECIFICATION (1.5)**

\[ \text{xtreg logY_real logK_real logL lit_rate Health1 trade_n_real listed_dom_comp,fe} \]

Fixed-effects (within) regression
Number of obs = 647
Number of groups = 69
R-sq: within = 0.7689
between = 0.8009
overall = 0.8246
Obs per group: min = 1
avg = 9.4
max = 13
F(6,572) = 317.26
Prob > F = 0.0000

corr(u_i, Xb) = -0.1998
\[ \text{logY_real} \quad \text{Coeff.} \quad \text{Std. Err.} \quad \text{t} \quad \text{P>|t|} \quad \text{95% Conf. Interval} \]

| logK_real | 0.1622399 | 0.0154071 | 10.53 | 0.00   | 0.1319786 - 0.1925012     |
| logL     | 0.8018812 | 0.0611808 | 13.11 | 0.00   | 0.6817148 - 0.920476      |

69
Random-effects GLS regression                   Number of obs      =       647  
Group variable (i): country                     Number of groups   =        69  
R-sq:  within  = 0.7677                         Obs per group: min =         1  
between = 0.8195                                        avg =       9.4  
overall = 0.8468                                        max =        13  
Random effects u_i ~ Gaussian                   Wald chi2(6)       =   1539.38  
corr(u_i, X)       = 0 (assumed)                Prob > chi2        =    0.0000  

-------------+----------------------------------------------------------------  
logY_real |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]  
-------------+----------------------------------------------------------------  
logK_real |    .1722696   .0154109    11.18   0.000     .1420649    .2024743  
logL |   .7036196   .0369412    19.05   0.000     .6312161    .7760231  
lit_rate |   .0023344   .0016591     1.41   0.159    -.0009173    .0055861  
Health1 |    .018124   .0067267     2.69   0.007     .0049399     .031308  
trade_n_real |   5.32e-13   6.16e-14     8.64   0.000     4.11e-13    6.53e-13  
listed_dom_comp |   .0001575   .0000362     4.35   0.000     .0000865    .0002285  
       _cons |   8.935066   .5067289    17.63   0.000     7.941896    9.928236  
-------------+----------------------------------------------------------------  
sigma_u |  .60189262  
sigma_e |  .06479186  
rho |  .98854489   (fraction of variance due to u_i)  
------------------------------------------------------------------------------  
F test that all u_i=0:     F(68, 572) =   511.58             Prob > F = 0.0000  

. est store fixed  
. xtreg logY_real logK_real logL lit_rate Health1 trade_n_real listed_dom_comp ,re  

Random-effects GLS regression                   Number of obs      =       647  
Group variable (i): country                     Number of groups   =        69  
R-sq:  within  = 0.7677                         Obs per group: min =         1  
between = 0.8195                                        avg =       9.4  
overall = 0.8468                                        max =        13  
Random effects u_i ~ Gaussian                   Wald chi2(6)       =   1539.38  
corr(u_i, X)       = 0 (assumed)                Prob > chi2        =    0.0000  

-------------+----------------------------------------------------------------  
logY_real |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]  
-------------+----------------------------------------------------------------  
logK_real |    .1622399   .0154109    11.18   0.000     .1420649    .2024743  
logL |    .8018812   .0369412    21.61   0.000     .7326419    .8711206  
lit_rate |   -.0011158   .0023870    -0.47   0.640    -.0058042    .0035727  
Health1 |    .0156904   .0067908     2.31   0.021     .0023525    .0290283  
trade_n_real |   5.37e-13   6.10e-14     8.80   0.000     4.17e-13    6.57e-13  
listed_dom_comp |   .0001602   .0000359     4.46   0.000     .0000896    .0002308  
        _cons |    8.040665   .8082521    9.95   0.000     6.453161    9.628168  
-------------+----------------------------------------------------------------  
sigma_u |    .7103779  
sigma_e |  .06479186  
rho |  .99174981   (fraction of variance due to u_i)  
------------------------------------------------------------------------------  
P test that all u_i=0:     F(68, 572) =   511.58             Prob > F = 0.0000  

. est store random  
. hausman fixed random  

Note: the rank of the differenced variance matrix (5) does not equal the number  
of coefficients being tested (6); be sure this is what you expect, or  
there may be problems computing the test. Examine the output of your  
estimators  
for anything unexpected and possibly consider scaling your variables so  
that the coefficients are on a similar scale.  

---- Coefficients ----  
|     (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))  
| fixed random Difference S.E.  
-------------+----------------------------------------------------------------  
logK_real |    .1622399   .1722696       -.0100297               .  
logL |    .8018812   .7036196        .0982616        .0487692  
lit_rate |   -.0011158   .0023870       -.0035027        .0017162  

70
|                | Coef.         | Std. Err. | t     | P>|t| | [95% Conf. Interval] |
|----------------|---------------|-----------|-------|-----|----------------------|
| logY_real      |               |           |       |     |                      |
| logK_real      | 0.0038857     | 0.0115398 | 0.34  | 0.736 | -0.0187861 - 0.0265576 |
| logL           | 1.614434      | 0.0346747 | 46.56 | 0.000 | 1.54631 - 1.682559   |
| lit_rate       | -0.012675     | 0.0041957 | -3.02 | 0.003 | -0.0209183 - 0.0044318 |
| Health1        | 0.0054984     | 0.0049927 | 1.10  | 0.271 | -0.0043105 - 0.0153074 |
| trade_n_real   | 8.33e-14      | 6.21e-14  | 1.34  | 0.180 | -3.86e-14 - 2.05e-13  |
| listed_dom~p   | -9.82e-07     | 0.0000287 | -0.03 | 0.973 | -0.0000574 - 0.0000554 |
| _cons          | 0.3989831     | 0.0517626 | 7.71  | 0.000 | 0.2972866 - 0.5006797 |

Test: Ho: difference in coefficients not systematic

$\chi^2(5) = (b-B)'[(V_b-V_B)^{-1}](b-B)$

$\chi^2 < 0 \Rightarrow$ model fitted on these data fails to meet the asymptotic assumptions of the Hausman test; see suest for a generalized test.

```
xtdregar logY_real logK_real logL lit_rate Health1 trade_n_real
>   listed_dom_comp , f
e
```

FE within regression with AR(1) disturbances

|                | Coef.         | Std. Err. | t     | P>|t| | [95% Conf. Interval] |
|----------------|---------------|-----------|-------|-----|----------------------|
| logY_real      |               |           |       |     |                      |
| logK_real      | 0.038857      | 0.0115398 | 0.34  | 0.736 | -0.0187861 - 0.0265576 |
| logL           | 1.614434      | 0.0346747 | 46.56 | 0.000 | 1.54631 - 1.682559   |
| lit_rate       | -0.012675     | 0.0041957 | -3.02 | 0.003 | -0.0209183 - 0.0044318 |
| Health1        | 0.0054984     | 0.0049927 | 1.10  | 0.271 | -0.0043105 - 0.0153074 |
| trade_n_real   | 8.33e-14      | 6.21e-14  | 1.34  | 0.180 | -3.86e-14 - 2.05e-13  |
| listed_dom~p   | -9.82e-07     | 0.0000287 | -0.03 | 0.973 | -0.0000574 - 0.0000554 |
| _cons          | 0.3989831     | 0.0517626 | 7.71  | 0.000 | 0.2972866 - 0.5006797 |

F test that all u_i=0: $F(6,505) = 65.95$  Prob > F = 0.0000

```
xii: reg logY_real logK_real logL lit_rate Health1 trade_n_real
> country
```

Source | SS | df | MS | Number of obs = 647
-------|----|----|----|----------------------|
Model  | 1567.19781 | 74 | 21.1783488 | Prob > F = 0.0000
Residual | 2.40124767 | 572 | 0.004197985 | R-squared = 0.9985
Total | 1569.59906 | 646 | 2.42971991 | Adj R-squared = 0.9983

Root MSE = 0.06479

---

|                | Coef.         | Std. Err. | t     | P>|t| | [95% Conf. Interval] |
|----------------|---------------|-----------|-------|-----|----------------------|
| logY_real      |               |           |       |     |                      |
| logK_real      | 0.1622399     | 0.0154071 | 10.53 | 0.000 | 0.1319786 - 0.1925012 |
logL |   .8018812   .0611808    13.11   0.000     .6817148    .9220476  
lit_rate |  -.0011158    .002387    -0.47   0.640    -.0058042    .0035727  
Health1 |   .0156904   .0067908     2.31   0.021     .0023525    .0290283  
trade_n_real |   5.37e-13   6.10e-14     8.80   0.000     4.17e-13    6.57e-13  
listed_dom-p |   .0001602   .0000359     4.46   0.000     .0000896    .0002308  
_cons |   6.875375   1.084197     6.34   0.000     4.745882    9.004867  

------------------------------------------------------------------------------
   hettest
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
Ho: Constant variance
Variables: fitted values of logY_real

chi2(1)      =     3.72
Prob > chi2  =   0.0537

SPECIFICATION (1.6)

> xtreg logY_real logK_real logL lit_rate Health1 Health1_t trade_n_real
    listed_dom > _comp ,fe
Fixed-effects (within) regression
Number of obs      =       647
Group variable (i): country
Number of groups   =        69

R-sq:  within  = 0.7694
       between = 0.7998
       overall = 0.8239

F(7,571)           =    272.11
corr(u_i, Xb)  = -0.2039

F test that all u_i=0:     F(68, 571) =   413.05             Prob > F = 0.0000

est store fixed

> xtreg logY_real logK_real logL lit_rate Health1 Health1_t trade_n_real
    listed_dom > _comp ,re
Random-effects GLS regression
Number of obs      =       647
Group variable (i): country
Number of groups   =        69

R-sq:  within  = 0.7678
       between = 0.8199

sigma_u |    .71300856
sigma_e |    .06478935
rho     |    .98181071 (fraction of variance due to u_i)

F test that all u_i=0:     F(68, 571) =   413.05             Prob > F = 0.0000

est store fixed
Overall $= 0.8478$  
$max = 13$

Random effects $u_i ~ $ Gaussian  
Wald $\chi^2(7) = 1557.98$  
$Prob > \chi^2 = 0.0000$

| Fixed Effects | Coef. | Std. Err. | z     | P>|z|  | [95% Conf. Interval] |
|---------------|-------|-----------|-------|-------|----------------------|
| $\log K_{real}$ | 0.1745446 | 0.0155823 | 11.20 | 0.000 | [0.1440039, 0.2050852] |
| $\log L$ | 0.6980776 | 0.0354743 | 19.68 | 0.000 | [0.6285493, 0.767606] |
| $\text{lit rate}$ | 0.002521 | 0.0016249 | 1.55 | 0.121 | [-0.0006637, 0.0057058] |
| $\text{Health1}$ | 0.0177655 | 0.006873 | 2.58 | 0.010 | [0.0042947, 0.0312363] |
| $\text{Health1}_t$ | 0.0226519 | 0.0446691 | 0.51 | 0.612 | [-0.064898, 0.1102017] |
| $\text{trade}_n_{real}$ | 5.32e-13 | 6.24e-14 | 8.52 | 0.000 | [4.09e-13, 6.54e-13] |
| $\text{listed}_{dom-p}$ | 0.0001563 | 0.0000367 | 4.26 | 0.000 | [0.0000843, 0.0002282] |
| $\_cons$ | 8.942408 | 0.4906085 | 18.23 | 0.000 | [7.980833, 9.903983] |

| Random Effects | Coef. | Std. Err. | $z$  | $P>|z|$  | 95% Conf. Interval |
|----------------|-------|-----------|------|---------|-------------------|
| $\sigma_u$ | 0.54812598 |  
| $\sigma_e$ | 0.06478935 |  
| $\rho$ | 0.98622091 | (fraction of variance due to $u_i$)  

Note: the rank of the differenced variance matrix (6) does not equal the number of coefficients being tested (7); be sure this is what you expect, or there may be problems computing the test. Examine the output of your estimators for anything unexpected and possibly consider scaling your variables so that the coefficients are on a similar scale.

---- Coefficients ----  
<table>
<thead>
<tr>
<th></th>
<th>(b)</th>
<th>(B)</th>
<th>(b-B)</th>
<th>sqrt(diag(V_b-V_B))</th>
</tr>
</thead>
<tbody>
<tr>
<td>fixed</td>
<td>random</td>
<td>Difference</td>
<td>S.E.</td>
<td></td>
</tr>
<tr>
<td>$\log K_{real}$</td>
<td>0.1630863</td>
<td>0.1745446</td>
<td>-0.0114583</td>
<td></td>
</tr>
<tr>
<td>$\log L$</td>
<td>0.8029305</td>
<td>0.6980776</td>
<td>0.1048529</td>
<td>0.0498541</td>
</tr>
<tr>
<td>$\text{lit rate}$</td>
<td>-0.003224</td>
<td>-0.0016249</td>
<td>0.00362</td>
<td>0.0017645</td>
</tr>
<tr>
<td>$\text{Health1}$</td>
<td>0.0146725</td>
<td>0.0177655</td>
<td>-0.003093</td>
<td></td>
</tr>
<tr>
<td>$\text{Health1}_t$</td>
<td>0.0469597</td>
<td>0.0226519</td>
<td>0.0243078</td>
<td>0.010775</td>
</tr>
<tr>
<td>$\text{trade}<em>n</em>{real}$</td>
<td>5.37e-13</td>
<td>5.32e-13</td>
<td>5.82e-15</td>
<td></td>
</tr>
<tr>
<td>$\text{listed}_{dom-p}$</td>
<td>0.0001563</td>
<td>0.0001563</td>
<td>2.07e-06</td>
<td></td>
</tr>
</tbody>
</table>

$b$ = consistent under $H_0$ and $H_1$; obtained from xtreg  
$B$ = inconsistent under $H_1$, efficient under $H_0$; obtained from xtreg  

Test: $H_0$: difference in coefficients not systematic  
$\chi^2(6) = (b-B)'[(V_b-V_B)^{-1}](b-B)$  
$= -89.82$  
$chi2<0$ $\rightarrow$ model fitted on these data fails to meet the asymptotic assumptions of the Hausman test; see surest for a generalized test

`. xtregar logY_real logK_real logL lit_rate Health1 Health1_t trade_n_real listed_d > om_comp ,re`  

RE GLS regression with AR(1) disturbances  
Number of obs $= 647$
Group variable (i): country  
Number of groups = 69

R-sq: within = 0.7343  
Obs per group: min = 1
between = 0.8052  
avg = 9.4
overall = 0.8369  
max = 13

corr(u_i, Xb) = 0 (assumed)  
Wald chi2(8) = 1206.49
Prob > chi2 = 0.0000

--------- theta ---------
  min    0.7409    0.7785     0.8174     0.8214   0.8214
  5%    95%  median  max

logY_real |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  logK_real |   .073677   .0149347     4.93   0.000     .0444056    .1029484
  logL |   .7877432   .0296043    26.61   0.000     .7297199    .8457666
  lit_rate |   .0119351   .0018765     6.36   0.000     .0082571     .015613
  Health1 |    .006146   .0066258     0.93   0.354    -.0068404    .0191324
  Health1_t |  -.0039964   .0361957    -0.11   0.912    -.0749385    .0669458
  trade_n_real |   4.06e-13    7.03e-14     5.77   0.000     2.68e-13    5.44e-13
  listed_dom-p |   .0001035   .0000387     2.68   0.007     .0000278    .0001793
  _cons |    9.34938   .4528406    20.65   0.000     8.461828    10.23693
-------------+----------------------------------------------------------------
  rho_ar |  .82044763   (estimated autocorrelation coefficient)
  sigma_u |  .49508982
  sigma_e |  .07591785
  rho_fov |  .97702656   (fraction of variance due to u_i)

Source |       SS       df       MS              Number of obs =     647
-------------+------------------------------           F( 75,   571) = 4978.02
Model |   1567.2022    75  20.8960293           Prob > F      =  0.0000
Residual |  2.39686357   571  .004197659           R-squared     =  0.9985
-------------+------------------------------           Adj R-squared =  0.9983
Total |  1569.59906   646  2.42971991           Root MSE      =  .06479

logK_real |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  logL |   .1630863   .0154287    10.57   0.000     .1327824    .1933902
  lit_rate |   .0829305   .061187    13.12   0.000     .058123     .107740
  Health1 |   .0146725   .0068632     2.14   0.033    -.0011923    .0255526
  Health1_t |   .0469597   .0459503     1.02   0.307    -.0432926    .137212
  trade_n_real |   5.37e-13    6.1e-14     8.91   0.000     4.18e-13    6.57e-13
  listed_dom-p |   .0001583   .0000366     4.40   0.000     .0000877    .000229
  _cons |   6.8308751   1.085029    6.30   0.000     4.699744    8.962009

hettest
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
Ho: Constant variance
Variables: fitted values of logY_real
\[ \chi^2(1) = 3.19 \]
\[ \text{Prob} > \chi^2 = 0.0743 \]

**SPECIFICATION (1.7)**

. xtreg logY_real logK_real logL lit_rate lit_rate_t Health1 Health1_t trade_n_real > listed_dom_comp ,fe

Fixed-effects (within) regression

| Variable | Coef. | Std. Err. | t    | P>|t|  | [95% Conf. Interval] |
|----------|-------|-----------|------|------|----------------------|
| logY_real | .1680286 | .0154077 | 10.91 | 0.000 | [.1377659 , .1982914] |
| logK_real | .8100157 | .0608027 | 13.32 | 0.000 | [.690591 , .9294405] |
| logL | .8100157 | .0608027 | 13.32 | 0.000 | [.690591 , .9294405] |
| lit_rate | -.0015189 | .0023738 | -0.64 | 0.523 | [-.0061814 , .0031436] |
| lit_rate_t | .1488788 | .0493403 | 3.02 | 0.003 | [.0519679 , .2457898] |
| Health1 | .0144996 | .0068152 | 2.13 | 0.034 | [.0011136 , .0278856] |
| Health1_t | .0177999 | .0466398 | 0.38 | 0.703 | [-.073807 , .1094068] |
| trade_n_real | 5.55e-13 | 6.09e-14 | 9.12 | 0.000 | [4.35e-13 , 6.74e-13] |
| listed_dom-comp | .0001293 | .000037 | 3.49 | 0.001 | [.0000566 , .000202] |
| _cons | 5.81968 | 1.080044 | 5.39 | 0.000 | [3.698327 , 7.941033] |

\[ F(8,570) = 242.61 \]
\[ \text{Prob} > F = 0.0000 \]

. xtreg logY_real logK_real logL lit_rate lit_rate_t Health1 Health1_t trade_n_real > listed_dom-comp ,re

Random-effects GLS regression

| Variable | Coef. | Std. Err. | t    | P>|t|  | [95% Conf. Interval] |
|----------|-------|-----------|------|------|----------------------|
| logY_real | .1789263 | .0154777 | 11.40 | 0.000 | [.1481526 , .2097412] |
| logK_real | .6783337 | .034886 | 19.44 | 0.000 | [.6099583 , .7467091] |
| logL | .6783337 | .034886 | 19.44 | 0.000 | [.6099583 , .7467091] |
| lit_rate | .0034472 | .001629 | 2.12 | 0.034 | [.0002544 , .0066401] |
| lit_rate_t | -.0039863 | .001712 | -2.33 | 0.020 | [.0002544 , .0066401] |
| Health1 | .0174644 | .0069152 | 2.53 | 0.012 | [.0039106 , .0310183] |
| Health1_t | .056111 | .0474014 | 1.18 | 0.237 | [.0039106 , .0310183] |
| trade_n_real | 5.28e-13 | 6.28e-14 | 8.40 | 0.000 | [4.05e-13 , 6.51e-13] |

\[ F(68, 570) = 368.38 \]
\[ \text{Prob} > F = 0.0000 \]

. est store fixed

. xtreg logY_real logK_real logL lit_rate lit_rate_t Health1 Health1_t trade_n_real > listed_dom-comp ,re

Random-effects GLS regression

| Variable | Coef. | Std. Err. | t    | P>|t|  | [95% Conf. Interval] |
|----------|-------|-----------|------|------|----------------------|
| logK_real | .2135 | .0254 | 8.40 | 0.000 | [.1636 , .2634] |
| logL | .7613 | .0474 | 16.04 | 0.000 | [.6682 , .8544] |
| lit_rate | .00041 | .00013 | 3.16 | 0.000 | [.00016 , .00066] |
| lit_rate_t | -.0008 | .00015 | -5.29 | 0.000 | [-.0011 , -.0005] |
| Health1 | .0156 | .0042 | 3.71 | 0.000 | [.0073 , .0239] |
| Health1_t | .0561 | .0474 | 1.18 | 0.237 | [-.0367 , .1490] |
| trade_n_real | 5.28e-13 | 6.28e-14 | 8.40 | 0.000 | [4.05e-13 , 6.51e-13] |

\[ \text{F test that all } u_i=0: \] \[ F(68, 570) = 368.38 \]
\[ \text{Prob} > F = 0.0000 \]

. est store fixed
. est store random

. hausman fixed random

Note: the rank of the differenced variance matrix (7) does not equal the number of coefficients being tested (8); be sure this is what you expect, or there may be problems computing the test. Examine the output of your estimators for anything unexpected and possibly consider scaling your variables so that the coefficients are on a similar scale.

. xtregar logY_real logK_real logL lit_rate lit_rate_t Health1 Health1_t trade_n_re > al listed_dom_comp ,fe

FE (within) regression with AR(1) disturbances  Number of obs = 578
Group variable (i): country                     Number of groups = 67
R-sq: within  = 0.9369                         Obs per group: min = 1
between = 0.6996     avg = 8.6
overall = 0.6986     max = 12

corr(u_i, Xb) = -0.8582                        F(8,503) = 933.83
Prob > F = 0.0000

-----------------------------------------------------------------------------
logY_real |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
logK_real |   .0048309   .0114879     0.42   0.674    -.0177393    .0274011

listedom-p |  .0001524   .000037     4.12   0.000     .0000799    .0002249
_cons |   9.138083   .4821851    18.95   0.000     8.193018    10.08315
-------------+----------------------------------------------------------------
sigma_u |  .50813053
sigma_e |  .06433438
rho |  .98422283   (fraction of variance due to u_i)
------------------------------------------------------------------------------

b = consistent under Ho, efficient under Ha; obtained from xtreg

Test:  Ho: difference in coefficients not systematic
   chi2(7) = (b-B)’[(V_b-V_B)^(-1)](b-B) = -79.69  chi2<0 ==> model fitted on these data fails to meet the asymptotic assumptions of the Hausman test; see suest for a generalized test

b = consistent under Ho and Ha; efficient under Ho; obtained from xtreg

R = inconsistent under Ha, efficient under Ho; obtained from xtreg
| Variable | Coef.   | Std. Err. | t     | P>|t|  | [95% Conf. Interval] |
|---------|---------|-----------|-------|------|----------------------|
| logK_real | 0.1680286 | 0.0154077 | 10.91 | 0.000 | 0.1377659 - 0.1982914 |
| logL     | 0.8100157 | 0.0608027 | 13.32 | 0.000 | 0.690591 - 0.9294405 |
| lit_rate | -0.0015189 | 0.0023738 | -0.64 | 0.523 | -0.0061814 - 0.0031436 |
| lit_rate_t | 0.1488788 | 0.0493403 | 3.02 | 0.003 | 0.0519678 - 0.2457998 |
| Health1  | 0.0144996 | 0.0068152 | 2.13 | 0.034 | 0.0011336 - 0.0278856 |
| Health1_t | 0.0177999 | 0.0463998 | 0.38 | 0.703 | -0.073807 - 0.1094068 |
| trade_n_real | 5.55e-13 | 6.09e-14 | 9.12 | 0.000 | 4.35e-13 - 6.74e-13 |
| listed_dom-p | -5.44e-06 | .0000287 | 1.20 | 0.231 | -0.0000619 - 0.0000513 |
| _cons    | -6.732624 | 5.014772 | -1.34 | 0.180 | -16.58231 - 3.117062 |

**HEALTH 2**

**SPECIFICATION (2.1)**
overall = 0.8167                               
max = 13                                      
corr(u_i, Xb) = -0.3892                        
Prob > F = 0.0000                             

F(4, 488) = 187.43                            
corr(u_i, Xb) = -0.3892                        
Prob > F = 0.0000                             

------------------------------------------------------------------
logY_real |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
logK_real |   0.306207   0.023751    13.47   0.000     0.259240    0.353174
logL |   0.865195   0.106721     8.11   0.000     0.656111    1.074279
lit_rate |  -0.004166   0.003683    -1.13   0.258    -0.010402    0.002070
Health2 |   0.017636   0.010131     1.74   0.082    -0.002269    0.037535
_cons |   3.665579   1.348147     2.72   0.007     1.016690    6.314468
-------------+----------------------------------------------------------------
sigma_u |  0.79776541
sigma_e |  0.10064747
rho |  0.98433259   (fraction of variance due to u_i)
------------------------------------------------------------------
F test that all u_i=0: F(96, 488) = 233.20             Prob > F = 0.0000

.est store fixed
.xtreg logY_real logK_real logL lit_rate Health2, re
Random-effects GLS regression                   Number of obs      =       589
Group variable (i): country                     Number of groups   =        97
R-sq:  within  = 0.5998                         Obs per group: min =         1
between = 0.8795                                        avg =       6.1
overall = 0.8592                                        max =        13
Random effects u_i ~ Gaussian                   Wald chi2(4)       =   1455.36
corr(u_i, X)       = 0 (assumed)                Prob > chi2        =    0.0000

------------------------------------------------------------------
logY_real |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
logK_real |    0.306207   0.023751    13.47   0.000     0.259240    0.353174
logL |    0.865195   0.106721     8.11   0.000     0.656111    1.074279
lit_rate |  -0.004166   0.003683    -1.13   0.258    -0.010402    0.002070
Health2 |    0.017636   0.010131     1.74   0.082    -0.002269    0.037535
_cons |    3.665579   1.348147     2.72   0.007     1.016690    6.314468
-------------+----------------------------------------------------------------
sigma_u |  0.79776541
sigma_e |  0.10064747
rho |  0.97073141   (fraction of variance due to u_i)
------------------------------------------------------------------
F test that all u_i=0: F(96, 488) = 233.20             Prob > F = 0.0000

.est store random
.houseman fixed random

---- Coefficients ----
|           (b)          (B)            (b-B)     sqrt(diag(V_b-V_B)) |
| fixed       random       Difference          S.E.|
| logK_real |    0.306207   0.331103    -0.0248962        0.0063478
| logL |    0.865195   0.6177891    0.2474061        0.088925
| lit_rate |  -0.004166   0.004556    -0.0087222        0.0030597
| Health2 |    0.017636   0.027966     -0.010333        0.0028209

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg
Test: Ho: difference in coefficients not systematic
\[ \chi_2(4) = (b-B)'[(V_b-V_B)^{-1}](b-B) \]
\[ = 8.76 \]
\[ \text{Prob} > \chi_2 = 0.0674 \]
(V_b-V_B is not positive definite)

.xtregar logY_real logK_real logL lit_rate Health2, fe
FE (within) regression with AR(1) disturbances
Number of obs = 492
Group variable (i): country
Number of groups = 95
R-sq: within = 0.9928
between = 0.8251
overall = 0.8232
F(4,393) = 13597.07
corr(u_i, Xb) = -0.6327
Prob > F = 0.0000

\| Coef. Std. Err. t P>|t| [95% Conf. Interval]
\|-----------------|-----------------|-----------------|--------|-----------------|-----------------|
logY_real | .0471319 .0216086 2.18 0.030 .004649 .0896149
logK_real | 1.286217 .0388606 33.10 0.000 1.209816 1.362618
logL | 1.286217 .0388606 33.10 0.000 1.209816 1.362618
lit_rate | 0.0344647 .0048545 7.10 0.000 .0249207 .0440087
Health2 | .0173389 .0086169 2.01 0.045 .0003979 .0342799
_cons | .4703239 .0172344 27.29 0.000 .4364407 .5042072
-------------+----------------------------------------------------------------
rho_ar | .8736307
sigma_u | .9478893
sigma_e | .05877118
rho_fov | .99617046 (fraction of variance due to u_i)
-------------+----------------------------------------------------------------
F test that all u_i=0: F(94,393) = 18.98
Prob > F = 0.0000

.xi: reg logY_real logK_real logL lit_rate Health2 i.country
i.country         _Icountry_1-135 (naturally coded; _Icountry_1 omitted)
Source |        SS       df       MS              Number of obs =     589
-------------+------------------------------           F(100,   488) = 1740.52
Model |  1763.131   100   17.63131           Prob > F      =  0.0000
Residual |  4.94339722  488  .010129912           R-squared     =  0.9972
-------------+------------------------------           Adj R-squared =  0.9966
Total |  1768.0744   588  3.00692924           Root MSE      =  .10065
-------------+------------------------------
logY_real |      Coef. Std. Err. t P>|t| [95% Conf. Interval]
-------------+-----------------|-----------------|--------|-----------------|-----------------|
logK_real | .3062068 .0237507 12.89 0.000 .2595406 .352873
logL | .8651951 .1067183 8.11 0.000 .6555111 1.074879
lit_rate | -0.0041665 .0036828 -1.13 0.258 -.0114026 .0030695
Health2 | .0176358 .0101306 1.74 0.082 -.0022693 .0375408
_cons | 3.391146 1.239671 2.74 0.006 .9553935 5.826898
-------------+-----------------|-----------------|--------|-----------------|-----------------|

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
Ho: Constant variance
Variables: fitted values of logY_real

hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
\[ \chi^2(1) = 17.54 \]
\[ \text{Prob > } \chi^2 = 0.0000 \]

**SPECIFICATION (2.2)**

```
.xtreg logY_real logK_real logL lit_rate Health2 trade_n_real, fe
```

Fixed-effects (within) regression

<table>
<thead>
<tr>
<th></th>
<th>Number of obs</th>
<th>Number of groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>572</td>
<td>14</td>
</tr>
</tbody>
</table>

R-sq: within = 0.8784  
Obs per group: min = 9  
between = 0.8179  
avg = 40.9  
overall = 0.8793  
max = 93  

\[ F(5, 553) = 798.92 \]
\[ \text{Prob > } F = 0.0000 \]

```
|                      | Coef.  | Std. Err. | t    | P>|t|  | [95% Conf. Interval] |
|----------------------|--------|-----------|------|------|---------------------|
|                      |        |           |      |      |                     |
| logY_real            |        |           |      |      |                     |
| logK_real            | 0.3764023 | 0.0362381 | 10.39| 0.000| 0.3052212 - 0.4475934|
| logL                 | 0.5309345 | 0.0408864 | 12.99| 0.000| 0.4506228 - 0.6112461|
| lit_rate             | -0.0002319 | 0.0024198 | -0.10| 0.924| -0.0049851 - 0.0045213|
| Health2              | 0.1444168 | 0.0270738 | 5.33 | 0.000| 0.0912367 - 0.1975969|
| trade_n_real         | 1.07e-12  | 2.27e-13  | 4.69 | 0.000| 6.19e-13 - 1.51e-12  |
| _cons                | 6.675983  | 0.4901596 | 13.62| 0.000| 5.713181 - 7.638785  |
```

```
.sigma_u | 1.8013086 | sigma_e | .60248121 |
.rho     | 0.8205515 |
```

F test that all u_i=0:  \[ F(13, 553) = 1.94 \]  
\[ \text{Prob > } F = 0.0233 \]

```
.est store fixed
```

```
.xtreg logY_real logK_real logL lit_rate Health2 trade_n_real, re
```

Random-effects GLS regression

<table>
<thead>
<tr>
<th></th>
<th>Number of obs</th>
<th>Number of groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>572</td>
<td>14</td>
</tr>
</tbody>
</table>

R-sq: within = 0.8782  
Obs per group: min = 9  
between = 0.8202  
avg = 40.9  
overall = 0.8798  
max = 93  

Random effects u_i ~ Gaussian  
Wald \[ \chi^2(5) = 1868.28 \]  
\[ \text{Prob > } \chi^2 = 0.0000 \]

```
|                      | Coef.  | Std. Err. | z    | P>|z|  | [95% Conf. Interval] |
|----------------------|--------|-----------|------|------|---------------------|
|                      |        |           |      |      |                     |
| logY_real            |        |           |      |      |                     |
| logK_real            | 0.3722195 | 0.0360722 | 10.32| 0.000| 0.3015193 - 0.4429196|
| logL                 | 0.5343432 | 0.0409532 | 13.05| 0.000| 0.4540789 - 0.6146076|
| lit_rate             | -0.0005812 | 0.0024010 | -0.24| 0.809| -0.0053057 - 0.0041433|
| Health2              | 0.1317087 | 0.0268551 | 4.90 | 0.000| 0.0790737 - 0.1843438|
| trade_n_real         | 1.01e-12  | 2.28e-13  | 4.41 | 0.000| 5.58e-13 - 1.45e-12  |
| _cons                | 6.757474  | 0.4858888 | 13.91| 0.000| 5.805165 - 7.709783  |
```

```
sigma_u | 0.0518954 | sigma_e | .60248121 |
rho     | 0.0073648 | (fraction of variance due to u_i) |
```

```
.est store random
```
Note: the rank of the differenced variance matrix (4) does not equal the number of coefficients being tested (5); be sure this is what you expect, or there may be problems computing the test. Examine the output of your estimators for anything unexpected and possibly consider scaling your variables so that the coefficients are on a similar scale.

Test: Ho: difference in coefficients not systematic

\[ \chi^2(4) = (b-B)'(V_{b-B})^{-1}(b-B) \]

-9.74 \chi^2 < 0 ==> model fitted on these data fails to meet the asymptotic assumptions of the Hausman test; see \textit{suest} for a generalized test.

\begin{verbatim}
.xtreg logY_real logK_real logL lit_rate Health2 trade_n_real, fe
. xi: reg logY_real logK_real logL lit_rate Health2 trade_n_real i.country
\end{verbatim}
### Table 1: Fixed-effects Regression Results

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>Number of obs = 572</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>1742.63305</td>
<td>100</td>
<td>17.4263305</td>
<td>F(100, 471) = 2137.84</td>
</tr>
<tr>
<td>Residual</td>
<td>3.8392939</td>
<td>471</td>
<td>.008151367</td>
<td>R-squared = 0.9978</td>
</tr>
<tr>
<td>Total</td>
<td>1746.47235</td>
<td>571</td>
<td>3.05862057</td>
<td>Root MSE = .09028</td>
</tr>
</tbody>
</table>

| logY_real | Coef. | Std. Err. | t    | P>|t| | 95% Conf. Interval |
|-----------|-------|-----------|------|------|---------------------|
| logK_real | .2460528 | .0222765 | 11.05 | 0.000 | .2022791 - .2898265 |
| logL     | .8952442 | .0985404 | 9.09  | 0.000 | .7016109 - 1.088877 |
| lit_rate | -.0063832 | .003346 | -1.91 | 0.057 | -.0129581 - .0001918 |
| Health2  | .0142215 | .0091208 | 1.56  | 0.120 | -.0037011 - .0321441 |
| trade_n_real | 5.72e-13 | 7.66e-14 | 7.48  | 0.000 | 4.22e-13 - 7.23e-13 |
| _cons    | 4.55814 | 1.145817 | 3.98  | 0.000 | 2.306594 - 6.809686 |

### Any additional notes
- **Heteroskedasticity Test:**
  - Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
  - Variables: fitted values of logY_real
  - chi2(1) = 26.41
  - Prob > chi2 = 0.0000

### Additional Results
- **xtreg** command with specified variables:
  - **logY_real**, **logK_real**, **logL**, **lit_rate**, **Health2**, **trade_n_real**, **listed_dom_comp**
  - Fixed-effects model with group variable: `year`
  - Number of obs = 377
  - Number of groups = 14
- **R-squared**:
  - Within: 0.8886
  - Between: 0.2271
  - Overall: 0.8793
- **F-test** for group effects: F(13, 357) = 2.58
- **Prob > F**: 0.0020

### Summary
- Fixed-effects regression with heteroskedasticity test
- Additional model specifications and coefficients

---

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. xtreg logY_real logK_real logL lit_rate Health2 trade_n_real listed_dom_comp, 
\re
Random-effects GLS regression                   Number of obs      =       377
Group variable (i): year                        Number of groups   =        14
R-sq:  within  = 0.8880                         Obs per group: min =         5
between = 0.2664                                   avg =      26.9
overall = 0.8801                                    max =        64
Random effects u_i ~ Gaussian                   Wald chi2(6)       =   1169.14
corr(u_i, X)       = 0 (assumed)                Prob > chi2        =    0.0000
------------------------------------------------------------------------------
      logY_real |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      logK_real |   .4510351   .0443609    10.17   0.000     .3640893    .5379809
      logL |    .427025    .05222     8.18   0.000     .3247154    .5293351
     lit_rate |   .0007375   .0030132     0.24   0.807    -.0051682    .0066433
     Health2 |   .0327033   .0377143     0.87   0.386    -.0412155    .1066221
  trade_n_real |   4.63e-13   2.38e-13     1.95   0.052    -.31e-15     .92e-13
listed_dom~p |   4.63e-13   2.38e-13     1.95   0.052    -.31e-15     .92e-13
      _cons |   6.373408   .6133378    10.39   0.000     5.171288    7.575528
------------------------------------------------------------------------------

Random-effects u_i ~ Gaussian
Wald chi2(4)       = 1169.14
Prob > chi2        = 0.0000

. est store random
. hausman fixed random

Note: the rank of the differenced variance matrix (5) does not equal the number of
coefficients being tested (6); be sure this is what you expect, or
there may be problems computing the test. Examine the output of your
estimators for anything unexpected and possibly consider scaling your variables so
that the coefficients are on a similar scale.

---- Coefficients ----
|       (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
-------------+----------------------------------------------------------------
      logK_real |    .4606687     .4510351        .0096336               
      logL |    .420689      .427025       -.0063361               
     lit_rate |   -.0000517     .0007375       -.0007892               
     Health2 |   .0778933     .0327033          .04519        .0107782 
  trade_n_real |    4.69e-13     4.63e-13        5.62e-15               
listed_dom~p |   .0006773     .0006654        .0000119               
      _cons |   6.373408    .6133378          10.39            .0000000
-------------+----------------------------------------------------------------
 sigma_u |     0
 sigma_e |   .53158974
 rho |     0  (fraction of variance due to u_i)

. est store random
. hausman fixed random

Test:  Ho: difference in coefficients not systematic 
B = inconsistent under Ha, efficient under Ho; obtained from xtreg
b = consistent under Ho and Ha; obtained from xtreg 

\chi^2(5) = \{b-B\}'\{V_b-V_B\}^{-1}\{b-B\} 
= -8.30  chi2<0  model fitted on these
\text{data fails to meet the asymptotic assumptions of the Hausman test;}
\text{see} \text{suest} \text{for a generalized test}

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. xtregar logY_real logK_real logL lit_rate Health2 trade_n_real listed_dom_comp, f
> e

FE (within) regression with AR(1) disturbances  Number of obs  =     363
Group variable (i): year                        Number of groups =        14

R-sq:  within  = 0.9801                         Obs per group: min =         4
        between = 0.3856                                        avg =     25.9
        overall = 0.8612                                        max =        63

corr(u_i, Xb)  = -0.0715                        F(6,343)           =   2821.09
                                    Prob > F           =    0.0000

------------------------------------------------------------------------------
  logY_real |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  logK_real  |   .7210841   .0388063    18.58   0.000     .6447559    .7974123
  logL      |   .4264152   .0551969     7.73   0.000     .3178482    .5349822
  lit_rate  |   .0049811   .0032192     1.55   0.123    -.0013508     .011313
  Health2   |   .0458596   .0421118     1.09   0.277    -.0369703    .1286895
  trade_n_real |  -8.11e-13   1.99e-13    -4.07   0.000    -1.20e-12   -4.19e-13
  listed_dom_comp |   .0001514   .0001919     0.79   0.431     -.000226    .0005289
     _cons   |  -1.076761   .1412118    -7.63   0.000    -1.354511    -.799011
-------------+----------------------------------------------------------------
     rho_ar   |  .52127343   (estimated autocorrelation coefficient)
     sigma_u  |  .23967882
     sigma_e  |  .57199006
     rho_fov  |  .14935821   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(13,343) =    -2.31              Prob > F = 1.0000

. xtregar logY_real logK_real logL lit_rate Health2 trade_n_real
list Domestic, r
> e

RE GLS regression with AR(1) disturbances       Number of obs      =       377
Group variable (i): year                        Number of groups =        14

R-sq:  within  = 0.8876                         Obs per group: min =         5
        between = 0.2539                                        avg =     26.9
        overall = 0.8790                                        max =        64

corr(u_i, Xb)      = 0 (assumed)                Wald chi2(7)       =  1344.07
                                    Prob > chi2        =    0.0000

------------------- theta --------------------
                   min      5%       median        95%      max
0.0133   0.0269     0.0626     0.0890   0.0890

------------------------------------------------------------------------------
  logY_real |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  logK_real  |   .510248   .0425951    11.98   0.000     .4267632    .5937328
  logL      |   .4264152   .0551969     7.73   0.000     .3178482    .5349822
  lit_rate  |   .0049811   .0032192     1.55   0.123    -.0013508     .011313
  Health2   |   .046926   .0379726     1.24   0.217    -.0274997    .1213509
  trade_n_real |   2.25e-13   2.24e-13     1.01   0.313    -.0313e-13    6.46e-13
  listed_dom-comp |   .0005702   .0001745     3.27   0.001     .0002282    .0009122
      _cons   |  4.915761   .5971431     8.23   0.000     3.745382     6.08514
-------------+----------------------------------------------------------------
     rho_ar   |  .52127343   (estimated autocorrelation coefficient)
xi: reg logY_real logK_real logL lit_rate Health2 trade_n_real listed_dom_comp i.country

. hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
Ho: Constant variance
Variables: fitted values of logY_real

. xtabs

xtreg logY_real logK_real logL lit_rate Health2 listed_dom_comp, fe

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|           |      Coef.   Std. Err. |      z    |    P>|z|     |   [95% Conf. Interval] |
|-----------|----------------------|-----------|---------|----------------|-----------------------|
| logK_real |     .5415512   .0377629   14.34   0.000     .4675372    .6155651 |
| logK   |     .3851469   .0437592    8.80   0.000     .2993804    .4709134 |
| lit_rate |      .005531   .0025486    2.17   0.030     .0005358    .0105262 |
| lit_rate_t |    -.0110062   .0017875   -6.16   0.000    -.0145097   -.0075027 |
| Health2 |     .0880268    .032282     2.73   0.006     .0247553    .1512984 |
| Health2_t |     .2894135   .1969039     1.47   0.142     -.096511     .675338 |
| trade_n_real |    2.62e-13  2.01e-13    1.31   0.193    -1.33e-13    6.57e-13 |
| listed_dom-p |     .0001917  .0001497    1.31   0.193    -.0001028    .0004861 |
| _cons    |   4.51846    .5365894     8.61   0.000     3.563167    5.473754 |

\[ \text{sig}_{\text{u}} | \quad 0.12202986 \]
\[ \text{sig}_{\text{e}} | \quad 0.45371265 \]
\[ \text{rho} | \quad 0.06745878 \] (fraction of variance due to \( u_i \))

F test that all \( u_i=0 \): \( F(13, 355) = 1.34 \) Prob > \( F = 0.1865 \)

\[ \text{est store fixed} \]
\[ \text{xtreg logY\_real logK\_real logL lit\_rate lit\_rate\_t Health2 Health2\_t trade\_n\_real listed\_dom\_comp, re} \]

Note: the rank of the differenced variance matrix (7) does not equal the number of
coefficients being tested (8); be sure this is what you expect, or there
may be problems computing the test. Examine the output of your
estimators
for anything unexpected and possibly consider scaling your variables so
that the coefficients are on a similar scale.
logL |    .3812284     .3851469       -.0039185        .0036599
lit_rate |    .0048449      .005531       -.0006861        .0003157
lit_rate_t |   -.0112317    -.0110062       -.0002255        .0003143
Health2 |     .105868     .0880268        .0178411        .0103151
Health2_t |     .387154     .2894135        .0977405        .0414275
trade_n_real |    2.62e-13     2.44e-13        1.83e-14        1.63e-14
listed_dom-p |    .0001917     .0001414        .0000503        .0000174
------------------------------------------------------------------------------
  b = consistent under Ho and Ha; obtained from xtreg
  B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test:  Ho: difference in coefficients not systematic
   chi2(7) = (b-B)'[(V_b-V_B)^(-1)](b-B)
           =       14.18
   Prob > chi2 =      0.0481

(V_b-V_B is not positive definite)
xtregar logY_real logK_real logL lit_rate lit_rate_t Health2 Health2_t trade_n_r
> eal listed_dom_comp, fe
FE (within) regression with AR(1) disturbances  Number of obs      =       363
Group variable (i): year                        Number of groups   =        14
R-sq:  within  = 0.9891                         Obs per group: min =         4
        between = 0.7611                                        avg =      25.9
        overall = 0.9050                                        max =        63
F(8,341)           =   3874.13
corr(u_i, Xb)  = -0.0371                        Prob > F           =    0.0000
------------------------------------------------------------------------------
logY_real |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
logK_real |   .7095302   .0297211    23.87   0.000     .6510704      .76799
logL |   .4427138   .0420214    10.54   0.000     .3600601    .5253734
lit_rate |   .0102592   .0025215     4.07   0.000     .0052995    .0152189
lit_rate_t |  -.0117067   .0018139    -6.45   0.000    -.0152745   -.0081388
Health2 |   .1299957   .0327665     3.97   0.000     .0655458    .1944455
Health2_t |   .1178829   .2048449     0.58   0.565    -.2850358    .5208015
trade_n_real |  -6.61e-13   1.50e-13    -4.41   0.000    -9.56e-13    -3.66e-13
listed_dom-p |  -.0004998   .0001553    -3.22   0.001    -.0008053   -.0001944
    _cons |  -1.367242   .0843699   -16.21   0.000    -1.533193   -1.201291
rho_ar |   .6597364
sigma_u |   .1323433
sigma_e |   .4398482
rho_fov |   .0830585   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(13,341) =    -0.10              Prob > F = 1.0000

. xi: reg logY_real logK_real logL lit_rate lit_rate_t Health2 Health2_t
trade_n_r
> eal listed_dom_comp i.country, robust
i.country         _Icountry_1-135     (naturally coded; _Icountry_1 omitted)
Regression with robust standard errors          Number of obs =     377
F( 68,   302) =       .
Prob > F =       .
R-squared     =  0.9985
Root MSE      =  .06691

------------------------------------------------------------------------------
### HEALTH 3

#### SPECIFICATION (3.1)

| Coef. | Std. Err. | t | P>|t| | 95% Conf. Interval |
|-------|-----------|---|-----|------------------|
| logK_real | 0.1968904 | 0.0269327 | 7.31 | 0.000 | 0.1438909 | 0.24989 |
| logL | 1.127201 | 0.13743 | 8.20 | 0.000 | 0.856759 | 1.397642 |
| lit_rate | -0.0072979 | 0.0046959 | -1.55 | 0.121 | -0.0165388 | 0.001943 |
| lit_rate_t | 0.1881423 | 0.0590562 | 3.19 | 0.002 | 0.0719286 | 0.304356 |
| Health2 | 0.0020768 | 0.0115773 | 0.18 | 0.858 | -0.0207056 | -0.048952 |
| trade_n_real | 5.07e-13 | 5.09e-14 | 9.97 | 0.000 | 4.07e-13 | 6.07e-13 |
| listed_dom-p | 0.0000117 | 0.0000455 | 0.26 | 0.798 | -0.0000778 | -0.000012 |
| _cons | 4.557073 | 1.44152 | 3.16 | 0.002 | 1.720378 | 7.393768 |

#### HEALTH 4

**Note:** The table content for HEALTH 4 is not fully visible in the image. The remainder of the content is not included in this transcription.
. est store fixed

. xtreg logY_real logK_real logL lit_rate Health4, re
Random-effects GLS regression                   Number of obs      =       425
Group variable (i): year                        Number of groups   =        14
R-sq:  within  = 0.8847                         Obs per group: min =         3
        between = 0.8567                                        avg =      30.4
        overall = 0.8826                                        max =        93
Random effects u_i ~ Gaussian                   Wald chi2(4)       =   3156.70
        corr(u_i, X)       = 0 (assumed)                Prob > chi2        =    0.0000
------------------------------------------------------------------------------
logY_real |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    logK_real |    .252017   .0420023     6.00   0.000     .1696939    .3343401
     logL |   .7291325   .0459474    15.87   0.000     .6390773    .8191877
     lit_rate |  -.0066364    .002744    -2.42   0.016    -.0120145   -.0012583
     Health4 |   .2532776   .0286512     8.84   0.000     .1971223     .309433
     _cons |   7.420308   .5185111    14.31   0.000     6.404045    8.436571
------------------------------------------------------------------------------
sigma_u |          0
sigma_e |  .58283272
rho |          0   (fraction of variance due to u_i)
------------------------------------------------------------------------------

. est store random

. hausman fixed random

---- Coefficients ----
|      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
-------------+----------------------------------------------------------------
    logK_real |    .2830601      .252017        .0310431        .0086929
     logL |     .696687     .7291325       -.0324455        .0077473
    lit_rate |  -.0057209    -.0066364        .0009155               .
    Health4 |   .2578014     .2532776        .0045238               .
     _cons |  7.420308     .5185111       6.9017971               .
-------------+----------------------------------------------------------------

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test:  Ho: difference in coefficients not systematic
ch2(4) = (b-B)'[V_b-V_B]^-1 (b-B) = 9.03
Prob>ch2 = 0.0603
(V_b-V_B is not positive definite)

. xtregar logY_real logK_real logL lit_rate Health4, fe
FE (within) regression with AR(1) disturbances Number of obs      =       411

89
overall = 0.8952
max = 92

F(5, 395) = 701.82
Prob > F = 0.0000

corr(u_i, Xb) = -0.1582

Random-effects GLS regression
Number of obs = 414
Group variable (i): year
Number of groups = 14
R-sq: within  = 0.8987
between = 0.8574
overall = 0.8962

Random effects u_i ~ Gaussian
Wald chi2(5) = 1523.11
Prob > chi2 = 0.0000

corr(u_i, X) = 0 (assumed)

Note: the rank of the differenced variance matrix (4) does not equal the number of coefficients being tested (5); be sure this is what you expect, or there may be problems computing the test. Examine the output of your estimators for anything unexpected and possibly consider scaling your variables so that the coefficients are on a similar scale.
--- Coefficients ---

<table>
<thead>
<tr>
<th>(b)</th>
<th>(B)</th>
<th>(b-B)</th>
<th>sqrt(diag(V_b-V_B))</th>
</tr>
</thead>
<tbody>
<tr>
<td>fixed</td>
<td>random</td>
<td>Difference</td>
<td>S.E.</td>
</tr>
</tbody>
</table>

| | | | |
| logK_real | .2594821 | .2425085 | .0169736 | .0071916 |
| logL | .6226619 | .6401031 | -.0174412 | .0062309 |
| lit_rate | -.0045919 | -.0051527 | .0005608 | . |
| min Health4 | .2267043 | .2217366 | .0049677 | . |
| trade_n_real | 1.87e-12 | 1.88e-12 | -1.20e-14 | . |

---

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

\[
\text{ch}^2(4) = (b-B)' \left( (V_b-V_B)^{-1} \right) (b-B) = 4.74
\]
Prob > ch2 = 0.3145

(V_b-V_B is not positive definite)

Random effect is more preferable.

. xtregar logY_real logK_real logL lit_rate Health4 trade_n_real, re

RE GLS regression with AR(1) disturbances

Number of obs = 414
Group variable (i): year
Number of groups = 14

R-sq: within = 0.8969 Obs per group: min = 3
between = 0.8435 avg = 29.6
overall = 0.8921 max = 92

corr(u_i, Xb) = 0 (assumed)

. xi: reg logY_real logK_real logL lit_rate Health4 trade_n_real i.country

Source | SS df MS Number of obs = 414
-------------+-----------------------------------------------
Model | 1253.418 99 12.6607879 Prob > F = 0.0000
Residual | 2.86677091 314 .009129844 R-squared = 0.9977
-------------+-----------------------------------------------
Total | 1256.28477 413 3.0418517 Root MSE = .09555
logY_real |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
logK_real |   .2164128   .0285638     7.58   0.000     .1602121    .2726134
logL |   .8275381   .1389414     5.96   0.000     .5541642    1.100912
lit_rate |  -.0059909   .0042749    -1.40   0.162    -.0144019      .00242
Health4 |   .0227176   .0149117     1.52   0.129    -.0066218     .052057
trade_n_real |   6.21e-13   1.08e-13     5.75   0.000     4.09e-13    8.34e-13
_cons |   6.210222   1.651116     3.76   0.000     2.961572    9.458872
-------------+----------------------------------------------------------------

SPECIFICATION (3.3)
.xtreg logY_real logK_real logL lit_rate Health4 trade_n_real listed_dom_comp,
fe

Fixed-effects (within) regression
Number of obs =       250
Group variable (i): year
Number of groups =        14
R-sq:  within  = 0.8939
        between = 0.9519
        overall = 0.8844
Obs per group: min =         1
                avg =      17.9
                max =        63
F(6,230) = 322.90 Prob > F = 0.0000
corr(u_i, Xb) = 0.0588

logY_real |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
logK_real |   .3039242   .0596471     5.10   0.000     .1863997    .4214488
logL |   .559021   .0664425     8.41   0.000     .4281073    .6899347
lit_rate |  -.0036707   .0036053    -1.02   0.310    -.0107744     .003433
Health4 |   .1869534   .0438602     4.26   0.000     .1005342    .2733726
trade_n_real |   1.28e-12   3.43e-13     3.75   0.000     6.09e-13    1.96e-12
listed_dom-p |  .0006186   .0002187     2.83   0.005     .0001877    .0010495
_cons |   8.386773   .8391087     9.99   0.000     6.733451    10.0401
-------------+----------------------------------------------------------------
sigma_u |  .32312436
sigma_e |  .52900128  (fraction of variance due to u_i)
rho |  .27172124
F test that all u_i=0: F(13, 230) = 2.35 Prob > F = 0.0058

.est store fixed
.xtreg logY_real logK_real logL lit_rate Health4 trade_n_real listed_dom_comp,
re

Random-effects GLS regression
Number of obs =       250
Group variable (i): year
Number of groups =        14
R-sq:  within  = 0.8933
        between = 0.9571
        overall = 0.8852
Obs per group: min =         1
                avg =      17.9
                max =        63
Wald chi2(6) = 725.71 Prob > chi2 = 0.0000
corr(u_i, X) = 0 (assumed)

logY_real |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
logK_real |   .3075167   .0590409     5.21   0.000     .1917986    .4232348

93
. est store random
. hausman fixed random

Note: the rank of the differenced variance matrix (5) does not equal the number of coefficients being tested (6); be sure this is what you expect, or there may be problems computing the test. Examine the output of your estimators for anything unexpected and possibly consider scaling your variables so that the coefficients are on a similar scale.

---- Coefficients ----
|      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B)) |
|     fixed        random       Difference          S.E.          |
-------------+----------------------------------------------------------------
logK_real |    .3039242     .3075167       -.0035924        .0084819 |
logL      |     .559021     .5654373       -.0064163               .         |
lit_rate |   -.0036707    -.0036252       -.0000454               .         |
Health4   |    .1869534     .1556393        .0313141        .0061275 |
trade_n_real |    1.28e-12     1.30e-12       -1.90e-14               .         |
listed_dom~p |    .0006186     .0006163        2.24e-06               .         |
_cons     |  .3951264      .3705167        .0246097        .0304819 |
-------------+----------------------------------------------------------------

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

chi2(5) = (b-B)'[(V_b-V_B)^{-1}](b-B)
  =  89.89

chi2<0 ==> model fitted on these data fails to meet the asymptotic assumptions of the Hausman test;
see suest for a generalized test

Random will be more preferable at this point.

. xtregar logY_real logK_real logL lit_rate Health4 trade_n_real
   listed_dom_COMP, r
   e
RE GLS regression with AR(1) disturbances
Number of obs      =       250
Group variable (i): year                        Number of groups   =        14
R-sq: within  = 0.8998                         Obs per group: min =         1
            between = 0.9503                avg =       17.9
            overall = 0.8811               max =        63
Wald ch2(7) = 875.31

------------- theta -------------

94
|            | Coef. | Std. Err. | z     | P>|z| | [95% Conf. Interval] |
|------------|-------|-----------|-------|------|-----------------------|
| logY_real  |       |           |       |      |                       |
| logK_real  | 0.4206 | .0532     | 7.91  | 0.000| .3163 - .5249         |
| logL       | 0.4584 | .0612     | 7.49  | 0.000| .3383 - .5784         |
| lit_rate   | -.0002 | .0003     | -0.68 | 0.494| -.0008 - .0001        |
| Health4    | 0.1116 | .0388     | 2.87  | 0.004| .0354 - .1878         |
| trade_n_real | 6.09E-13 | 3.01E-13 | 2.02  | 0.043| 1.89E-14 - 1.20E-12   |
| listed_dom-p | .000692 | .000221 | 3.14  | 0.002| .000259 - .001125     |
| _cons      | 6.8935 | .7687     | 8.97  | 0.000| 5.39E+03 - 8.39E+03   |

Checking for heteroskedasticity:
```
> xi: reg logY_real logK_real logL lit_rate Health4 trade_n_real listed_dom_comp i.country
```
```
Source |       SS       df       MS              Number of obs =     250
-------------+------------------------------           F( 71,   178) = 1830.98
Model |  634.414145    71  8.93541049           Prob > F      =  0.0000
Residual |  .86866277    178  .004880128           R-squared     =  0.9986
-------------+------------------------------           Adj R-squared =  0.9981
Total |  635.282808   249  2.55133658           Root MSE      =  .06986

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
Ho: Constant variance
Variables: fitted values of logY_real
```
.chi2(1) = 6.81
Prob > chi2 = 0.0091
```

xtreg logY_real logK_real logL lit_rate Health4 Health4_t trade_n_real listed_dom_comp, fe
Fixed-effects (within) regression
Number of obs  =  250
Group variable (i): year
Number of groups = 14
R-sq: within = 0.9278
Obs per group: min = 1
between = 0.9858
overall = 0.9258
avg = 17.9
max = 63
F(8,228) = 366.43
Prob > F = 0.0000

corr(u_i, Xb) = 0.0889

| logY_real | Coef. | Std. Err. | t | P>|t| | [95% Conf. Interval] |
|-----------|-------|-----------|---|------|---------------------|
| logK_real | 0.4107209 | 0.0504807 | 8.14 | 0.000 | 0.3112526 - 0.5101892 |
| logL | 0.5203796 | 0.0551585 | 9.43 | 0.000 | 0.4116938 - 0.6290649 |
| lit_rate | 0.0037558 | 0.0030736 | 1.22 | 0.223 | -0.0023005 - 0.0083621 |
| lit_rate_t | -0.0166738 | 0.0024314 | -6.86 | 0.000 | -0.0214647 - 0.0118829 |
| Health4 | 0.151061 | 0.0366823 | 4.12 | 0.000 | 0.0787813 - 0.2234008 |
| Health4_t | 0.863144 | 0.258249 | 3.48 | 0.000 | 0.4181734 - 1.308115 |
| trade_n_real | 7.79e-13 | 2.91e-13 | 2.68 | 0.008 | 2.06e-13 - 1.35e-12 |
| listed_dom-p | 5.92e-13 | 0.753055 | 8.06 | 0.000 | 4.479579 - 7.377305 |

| Coef. | Std. Err. | t | P>|t| | [95% Conf. Interval] |
|-------|-----------|---|------|---------------------|
| sigma_u | 0.1740818 | | | |
| sigma_e | 0.48314733 | | | |
| rho | 0.1363534 | | | |

F test that all u_i=0: F(13, 228) = 1.28
Prob > F = 0.2263

. est store fixed
. xtreg logY_real logK_real logL lit_rate lit_rate_t Health4 Health4_t trade_n_real
>  listed_dom_comp, re

Random-effects GLS regression
Number of obs = 250
Group variable (i): year
Number of groups = 14
R-sq: within = 0.9276
Obs per group: min = 1
between = 0.9880
overall = 0.9261
max = 63
Random effects u_i - Gaussian
Wald chi2(8) = 1250.66
Prob > chi2 = 0.0000

. est store random
. hausman fixed random

96
Note: the rank of the differenced variance matrix (?) does not equal the number of coefficients being tested (8); be sure this is what you expect, or there may be problems computing the test. Examine the output of your estimators for anything unexpected and possibly consider scaling your variables so that the coefficients are on a similar scale.

<table>
<thead>
<tr>
<th>---- Coefficients ----</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>(b)</td>
</tr>
<tr>
<td>fixed</td>
</tr>
<tr>
<td>--------+-----------------+-------------+-------------------</td>
</tr>
<tr>
<td>logK_real</td>
</tr>
<tr>
<td>logL</td>
</tr>
<tr>
<td>lit_rate</td>
</tr>
<tr>
<td>lit_rate_t</td>
</tr>
<tr>
<td>Health4</td>
</tr>
<tr>
<td>Health4_t</td>
</tr>
<tr>
<td>trade_n_real</td>
</tr>
<tr>
<td>listed_dom_p</td>
</tr>
</tbody>
</table>

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

\[
\chi^2(7) = (b-B)'[(V_b-V_B)^{-1}](b-B) = 11.07
\]

Prob > \chi^2 = 0.1355

(V_b-V_B is not positive definite)

Fixed effect could not be rejected at 15 % s.l., along with the better results in probabilities, so fixed effect would be chosen in this model specification.

```
xtdrar logY_real logK_real logL lit_rate lit_rate_t Health4 Health4_t trade_n_r>
> al listed_dom_comp, fe
```

FE (within) regression with AR(1) disturbances

```
Number of obs = 236
Group variable (i): year
Number of groups = 13
R-sq: within = 0.9817
between = 0.8828
overall = 0.9090
```

```
\( F(8, 215) = 1437.80 \)
Prob > F = 0.0000
```

```
| logY_real | Coef. | Std. Err. | t | P>|t| [95% Conf. Interval] |
|-----------+-------+-----------+---+------------------------|
| logK_real | .7061512 | .0392012 | 18.01 | 0.000 | .6288832 | .7834193 |
| logL | .4212892 | .0559008 | 7.54 | 0.000 | .3110555 | .531473 |
| lit_rate | .0092481 | .0029708 | 3.11 | 0.002 | .0033924 | .0151038 |
| lit_rate_t | -.0166857 | .0024912 | -6.70 | 0.000 | -.021596 | -.0117753 |
| Health4 | .0649358 | .034316 | 1.89 | 0.060 | -.002703 | .1325746 |
| Health4_t | .6531804 | .2363879 | 2.76 | 0.006 | .2363879 | .119115 |
| trade_n_real | -.819e-13 | 2.40e-13 | -.341 | 0.001 | -1.29e-12 | -3.46e-13 |
| listed_dom_p | -.0005634 | .0002089 | -2.70 | 0.006 | -.0009751 | -.0001517 |
| _cons | -.5836464 | .1030652 | -5.70 | 0.000 | -.7903121 | -.3840171 |
```

```
rho_ar | .7936156
sigma_u | .1158058
```

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\[
\text{sigma}_e = 0.43679663 \\
\text{rho}_\text{fov} = 0.065675 \quad \text{(fraction of variance due to } u_i) \\
\]

F test that all \( u_i = 0 \) \( F(12,215) = -3.70 \) \( \text{Prob} > F = 1.0000 \)

```
xi: reg logY_real logK_real logL lit_rate lit_rate_t Health4 Health4_t trade_n_re > al listed_dom_comp i.country 
```

```
i.country         _Icountry_1-135     (naturally coded; _Icountry_1 omitted)
```

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>Number of obs = 250</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>634.455765</td>
<td>73</td>
<td>8.69117486</td>
<td>F(73, 176) = 1849.54</td>
</tr>
<tr>
<td>Residual</td>
<td>.827042807</td>
<td>176</td>
<td>.004699107</td>
<td>R-squared = 0.9987</td>
</tr>
<tr>
<td>Total</td>
<td>635.282808</td>
<td>249</td>
<td>2.55133658</td>
<td>Root MSE = 0.06855</td>
</tr>
</tbody>
</table>

| logY_real | Coef. | Std. Err. | t     | P>|t| | [95% Conf. Interval] |
|-----------|-------|-----------|------|------|---------------------|
| logK_real | .143185 | .0320496 | 4.47 | 0.000 | .0799341 - .2064359 |
| logL      | .938087 | .1539332 | 6.09 | 0.000 | .6342945 - 1.24188 |
| lit_rate  | .0004935 | .0059497 | 0.08 | 0.934 | -.0112484 - .0122354 |
| lit_rate_t | .1195136 | .0804151 | 1.49 | 0.139 | -.0322644 - .0495108 |
| Health4   | .0086232 | .020718 | 0.42 | 0.678 | -.0322644 - .0495108 |
| Health4_t | .1467713 | .0706718 | 2.08 | 0.039 | .0072982 - .286244 |
| trade_n_real | 6.14e-13 | 9.44e-14 | 6.50 | 0.000 | 4.28e-13 - 8.00e-13 |
| listed_dom_p | -5.08e-06 | .0000525 | -0.10 | 0.923 | -.0001087 - .0000986 |
| _cons     | 6.597763 | 1.78492 | 3.70 | 0.000 | 3.075162 - 10.12036 |

```
hettest
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
Ho: Constant variance
Variables: fitted values of logY_real
chisq(1) = 2.33
Prob > chi2 = 0.1269
```

SPECIFICATION (4.1)

```
xtreg logY_real logK_real logL lit_rate Health5, fe
Fixed-effects (within) regression Number of obs = 301
Group variable (i): year Number of groups = 14
R-sq: within = 0.8610 Obs per group: min = 1
between = 0.7548 avg = 21.5
overall = 0.8539 max = 64
F(4,283) = 438.24 Prob > F = 0.0000
```

```
logK_real | Coef. | Std. Err. | t     | P>|t| | [95% Conf. Interval] |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>logK_real</td>
<td>.196325</td>
<td>.0569319</td>
<td>3.45</td>
<td>0.001</td>
<td>.0842614 - .308386</td>
</tr>
<tr>
<td>logL</td>
<td>.7995843</td>
<td>.0617437</td>
<td>12.95</td>
<td>0.000</td>
<td>.6780461 - .921195</td>
</tr>
<tr>
<td>lit_rate</td>
<td>-.0062873</td>
<td>.0041278</td>
<td>-1.52</td>
<td>0.129</td>
<td>-.0144125 - .0018378</td>
</tr>
<tr>
<td>Health5</td>
<td>.2393755</td>
<td>.0372869</td>
<td>6.42</td>
<td>0.000</td>
<td>.1659807 - .3127703</td>
</tr>
</tbody>
</table>
```

98
. est store fixed

. xtreg logY_real logK_real logL lit_rate Health5, re

Random-effects GLS regression                   Number of obs      =       301
Group variable (i): year                        Number of groups   =        14
R-sq:  within  = 0.8593                         Obs per group: min =         1
between = 0.8036                                        avg =      21.5
overall = 0.8564                                        max =        64

Random effects u_i ~ Gaussian                   Wald chi2(4)       =   1764.67
corr(u_i, X)       = 0 (assumed)                Prob > chi2        =    0.0000

------------------------------------------------------------------------------
logY_real |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
logK_real |   .1664136   .0562134     2.96   0.003     .0562375    .2765898
logL |   .8340141      .0607    13.74   0.000     .7150443    .9529838
lit_rate |  -.0056543   .0041385    -1.37   0.172    -.0137657     .002457
Health5 |   .2101373   .0357127     5.88   0.000     .1401416     .280133
_cons |   7.949893   .7414878    10.72   0.000     6.496603    9.403182
-------------+----------------------------------------------------------------
sigma_u |          0
sigma_e |  .64073495
rho |          0   (fraction of variance due to u_i)
------------------------------------------------------------------------------

. est store random

. hausman fixed random

---- Coefficients ----
          |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
          |     fixed        random       Difference          S.E.
-------------+----------------------------------------------------------------
logK_real |     .196325     .1664136        .0299114        .0090164
logL |    .7995843     .8340141       -.0344297        .0113049
lit_rate |  -.0062873    -.0056543        -.000633         .000633
Health5 |    .2393755     .2101373        .0292382        .0107197

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test:  Ho: difference in coefficients not systematic
       chi2(4) = (b-B)'[(V_b-V_B)^(-1)](b-B) =       10.07
       Prob>chi2 =      0.0392
(V_b-V_B is not positive definite)

. xtregar logY_real logK_real logL lit_rate Health5, fe

FE (within) regression with AR(1) disturbances  Number of obs      =       287
Group variable (i): year                        Number of groups   =        12
R-sq: within = 0.9486  
between = 0.7558  
overall = 0.8160  

F(4,271) = 1249.97  
Prob > F = 0.0000  

corr(u_i, Xb) = -0.1865  

logY_real |      Coef.   Std. Err.      t    P>|t|    [95% Conf. Interval]
-------------+----------------------------------------------------------------
logK_real |   .6361601   .0466082    13.65   0.000      .5444    .7279203
logL |   .5024626   .0595442     8.44   0.000     .3852346    .6196906
lit_rate |   .0097732   .0038571     2.53   0.012     .0021796    .0173668
Health5 |  -.0316701   .0327281    -0.97   0.334    -.0961038    .0327635
_cons |  -1.140595    .131782    -8.66   0.000    -1.400042   -.8811485
-------------+----------------------------------------------------------------
rho_ar |  .81735215
sigma_u |  .28518364
sigma_e |  .65601256
rho_fov |  .15894575  (fraction of variance due to u_i)

F test that all u_i=0:  
F(11,271) = -6.26  
Prob > F = 1.0000

.xi: reg logY_real logK_real logL lit_rate Health5 i.country  
.i.country         _Icountry_1-135     (naturally coded; _Icountry_1 omitted)

Source |       SS       df       MS              Number of obs =     301
-------------+------------------------------           F( 90,   210) =  889.83
Model |  865.345519    90  9.61495021           Prob > F      =  0.0000
Residual |  2.26911776   210  .010805323           R-squared     =  0.9974
-------------+------------------------------           Adj R-squared =  0.9963
Total |  867.614636   300  2.89204879           Root MSE      =  .10395

logY_real |      Coef.   Std. Err.      t    P>|t|    [95% Conf. Interval]
-------------+----------------------------------------------------------------
logK_real |   .3790364   .0452261     8.38   0.000      .289881    .4681919
logL |   .5529081   .2015702     2.74   0.007     .1555478    .9502685
lit_rate |   .0083157   .0080548     1.03   0.303    -.0075629    .0241942
Health5 |   .0229638   .0226945     1.01   0.313    -.0217744     .0677028
_cons |   5.166566   2.351393     2.20   0.029     .5312059    9.801926
-------------+----------------------------------------------------------------

.hettest

Breusch-Pagan / Cook-Mueller test for heteroskedasticity  
Ho: Constant variance  
Variables: fitted values of logY_real  

chi2(1) = 5.07  
Prob > chi2 = 0.0244

SPECIFICATION (4.2)

.xtreg logY_real logK_real logL lit_rate Health5 trade_n_real, fe

Fixed-effects (within) regression  
Number of obs = 293  
Number of groups = 14

R-sq: within = 0.8742  
between = 0.8089

Obs per group: min = 1  
avg = 20.9
overall = 0.8691                                        max =        63
F(5,274)           =    380.64
corr(u_i, Xb)  = -0.1555                        Prob > F           =    0.0000

logY_real |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
logK_real |   .1854205   .0556104     3.33   0.001     .0759425    .2948985
logL |   .7114467   .0628737    11.32   0.000     .5876699    .8352235
lit_rate |  -.0025597   .0040646    -0.63   0.529    -.0105615     .005442
Health5 |   .1848557   .0375616     4.92   0.000     .1109097    .2588018
trade_n_real |   1.64e-12   3.63e-13     4.53   0.000     9.27e-13    2.36e-12
_cons |   8.942101   .8027652    11.14   0.000     7.361729    10.52247
-------------+----------------------------------------------------------------
sigma_u |  .19526175
sigma_e |   .6147578
rho |  .09163985   (fraction of variance due to u_i)
F test that all u_i=0:     F(13, 274) =     1.35             Prob > F = 0.1847

Note: the rank of the differenced variance matrix (4) does not equal the number of coefficients being tested (5); be sure this is what you expect, or there may be problems computing the test. Examine the output of your estimators for anything unexpected and possibly consider scaling your variables so that the coefficients are on a similar scale.
---- Coefficients ----
|                      | (b)          | (B)            | (b-B)     | sqrt(diag(V_b-V_B)) |
|-----------------------+--------------+----------------+------------+---------------------|
| fixed                 | random       | Difference     | S.E.       |                     |
| logK_real             | .1854205     | .1644782       | .0209424   | .0094092            |
| logL                  | .7114467     | .7341624       | -.0227157  | .0111428            |
| lit_rate              | -.0025597    | -.0016678      | -.0008919  | .0003587            |
| Health5               | .1848557     | .1534041       | .0314516   | .013601             |
| trade_n_real          | 1.64e-12     | 1.67e-12       | -2.95e-14  |                     |

Test: Ho: difference in coefficients not systematic

<table>
<thead>
<tr>
<th>Test:  Ho:  difference in coefficients not systematic</th>
</tr>
</thead>
<tbody>
<tr>
<td>chi2(4) = (b-B)'<a href="b-B">(V_b-V_B)^{-1}</a></td>
</tr>
<tr>
<td>Prob&gt;chi2 = 0.2160</td>
</tr>
<tr>
<td>(V_b-V_B is not positive definite)</td>
</tr>
</tbody>
</table>

b = inconsistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

FE (within) regression with AR(1) disturbances

<table>
<thead>
<tr>
<th>logK_real</th>
<th>logL</th>
<th>lit_rate</th>
<th>Health5</th>
<th>trade_n_real</th>
</tr>
</thead>
<tbody>
<tr>
<td>.2990674</td>
<td>.0433581</td>
<td>6.90</td>
<td>0.0000</td>
<td>.3845599</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>logL</th>
<th>0.6127892</th>
<th>0.1899498</th>
<th>3.23</th>
<th>0.001</th>
<th>0.2382505</th>
<th>0.9873278</th>
</tr>
</thead>
<tbody>
<tr>
<td>lit_rate</td>
<td>0.004665</td>
<td>0.0074887</td>
<td>0.62</td>
<td>0.534</td>
<td>-0.010101</td>
<td>0.019431</td>
</tr>
<tr>
<td>Health5</td>
<td>0.0223609</td>
<td>0.020844</td>
<td>1.07</td>
<td>0.285</td>
<td>-0.0187388</td>
<td>0.0634606</td>
</tr>
<tr>
<td>trade_n_real</td>
<td>4.74e-13</td>
<td>1.17e-13</td>
<td>4.04</td>
<td>0.000</td>
<td>2.43e-13</td>
<td>7.05e-13</td>
</tr>
<tr>
<td>_cons</td>
<td>6.488792</td>
<td>2.223303</td>
<td>2.92</td>
<td>0.004</td>
<td>2.104934</td>
<td>10.87265</td>
</tr>
</tbody>
</table>

**hettest**

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
Ho: Constant variance
Variables: fitted values of logY_real

chi2(1) = 4.91
Prob > chi2 = 0.0267

**SPECIFICATION (4.3)**

```plaintext
.specification (4.3)
```

**xtreg logY_real logK_real logL lit_rate Health5 trade_n_real listed_dom_comp, fe**

| logY_real | Coef. | Std. Err. | t     | P>|t| | [95% Conf. Interval] |
|-----------|-------|-----------|-------|------|----------------------|
| logK_real | 0.1643164 | 0.0832032 | 1.97 | 0.050 | 0.0000508 | 0.328582 |
| logL      | 0.7000006 | 0.0972311 | 7.20 | 0.000 | 0.50804 | 0.891961 |
| lit_rate  | 0.0023807 | 0.0053044 | 0.45 | 0.654 | -0.0080916 | 0.012853 |
| Health5   | 0.1436442 | 0.050042 | 2.87 | 0.005 | 0.0446577 | 0.2422607 |
| trade_n_real | 1.14e-12 | 4.10e-13 | 2.78 | 0.006 | 3.29e-13 | 1.95e-12 |
| listed_dom-p | 0.0008484 | 0.0002714 | 3.13 | 0.002 | 0.0003126 | 0.0013841 |
| _cons     | 9.280612 | 1.133244 | 8.19 | 0.000 | 7.043282 | 11.51794 |

**F test that all u_i=0:**
F(6,167) = 194.24
Prob > F = 0.0000

**est store fixed**

**xtreg logY_real logK_real logL lit_rate Health5 trade_n_real listed_dom_comp, re**

| logY_real | Coef. | Std. Err. | t     | P>|t| | [95% Conf. Interval] |
|-----------|-------|-----------|-------|------|----------------------|
| logK_real | 0.1643164 | 0.0832032 | 1.97 | 0.050 | 0.0000508 | 0.328582 |
| logL      | 0.7000006 | 0.0972311 | 7.20 | 0.000 | 0.50804 | 0.891961 |
| lit_rate  | 0.0023807 | 0.0053044 | 0.45 | 0.654 | -0.0080916 | 0.012853 |
| Health5   | 0.1436442 | 0.050042 | 2.87 | 0.005 | 0.0446577 | 0.2422607 |
| trade_n_real | 1.14e-12 | 4.10e-13 | 2.78 | 0.006 | 3.29e-13 | 1.95e-12 |
| listed_dom-p | 0.0008484 | 0.0002714 | 3.13 | 0.002 | 0.0003126 | 0.0013841 |
| _cons     | 9.280612 | 1.133244 | 8.19 | 0.000 | 7.043282 | 11.51794 |

**F test that all u_i=0:**
F(6,167) = 194.24
Prob > F = 0.0000

**est store fixed**

**xtreg logY_real logK_real logL lit_rate Health5 trade_n_real listed_dom_comp, fe**

<table>
<thead>
<tr>
<th>R-sq:  overall = 0.8668</th>
<th>Obs per group: max = 44</th>
</tr>
</thead>
</table>

**rho | 0.1417277**

**Estimation results**

- Fixed-effects (within) regression
  - Number of obs = 185
  - Group variable (i): year
  - Number of groups = 12
  - R-sq: within = 0.8747
  - Obs per group: min = 1
  - between = 0.7989
  - avg = 15.4
  - overall = 0.8654
  - max = 44
  - F(6,167) = 194.24
  - Prob > F = 0.0000

- Random-effects GLS regression
  - Number of obs = 185
  - Group variable (i): year
  - Number of groups = 12
  - R-sq: within = 0.8736
  - Obs per group: min = 1
  - between = 0.8249
  - avg = 15.4
  - overall = 0.8668
  - F(6,167) = 194.24
  - Prob > F = 0.0000

- Fixed-effects (within) regression
  - Number of obs = 185
  - Group variable (i): year
  - Number of groups = 12
  - R-sq: within = 0.8747
  - Obs per group: min = 1
  - between = 0.7989
  - avg = 15.4
  - overall = 0.8654
  - max = 44
  - F(6,167) = 194.24
  - Prob > F = 0.0000

- Random-effects GLS regression
  - Number of obs = 185
  - Group variable (i): year
  - Number of groups = 12
  - R-sq: within = 0.8736
  - Obs per group: min = 1
  - between = 0.8249
  - avg = 15.4
  - overall = 0.8668
  - F(6,167) = 194.24
  - Prob > F = 0.0000

---

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logY_real |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
logK_real |   .1615207   .0833793     1.94   0.053    -.0018996    .3249411
logL |   .7196796   .0971637     7.41   0.000     .5292423    .9101169
lit_rate |    .002527   .0053272     0.47   0.635    -.0079141    .0129681
Health5 |   .1143988    .048544     2.36   0.018     .0192542    .2095433
trade_n_real |   1.13e-12   4.10e-13     2.75   0.006     3.24e-13    1.93e-12
listed_dom-p |     .00078   .0002662     2.93   0.003     .0002583    .0013017
_cons |   9.040647   1.138418     7.94   0.000     6.809389    11.27191
-------------+----------------------------------------------------------------
sigma_u |          0
sigma_e |  .57175233
rho |          0   (fraction of variance due to u_i)
-------------+----------------------------------------------------------------

. est store random
. hausman fixed random

Note: the rank of the differenced variance matrix (5) does not equal the number of
coefficients being tested (6); be sure this is what you expect, or
there may be problems computing the test. Examine the output of your
estimators for anything unexpected and possibly consider scaling your variables so
that the coefficients are on a similar scale.

---- Coefficients ----
|      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
|     fixed        random       Difference          S.E.
-------------+----------------------------------------------------------------
logK_real |    .1643164     .1615207        .0027957               .
logL |    .7000006     .7196796       -.0196789        .0036216
lit_rate |    .0023807      .002527       -.0001462               .
Health5 |    .1434642     .1143988        .0290655        .0121524
trade_n_real |    1.14e-12     1.13e-12        1.05e-14               .
listed_dom-p |    .0008484       .00078        .0000683        .0000528
-------------+----------------------------------------------------------------

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test:  Ho: difference in coefficients not systematic

    chi2(5) =  (b-B)'[(V_b-V_B)^(-1)](b-B) =        3.09
    Prob>chi2 =      0.6867
(V_b-V_B is not positive definite)

xtregar logY_real logK_real logL lit_rate Health5 trade_n_real listed_dom_comp,

RE GLS regression with AR(1) disturbances       Number of obs      =       185
Group variable (i): year                        Number of groups   =        12
R-sq: within  = 0.8698                         Obs per group: min =         1
                         between = 0.8154                  avg =      15.4
                         overall = 0.8636                 max =        44
Wald chi2(7) =  543.83
corr(u_i, Xb) = 0 (assumed)  Prob > chi2 = 0.0000

------------------- theta --------------------

\[
\begin{array}{cccccccc}
\text{min} & 5\% & \text{median} & 95\% & \text{max} \\
0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 \\
\end{array}
\]

\[\begin{array}{l}
\text{logY_real} \\
\text{logK_real} \\
\text{logL} \\
lit_rate \\
\text{Health5} \\
\text{trade_n_real} \\
l真正_ | 6.24e-13 \\
\text{listed_dom_comp} |
\end{array}\]

\[\begin{array}{l}
\text{rho_ar} \\
\text{sigma_u} \\
\text{sigma_e} \\
\text{rho_fov} \\
\text{xi:reg logY_real logK_real logL lit_rate Health5 trade_n_real listed_dom_comp}
\end{array}\]

Source | \(\text{SS}\) | \(\text{df}\) | \(\text{MS}\) | Number of obs = 185
\hline
\text{Model} | 456.171745 | 62 | 7.35760878 | \(F(62, 122) = 1804.58\)
\text{Residual} | 0.497417103 | 122 | 0.004077189 | \text{R-squared} = 0.9989
\text{Total} | 456.669162 | 184 | 2.48189762 | \text{Root MSE} = 0.06385
\hline
\text{logK_real} | \(0.2479885\) | \(0.0719991\) | 3.44 | 0.001 | \(0.1068729, 0.3891041\)
\text{logL} | 0.6329586 | 0.0836464 | 7.57 | 0.000 | \(0.4690147, 0.796025\)
\text{lit_rate} | \(0.0024063\) | \(0.0044826\) | 0.54 | 0.591 | \(-0.0063794, \text{e}^{0.01192}\)
\text{Health5} | \(0.0702979\) | \(0.0416991\) | 1.69 | 0.092 | \(-0.0114309, 1.5202679\)
\text{trade_n_real} | \(6.24e-13\) | \(3.54e-13\) | 1.76 | 0.079 | \(-6.92e-14, 1.32e-12\)
\text{listed_dom_comp} | \(0.0009868\) | \(0.0002838\) | 3.50 | 0.000 | \(0.0000434, 0.0015387\)
\text{_cons} | \(8.161152\) | \(0.9685091\) | 8.43 | 0.000 | \(6.262909, 10.0594\)
\hline
\text{rho_ar} | 0.85315724 | \(\text{estimated autocorrelation coefficient}\) | \(\text{rho_fov} | 0 | \(\text{fraction of variance due to u_i}\) |
\hline
\text{hettest}

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

\(\text{chi2(1)} = 12.22\)

\(\text{Prob > chi2} = 0.0005\)

\[\text{SPECIFICATION (4.4)\]

\[\text{. xtreg logY_real logK_real logL lit_rate Health5 trade_n_real listed_dom_comp, fe}\]
Fixed-effects (within) regression
Number of obs = 185
Group variable (i): year
Number of groups = 12

R-sq: within = 0.9208
between = 0.9586
overall = 0.9210

F(8,165) = 239.83
Prob > F = 0.0000

corr(u_i, Xb) = 0.0852

logY_real | Coef. Std. Err. t P>|t| [95% Conf. Interval]
-------------+--------------------------------------------------
logK_real | 0.2070035 .06707 3.09 0.002 .0745775 .3394296
logL | 0.7178344 .0786014 9.13 0.000 .5626401 .8730287
lit_rate | 0.0084853 .004314 1.97 0.051 -.0000325 .0170031
lit_rate_t | -0.0124884 .0021585 -5.79 0.000 -.0167502 -.0082265
Health5 | 0.1898055 .0403819 4.68 0.000 .1093536 .2698173
Health5_t | 0.3485109 .1971724 1.77 0.079 -.0407952 .7378171
trade_n_real | 4.30e-13 .32e-13 1.28 0.202 -.23e-13 1.09e-12
listed_dom_comp | 0.0002696 .0002157 .99 0.324 .0000389 .0005003
_cons | 7.832877 .918993 8.52 0.000 6.018376 9.647379
-------------+--------------------------------------------------
sigma_u | .10349939
sigma_e | .45721574
rho | .04874501 (fraction of variance due to u_i)

F test that all u_i=0: F(11,165) = 0.64 Prob > F = 0.7919

est store fixed

Random-effects GLS regression
Number of obs = 185
Group variable (i): year
Number of groups = 12

R-sq: within = 0.9206
between = 0.9651
overall = 0.9212

Random effects u_i ~ Gaussian Wald chi2(8) = 818.07 Prob > chi2 = 0.0000

corr(u_i, X) = 0 (assumed)

logY_real | Coef. Std. Err. z P>|z| [95% Conf. Interval]
-------------+--------------------------------------------------
logK_real | 0.2170669 .0650605 3.34 0.001 .0895506 .3445831
logL | 0.7132855 .0760551 9.38 0.000 .5642204 .8623507
lit_rate | 0.0083082 .0041783 1.99 0.047 .000119 .0164975
lit_rate_t | -0.0121623 .002055 -5.52 0.000 -.01619 -.0081366
Health5 | 0.1935083 .0383658 5.04 0.000 .1183128 .2687038
Health5_t | 0.2665207 .1835854 1.45 0.147 -.0930001 .6263415
trade_n_real | 4.06e-13 3.24e-13 1.25 0.213 -.23e-13 1.04e-12
listed_dom_comp | 0.0002043 .0002154 .95 0.343 -.0002177 .0006264
_cons | 7.690472 .8898181 8.64 0.000 5.94646 9.434483
-------------+--------------------------------------------------
sigma_u | 0
sigma_e | .45721574
rho | 0 (fraction of variance due to u_i)
. est store random
. hausman fixed random

Note: the rank of the differenced variance matrix (7) does not equal the number of
coefficients being tested (8); be sure this is what you expect, or
there may be problems computing the test. Examine the output of your
estimators for anything unexpected and possibly consider scaling your variables so
that the coefficients are on a similar scale.

<table>
<thead>
<tr>
<th></th>
<th>(b)</th>
<th>(B)</th>
<th>(b-B)</th>
<th>sqrt(diag(V_b-V_B))</th>
</tr>
</thead>
<tbody>
<tr>
<td>fixed</td>
<td>.2070035</td>
<td>.2170669</td>
<td>-.0100634</td>
<td>.0162946</td>
</tr>
<tr>
<td>random</td>
<td>.7178344</td>
<td>.7132855</td>
<td>.0045488</td>
<td>.0198448</td>
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<td>lit_rate</td>
<td>.0084853</td>
<td>.0083082</td>
<td>.0001771</td>
<td>.0001073</td>
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<tr>
<td>lit_rate_t</td>
<td>-.0124884</td>
<td>-.0121623</td>
<td>-.0003261</td>
<td>.0006605</td>
</tr>
<tr>
<td>Health5</td>
<td>.1890855</td>
<td>.1935083</td>
<td>-.0044228</td>
<td>.0044228</td>
</tr>
<tr>
<td>Health5_t</td>
<td>.3485109</td>
<td>.2665207</td>
<td>.0819902</td>
<td>.0719259</td>
</tr>
<tr>
<td>trade_n_real</td>
<td>4.30e-13</td>
<td>4.04e-13</td>
<td>.26e-14</td>
<td>8.80e-14</td>
</tr>
</tbody>
</table>

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic
chi2(7) = (b-B)'[(V_b-V_B)^(-1)](b-B) = 3.93
Prob>chi2 = 0.7873

. xtregar logY_real logK_real logL lit_rate lit_rate_t Health5 Health5_t
   trade_n_real al listed_dom_comp, re

RE GLS regression with AR(1) disturbances
Number of obs = 185
Group variable (i): year
Number of groups = 12
R-sq: within = 0.9179
       Obs per group: min = 1
       between = 0.9553
       avg = 15.4
       overall = 0.9183
       max = 44
corr(u_i, Xb) = 0 (assumed)
Wald chi2(9) = 1031.02
Prob > chi2 = 0.0000

<table>
<thead>
<tr>
<th></th>
<th>logK_real</th>
<th>logL</th>
<th>lit_rate</th>
<th>lit_rate_t</th>
<th>Health5</th>
<th>Health5_t</th>
<th>trade_n_real</th>
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<tbody>
<tr>
<td>Coef. Std. Err.</td>
<td>z</td>
<td>P&gt;</td>
<td>z</td>
<td>[95% Conf. Interval]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>logK_real</td>
<td>.245984</td>
<td>.0574145</td>
<td>4.28</td>
<td>0.000</td>
<td>.1334537</td>
<td>.3585143</td>
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<tr>
<td>logL</td>
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<td>.0673354</td>
<td>10.25</td>
<td>0.000</td>
<td>.5580064</td>
<td>.8219561</td>
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<tr>
<td>lit_rate</td>
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<td>.0015404</td>
<td>6.57</td>
<td>0.000</td>
<td>.0073979</td>
<td>.0135079</td>
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<tr>
<td>lit_rate_t</td>
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<td>.001738</td>
<td>-5.67</td>
<td>0.000</td>
<td>-.0132567</td>
<td>-.0064439</td>
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<tr>
<td>Health5</td>
<td>.1331372</td>
<td>.0328811</td>
<td>4.05</td>
<td>0.000</td>
<td>.0686914</td>
<td>.197583</td>
<td></td>
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<tr>
<td>Health5_t</td>
<td>.0907965</td>
<td>.1639746</td>
<td>0.55</td>
<td>0.580</td>
<td>-.2305879</td>
<td>.4121809</td>
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<tr>
<td>trade_n_real</td>
<td>1.43e-13</td>
<td>2.75e-13</td>
<td>0.52</td>
<td>0.604</td>
<td>-.397e-13</td>
<td>6.82e-13</td>
<td></td>
</tr>
</tbody>
</table>
Fixed-effects (within) IV regression
Number of obs      =       573
Group variable: country
Number of groups   =        66

R-sq: within  = 0.7635
        Obs per group: min =          2
between  = 0.0397    avg =   8.7
overall  = 0.0885     max =          12

corr(u_i, Xb) = -0.9175
Wald chi2(8)  = 1.26e+07
Prob > chi2   = 0.0000

I.V. ESTIMATION OUTPUT

\[ \frac{\hat{Y}}{\hat{X}} = \begin{bmatrix} \hat{a}_0 \\ \hat{a}_1 \\ \hat{a}_2 \\ \vdots \\ \hat{a}_n \end{bmatrix} + \begin{bmatrix} \hat{u}_1 \\ \hat{u}_2 \\ \hat{u}_3 \\ \vdots \\ \hat{u}_n \end{bmatrix} \]

\[ \hat{u}_i = \rho \hat{u}_{i-1} + \epsilon_i \]

\[ \sigma_u = 0 \]

\[ \sigma_e = 0.33684736 \]

\[ \rho_{fov} = 0 \]

\[ \rho_{ar} = 0.90421987 \]

\[ \text{Adj R-squared} = 0.9985 \]

\[ \text{Root MSE} = 0.06183 \]

\[ \text{F(} 64, 120) = 1864.65 \]

\[ \text{Prob > F} = 0.0000 \]

\[ \text{R-squared} = 0.9990 \]

\[ \text{Prob > F} = 0.0000 \]

\[ \text{Adj R-squared} = 0.9985 \]

\[ \text{Root MSE} = 0.06183 \]

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\[ \text{Prob > F} = 0.0000 \]

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\[ \text{Root MSE} = 0.06183 \]

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\[ \text{F(} 64, 120) = 1864.65 \]

\[ \text{Prob > F} = 0.0000 \]

\[ \text{R-squared} = 0.9990 \]

\[ \text{Prob > F} = 0.0000 \]

\[ \text{Adj R-squared} = 0.9985 \]

\[ \text{Root MSE} = 0.06183 \]
| logY_real | Coef. | Std. Err. | z   | P>|z| | [95% Conf. Interval] |
|-----------|-------|-----------|-----|------|----------------------|
| lit_rate  | -.0056105 | .0026662  | -2.10 | 0.035 | -.0108361 to -.0003849 |
| Health1   | .03288 | .0147727  | 2.23 | 0.026 | .003926 to .061834   |
| Health1_t | .0034788 | .1254027  | 0.03 | 0.978 | -.2423059 to .2492635 |
| trade_n_real | 6.346-13 | 1.056-13  | 5.99 | 0.000 | 4.26e-13 to 8.38e-13  |
| listed_dom_p | .00016 | .000626  | 2.56 | 0.011 | -.2423059 to .2517275 |
| logK_real | .1558408 | .0173543  | 8.98 | 0.000 | .121827 to .189845   |
| logL     | .752711 | .0706096  | 12.11 | 0.000 | .7168788 to .7896334  |
| _cons | 6.37403 | 1.363195  | 4.68 | 0.000 | 3.702215 to 9.045839  |

| sigma_u | 4.732252 |
| sigma_e | .06033813 |
| rho | .99983755 |

F test that all u_i=0: F(65,499) = 344.63, Prob > F = 0.0000

Instrumented: lit_rate lit_rate_t Health1 Health1_t trade_n_real listed_dom_comp

Instruments: logK_real logL lit_rate_lit_rate_t Health1 Health1_t trade_n_real listed_dom_comp

**xtivreg logY_real logK_real logL (lit_rate lit_rate_t Health1 Health1_t trade_n_real listed_dom_comp = l.lit_rate l.lit_rate_t l.Health1 l.Health1_t l.trade_n_r l.listed_dom_comp), re**

G2SLS random-effects IV regression

Number of obs = 573

Group variable: country
Number of groups = 66

R-sq: within = 0.7539
Obs per group: min = 2
between = 0.8452
avg = 8.7
overall = 0.8611
max = 12

corr(u_i, X) = 0 (assumed)

Wald chi2(8) = 1258.94
Prob > chi2 = 0.0000

| logY_real | Coef. | Std. Err. | z   | P>|z| | [95% Conf. Interval] |
|-----------|-------|-----------|-----|------|----------------------|
| lit_rate  | .0016808 | .0017295  | 0.97 | 0.331 | -.001709 to .0050705 |
| Health1   | .0414116 | .0146753  | 2.82 | 0.005 | .0126484 to .0701747 |
| Health1_t | .1065414 | .0136731  | 7.80 | 0.000 | .0804464 to .1326381 |
| trade_n_real | 6.016-13 | 1.161-13  | 5.41 | 0.000 | 3.83e-13 to 8.19e-13 |
| listed_dom_p | .0001683 | .0006222  | 2.71 | 0.007 | .0000464 to .0002902 |
| logK_real | .1760102 | .0181096  | 9.72 | 0.000 | .1405161 to .2115044 |
| logL     | .6650815 | .0339362  | 19.92 | 0.000 | .5996312 to .7305317 |
| _cons | 9.581085 | .4834232  | 19.82 | 0.000 | .613553 to 10.52858 |

| sigma_u | 4.1050738 |
| sigma_e | .06003819 |
| rho | .97907149 |

Instruments: lit_rate lit_rate_t Health1 Health1_t trade_n_real listed_dom_comp

Instruments: logK_real logL lit_rate_lit_rate_t Health1 Health1_t trade_n_real listed_dom_comp
xtivreg logY_real logK_real logL (lit_rate lit_rate_t Health2 Health2_t trade_n_real listed_dom_comp) , fe

\text{Fixed-effects (within) IV regression}\n\text{Number of obs = 256}\n\text{Group variable: country}\n\text{Number of groups = 40}\n\text{R-sq: within = 0.7811}\n\text{Obs per group: min = 1}\n\text{between = 0.0002}\n\text{avg = 6.4}\n\text{overall = 0.0007}\n\text{max = 12}\n\text{corr(u_i, Xb) = -0.9902}\n\text{Wald chi2(8) = 4.82e+06}\n\text{Prob > chi2 = 0.0000}\n
\text{logY_real | Coef. Std. Err. z P>|z| [95% Conf. Interval]}\n\text{-------------+-------------------------------------------------}
\text{lit_rate | -0.001393 0.0063911 -0.22 0.827 -0.0139194 0.0111333}
\text{lit_rate_t | 0.2542259 0.0876547 2.90 0.004 0.0824259 0.4260259}
\text{Health2 | -0.088049 0.0512999 -1.72 0.086 -0.1885949 0.012497}
\text{Health2_t | 0.1147141 0.1138554 1.01 0.314 -0.0403238 0.2698426}
\text{trade_n_real | 6.52e-13 1.27e-13 5.13 0.000 4.03e-13 9.01e-13}
\text{listed_dom_comp | -0.0000939 0.0000835 -1.12 0.261 -0.0002576 0.0000697}
\text{logK_real | 1.456362 0.2145398 6.79 0.000 1.035872 1.876852}
\text{logL | 9.582737 4.245322 -2.26 0.024 -17.90342 -1.262058}
\text{-------------+-------------------------------------------------}
\text{sigma_u | 12.444054}
\text{sigma_e | 0.05972283}
\text{rho | 0.99997697 (fraction of variance due to u_i)}
\text{F test that all u_i=0: F(39,208) = 353.47 Prob > F = 0.0000}

Instrumented: lit_rate lit_rate_t Health2 Health2_t trade_n_real listed_dom_comp

Instruments: logK_real logL logK_real logL.logK_real logL.logK_real logL.logK_real listed_dom_comp

xtivreg logY_real logK_real logL (lit_rate lit_rate_t Health4 Health4_t trade_n_real listed_dom_comp) , fe

\text{Fixed-effects (within) IV regression}\n\text{Number of obs = 121}\n\text{Group variable: country}\n\text{Number of groups = 20}\n\text{R-sq: within = 0.2094}\n\text{Obs per group: min = 1}\n\text{between = 0.2312}\n\text{avg = 6.0}\n\text{overall = 0.2312}\n\text{max = 12}\n\text{corr(u_i, Xb) = -0.9932}\n\text{Wald chi2(8) = 468014.49}\n\text{Prob > chi2 = 0.0000}

\text{logY_real | Coef. Std. Err. z P>|z| [95% Conf. Interval]}\n\text{-------------+-------------------------------------------------}
\text{lit_rate | 0.036172 0.0288186 1.26 0.209 -0.0203114 0.0926554}
\text{lit_rate_t | -0.2702018 0.5493501 -0.49 0.622 -1.34905 1.808501}
\text{Health4 | -4.1668186 2.993662 -1.39 0.164 -1.003174 4.695584}

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xtivreg logY_real logK_real logL (lit_rate lit_rate_t Health5 Health5_t trade_n_real listed_dom_comp) (Health1 Health1_t = l.Health1 l.Health1_t), fe

Fixed-effects (within) IV regression Number of obs = 97
Group variable: country Number of groups = 19
R-sq: within = 0.4231 Obs per group: min = 1
between = 0.4758 avg = 5.1
overall = 0.4231 max = 10
Wald ch2(8) = 63526.90 Prob > ch2 = 0.0000

corr(u_i, Xb) = -0.9983

| logY_real | Coef. | Std. Err. | z | P>|z| [95% Conf. Interval] |
|-----------|-------|-----------|---|-------|-----------------------|
| lit_rate  | 0.0017493 | 0.0705717 | 0.02 | 0.980 | -0.1365686 0.1400672 |
| lit_rate_t | -0.3772936 | 1.490985 | -0.25 | 0.800 | -3.299571 2.544983 |
| Health5  | -1.156268 | 2.379902 | -0.49 | 0.627 | -5.820791 3.508255 |
| Health5_t | 1.488202 | 2.884759 | 0.52 | 0.606 | -4.185823 7.142227 |
| trade_n_real | 3.2381-12 | 4.41e-12 | 0.73 | 0.465 | -5.42e-12 1.19e-11 |
| listed_dom-p | 0.000368 | 0.001292 | 0.28 | 0.776 | -0.021643 0.002903 |
| logK_real | -0.66652 | 0.3550389 | -1.9 | 0.055 | -1.37 0.058 |
| logL | 5.737047 | 10.44436 | 0.55 | 0.583 | -14.73353 26.20762 |
| _cons | -43.33777 | 127.5982 | -0.34 | 0.734 | -293.4256 206.75 |

sigma_u | 20.677055
sigma_e | 0.2207341
rho | 0.9988605 (fraction of variance due to u_i)

F test that all u_i=0: F(18,70) = 12.52 Prob > F = 0.0000

Instrumented: lit_rate lit_rate_t Health5 Health5_t trade_n_real listed_dom_comp
Instruments: logK_real logL l.lit_rate l.lit_rate_t l.Health5 l.Health5_t l.trade_n_real l.listed_dom_comp

. xtivreg logY_real logK_real logL (lit_rate lit_rate_t Health5 Health5_t trade_n_real listed_dom_comp) (Health1 Health1_t = l.Health1 l.Health1_t), fe
Fixed-effects (within) IV regression

Number of obs  =  613
Group variable: country
Number of groups =  69

R-sq:  within = 0.7575
       Obs per group: min =  1
       between = 0.0126
                 avg =  8.9
       overall = 0.0254
                 max =  12

Wald ch2(8) = 2.03e+07
Prob > ch2  =  0.0000

corr(u_i, Xb) = -0.9618

| Coef.  | Std. Err. |     z  | P>|z|    | [95% Conf. Interval] |
|--------|-----------|-------|-------|----------------------|
| Health1 | 0.0288384 | 0.0146743 | 1.97 | 0.049 | 0.0000774 - 0.0575994 |
| Health1_t | 0.2220278 | 0.1321388 | 1.68 | 0.093 | -0.0369596 - 0.4810152 |
| logK_real | 0.1591376 | 0.0164042 | 9.70 | 0.000 | 0.126986 - 0.1912892 |
| logL | 0.84121 | 0.0566296 | 2.82 | 0.005 | 0.0488971 - 0.270881 |
| lit_rate | -0.002985 | 0.0025293 | -1.18 | 0.238 | -0.0079422 - 0.0019723 |
| trade_n_real | 5.27e-13 | 7.07e-14 | 7.46 | 0.000 | 3.88e-13 - 6.65e-13 |
| listed_dom_comp | 0.0000891 | 0.0000385 | 2.31 | 0.021 | 0.0000136 - 0.0001646 |
| _cons | 5.437993 | 1.269552 | 4.28 | 0.000 | 2.947916 - 7.926269 |

sigma_u = 6.7938648
sigma_e = .0622949
rho = .99991593

F test that all u_i=0:  F(68,536) = 369.78
Prob > F = 0.0000

Instrumented: Health1 Health1_t
Instruments: logK_real logL lit_rate_t trade_n_real listed_dom_comp

xtivreg logY_real logK_real logL lit_rate trade_n_real listed_dom_comp
(Health2 > Health2_t = 1.Health2 1. Health2_t),fe

Fixed-effects (within) IV regression

Number of obs  =  275
Group variable: country
Number of groups =  40

R-sq:  within = 0.7524
       Obs per group: min =  1
       between = 0.8260
                 avg =  6.9
       overall = 0.8404
                 max =  12

corr(u_i, Xb) = -0.7008

| Coef.  | Std. Err. |     z  | P>|z|    | [95% Conf. Interval] |
|--------|-----------|-------|-------|----------------------|
| Health2 | .0197119 | 0.0533152 | 0.37 | 0.712 | -0.084784 - 0.1242078 |
| Health2_t | 0.067008 | 0.067875 | 0.99 | 0.324 | 0.00002455 - 0.2000405 |
| logK_real | 0.1758371 | 0.0337498 | 5.21 | 0.000 | 0.1096888 - 0.2419564 |
| logL | 1.173279 | 0.0566296 | 20.39 | 0.000 | 1.0662045 - 1.280354 |
| lit_rate | 0.0011318 | 0.0058068 | 0.19 | 0.845 | 0.0000857 - 0.0001646 |
| trade_n_real | 3.77e-13 | 1.02e-13 | 3.68 | 0.000 | 1.76e-13 - 5.77e-13 |
| listed_dom_comp | -8.47e-06 | 1.02e-13 | -0.19 | 0.846 | -0.0000937 - 0.0000768 |
| _cons | 2.049792 | 2.797056 | 0.73 | 0.464 | -3.432337 - 7.531921 |

sigma_u = 1.0060199
sigma_e = 0.06384632
rho = .99991593

F test that all u_i=0:  F(39,228) = 434.10
Prob > F = 0.0000

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xtivreg logY_real logK_real logL lit_rate trade_n_real listed_dom_comp L.Health2 Health2_t  
   Health4_t = 1.Health4 1. Health4_t, fe

Fixed-effects (within) IV regression
Number of obs = 133
Group variable: country
Number of groups = 21
R-sq: within = 0.5335
between = 0.8177
overall = 0.8698
Wald chi2(7) = 1.62e+06
Prob > chi2 = 0.0000

logY_real |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
Health4 |   .1734932   .1807205     0.96   0.337    -.1807126    .5276989
Health4_t |   .0014025   .1818197     0.01   0.994    -.3549576    .3577625
logK_real |   .0756229   .0780127     0.97   0.332    -.0772791     .228525
logL |   1.210065   .4151123     2.92   0.004     .3964594     2.02367
lit_rate |  -.0027465   .0154926    -0.18   0.859    -.0331114    .0276183
trade_n_real |   2.21e-13   4.24e-13     0.52   0.602    -6.10e-13    1.05e-12
listed_dom~p |  -.0000722   .0000533    -1.36   0.175    -.0001766    .0000322
   _cons |   4.433817   5.333996     0.83   0.406    -6.020623    14.88826
-------------+----------------------------------------------------------------
sigma_u |  .80810277
sigma_e |  .06626612
corr(u_i, Xb)  = -0.3781
rho |  .99332057   (fraction of variance due to u_i)

F test that all u_i=0:     F(20,105) =   239.14      Prob > F    = 0.0000

xtivreg logY_real logK_real logL lit_rate trade_n_real listed_dom_comp L.Health4 Health4_t  
   Health4_t = 1. Health4 1. Health4_t, fe

Fixed-effects (within) IV regression
Number of obs = 275
Group variable: country
Number of groups = 40
R-sq: within = 0.7165
between = 0.0001
overall = 0.0000
Wald chi2(8) = 1.62e+06
Prob > chi2 = 0.0000

logY_real |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
Health2 |  -.0405764   .0553147    -0.73   0.463    -.1489912    .0678384
Health2_t |   .4301945   .1414608     3.04   0.002     .1529363     0.7074526
logK_real |   .2266902   .0377098     6.01   0.000      .1527804     .30066
xtivreg logY_real logK_real logL lit_rate lit_rate_t trade_n_real listed_dom_comp L.Health2 L.Health2_t
> mp (Health4 Health4_t = L.Health4  L.Health4_t), fe
 Fixed-effects (within) IV regression
 Number of obs      =       133
 Group variable: country                     Number of groups   =        21
 R-sq:  within  = 0.0764                      Obs per group: min =            1
 between   = 0.3563                                     avg =          5.4
 overall   = 0.3203                                     max =         12
 Wald chi2(8)       =  172.12          Prob > chi2        =    0.0000
 Fixed-effects (within) IV regression
 Number of obs      =       108
 Group variable: country                     Number of groups   =        20
 Wald chi2(8)       =  172.12          Prob > chi2        =    0.0000
 Fixed-effects (within) IV regression
 Number of obs      =       108
 Group variable: country                     Number of groups   =        20
 Wald chi2(8)       =  172.12          Prob > chi2        =    0.0000
overall = 0.3675   max = 10

corr(u_i, Xb) = -0.7628

-------------+----------------------------------------------------------------
  logY_real  |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  Health5    |  -0.2202045   .8895686    -0.25   0.804    -1.963727    1.523318
  Health5_t  |   .6009778   .9397467     0.64   0.522    -1.240892    2.442847
  logK_real  |   .0778554   .1122452     0.69   0.488    -.1421412    .297852
  logL       |  1.625782    3.662652     0.44   0.657    -5.552885    8.804448
  lit_rate   |   .012585    .0238663     0.53   0.598    -.0341921    .0593621
  lit_rate_t |   .0273895   .1397365     0.20   0.845    -.246489    .3012679
  trade_n_real |  1.12e-12    1.52e-12     0.74   0.459    -.24e-12      1e-12
  listed_dom-p |  -.0000993   .0000753    -1.32   0.188    -.0002469    .0000484
  _cons      |  -5.203495   54.24874    -0.10   0.924    -111.5291    101.1221
-------------+----------------------------------------------------------------
  sigma_u    |   2.237777
  sigma_e    |   .0777124
  rho        |   .99879545   (fraction of variance due to u_i)
-------------+----------------------------------------------------------------

F test that all u_i=0:     F(19,80) =   113.80           Prob > F    = 0.0000

FRONTIER ESTIMATION

.xtfrontier  logY_real logK_real logL lit_rate, tvd i(country) t(year)
.iterate(20> )

Time-varying decay inefficiency model

Number of obs = 1368
Number of groups = 99

Time variable (t): year
Obs per group: min = 1
avg = 13.8
max = 15

Log likelihood = -226.22037   Wald chi2(3) = 7469.62
 Prob > chi2 = 0.0000

-------------+----------------------------------------------------------------
  logY_real  |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  logK_real  |   .7526089   .0125226    60.10   0.000     .7280651    .7771528
  logL       |   .1607604   .0251834     6.38   0.000     .1114019    .210119
  lit_rate   |  -.0011088   .0013869    -0.80   0.424    -.0038271    .0016095
  _cons      |   3.601787   .3128495    11.51   0.000     2.988613    4.214961
-------------+----------------------------------------------------------------
  /mu        |  -3.960116   7.108935    -0.56   0.577    -17.89337     9.97314
  /eta       |  -.0107699   .0021929    -4.91   0.000    -.0150678   -.0064719
  /lnsigma2  |   1.244525   1.337789     0.93   0.352    -.1377493    3.665842
  /ilgtgamma |   4.001878   1.360913     2.94   0.003     1.334537    6.669219
-------------+----------------------------------------------------------------
  sigma2     |   3.471285   4.643845   0.2522102   0.777689
  gamma      |   .9820469   .0239939   .7915901   .9987322
  sigma_u2   |   3.408965   4.643727   0.574521   0.061883
  sigma_v2   |   0.623202   0.024838   12.5105

115
. predict te0, te
(793 missing values generated)

. xtfrontier logY_real logK_real logL_rate Health1, tvd i(country) t(year)
it > erate(20)

Time-varying decay inefficiency model           Number of obs      =      1162
Group variable (i): country                     Number of groups   =        98
Time variable (t): year                         Obs per group: min =         1
                                                                       avg =      11.9
                                                                       max =        13
Log likelihood  =  766.53475                    Wald chi2(4)       =  1462.86
Prob > chi2        =    0.0000

------------------------------------------------------------------------------
          logY_real |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          logK_real |   .2796857   .0144331    19.38   0.000     .2513972    .3079741
          logL |   .6800848   .0393957    17.26   0.000     .6028701    .7572984
         lit_rate |   .0007268   .0017136     0.42   0.671    -.0026318    .0040855
         Health1 |   .0176797   .0058691     3.01   0.003     .0061764     .029183
           _cons |   8.042952   .6070782    13.25   0.000     6.853101    9.232803
-------------+----------------------------------------------------------------
           /mu |   1.410736   .1259636    11.20   0.000     1.163852    1.65762
           /eta |  -.0007426   .0008827    -0.84   0.400    -.0024726    .0010873
          /lnsigma2 |  -.6335874   .1891424    -3.35   0.001      -.9943    -.2728751
         /ilgtgamma |   4.037351   .1986649    20.32   0.000     3.647975    4.426727
-------------+----------------------------------------------------------------
           /mu |   1.410736   .1259636    11.20   0.000     1.163852    1.65762
           /eta |  -.0007426   .0008827    -0.84   0.400    -.0024726    .0010873
          /lnsigma2 |  -.6335874   .1891424    -3.35   0.001      -.9943    -.2728751
         /ilgtgamma |   4.037351   .1986649    20.32   0.000     3.647975    4.426727
          sigma2 |   .5306846   .1203736     4.41   0.000     .393623    .667746
          gamma |   .9826618   .0033848     29.15   0.000     .976123    .989200
         sigma_u2 |   .5214835   .1203736     4.34   0.000     .385876    .657091
         sigma_v2 |   .0092011   .0004011     23.00   0.000     .008415    .0099872
          sigma2 |   .5306846   .1203736     4.41   0.000     .393623    .667746
          gamma |   .9826618   .0033848     29.15   0.000     .976123    .989200
         sigma_u2 |   .5214835   .1203736     4.34   0.000     .385876    .657091
         sigma_v2 |   .0092011   .0004011     23.00   0.000     .008415    .0099872
------------------------------------------------------------------------------
. predict te1, te
(999 missing values generated)

. xtfrontier logY_real logK_real logL_rate Health2, tvd i(country) t(year)
it > erate(20)

Time-varying decay inefficiency model           Number of obs      =       589
Group variable (i): country                     Number of groups   =        97
Time variable (t): year                         Obs per group: min =         1
                                                                       avg =       6.1
                                                                       max =        13
Log likelihood  = -10542.368                    Wald chi2(4)       =  538765.67
Prob > chi2        =    0.0000

------------------------------------------------------------------------------
          logY_real |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          logK_real |   .4485952   .0044543   100.71   0.000      .439865    .4573254
          logL |   .6442638   .0050337   127.99   0.000     .6343979    .6541297
         lit_rate |  -.0238443   .0003732   -63.90   0.000    -.0245756    -.0231129
           _cons |   6.480153   .3987431    16.21   0.000     5.700171    7.260136
------------------------------------------------------------------------------
. predict te1, te
(999 missing values generated)

. xtfrontier logY_real logK_real logL_rate Health2, tvd i(country) t(year)
it > erate(20)

convergence not achieved

Time-varying decay inefficiency model           Number of obs      =       589
Group variable (i): country                     Number of groups   =        97
Time variable (t): year                         Obs per group: min =         1
                                                                       avg =       6.1
                                                                       max =        13
Log likelihood  = -10542.368                    Wald chi2(4)       =  538765.67
Prob > chi2        =    0.0000

------------------------------------------------------------------------------
          logY_real |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          logK_real |   .4485952   .0044543   100.71   0.000      .439865    .4573254
          logL |   .6442638   .0050337   127.99   0.000     .6343979    .6541297
         lit_rate |  -.0238443   .0003732   -63.90   0.000    -.0245756    -.0231129
Health2 |  -.0682521   .0015237   -44.79   0.000    -.0712386   -.0652657  
\_cons |    5.487912   .054595   100.52   0.000     5.380907    5.594916  

\| \mu |  -1.224656   .2636153    -4.65   0.000    -1.741333    -.707989  
\_eta |   .0210759    .0002785   75.67   0.000     .0205301    .0216218  
\lnsigma2 |   .2221243          .        .       .            .           .  
\ilgtgamma |   8.494355          .        .       .            .           .  

\| \sigma2 |   1.248727          .                             .           .  
\gamma |   .9997954          .                             .           .  
\sigma_u2 |   1.248471          .                             .           .  
\sigma_v2 |   .0002555          .                             .           .  

. predict te2, te
(1786 missing values generated)

. xfrontier  logY\_real  logK\_real  logL  lit\_rate  Health4, tvd  i(country)  t(year)

Wald chi2(4) = 1200.29
Log prob > chi2 = 0.0000

\| logY\_real |    Coef.   Std. Err.      z    P>|z|  \[95% Conf. Interval\]  
\| logK\_real |   .2854082   .0289474     9.86   0.000     .2286722    .3421441  
\| logL |   .6682787    .044282    15.09   0.000     .5814875    .7550698  
\| lit\_rate |    .004885   .0022776     2.14   0.032      .000421    .0093489  
\| Health4 |   .0568743   .0156519     3.63   0.000     .0261971    .0875516  
\_cons |    7.63533    .631508    12.09   0.000     6.397596    8.873064  

\| \mu |   1.208869   .1188538    10.17   0.000     .9759198    1.441818  
\_eta |   .0050471    .0017134     2.95   0.004     .0016889    .0084053  
\lnsigma2 |  -.8599736   .1881193   -4.57   0.000    -1.228681    -.4912666  
\ilgtgamma |   3.623285   .2109947    17.17   0.000     3.209743    4.036827  

\| \sigma2 |   .4231704   .0796078                     .2926785    .6118509  
\gamma |   .9739992   .0053434                     .9611993    .9862528  
\sigma_u2 |   .0160028   .0008683                     .0093011    .027046  

. predict te3, te
(1736 missing values generated)

. xfrontier  logY\_real  logK\_real  logL  lit\_rate  Health5, tvd  i(country)  t(year)

Wald chi2(4) = 1200.29
Log prob > chi2 = 0.0000

\| logY\_real |    Coef.   Std. Err.      z    P>|z|  \[95% Conf. Interval\]  
\| logK\_real |   .0050471    .0017134     2.95   0.004     .0016889    .0084053  
\| logL |   .004885   .0022776     2.14   0.032      .000421    .0093489  
\| Health4 |   .0568743   .0156519     3.63   0.000     .0261971    .0875516  
\_cons |    7.63533   .0315087    12.09   0.000     6.397596    8.873064  

\| \mu |   .100869   .0188538     10.17   0.000     .0759198    1.441818  
\_eta |  -.0050471   .0017134    -2.95   0.004     -.0084053    -.0016889  
\lnsigma2 |  -.8599736   .1881193   -4.57   0.000    -1.228681    -.4912666  
\ilgtgamma |   3.623285   .2109947    17.17   0.000     3.209743    4.036827  

\| \sigma2 |   .0160028   .0008683                     .0093011    .027046  
\gamma |   .0160028   .0008683                     .0093011    .027046  
\sigma_u2 |   .0160028   .0008683                     .0093011    .027046  

. predict te3, te
(1736 missing values generated)
logY_real |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
logK_real |   .4237905   .0427595     9.91   0.000     .3399834    .5075976
logL |   .5409519   .0579009     9.34   0.000     .4274683    .6544356
lit_rate |   .0033438   .0032824     1.02   0.308    -.0030896    .0097773
Health5 |   .0567774   .0225187     2.52   0.012     .0126416    .1009133
_cons |   6.019432   .6517599     9.24   0.000     4.742006    7.296858
-------------+----------------------------------------------------------------
/mu |   .6946064    .288272     2.41   0.016     .1296037    1.259609
/eta |  -.0022903    .002598    -0.88   0.378    -.0073824    .0028017
/lnsigmaw2 |  -.548473    .3424799    -1.60   0.109    -.1219721    .1277552
/ilogtgamma |   3.962494    .3510204    11.29   0.000     3.274507    4.650482
-------------+----------------------------------------------------------------
sigma2 |   .5778315    .197857     2.94   0.003     .2032908    .9523722
gamma |   .9813392    .006428     151.5   0.000     .9687640    .9940168
sigma_u2 |   .5670487    .197857     2.94   0.003     .2032908    .9523722
sigma_v2 |   .0107828   .0010669     10.04   0.000     .0086935    .0128721

.predict te4,te
(1860 missing values generated)
.sum te*

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<th>Obs</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
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</tr>
</tbody>
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avg = 3.5
max = 13

Wald chi2(4) = 1391.77
Log likelihood = 70.179519
Prob > chi2 = 0.0000