The Effect of Life Expectancy on Economic Growth in the United States

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Introduction

Cross country analyses have demonstrated that health leads to economic growth (Jamison, Lau and Wang 2005; Bloom, Canning and Sevilla 2004; Bhargava, Jamison, Lau, and Murray 2001; Bloom, Canning and Malaney 1999; Bloom and Malaney 1998; Bloom and Williamson 1998; Sachs and Warner 1997; Barro and Sala-I-Martin 1995). These results have been questioned due to the possibility of omitted variable bias and reverse causality. Attempting to address these methodological issues, several papers have re-estimated the relationship between health and economic growth, providing some evidence that health may not lead to economic growth using instrumental variable analysis (Acemoglu and Johnson 2006 and 2007) and simulated modeling (Ashraf, Lester, and Weil 2008). This paper contributes to this debate by providing a rich data set, using state and county level data from the United States (US) to examine several models to predict economic growth, measured with earnings per capita. The results show mostly a null relationship between improvements in life expectancy and earnings per capita. However, after controlling for initial levels of life expectancy and net earnings per capita a positive, significant relationship between life expectancy and net earnings per capita is demonstrated in the county level model.

Acemoglu and Johnson (2006 and 2007) use ordinary least squares (OLS) and two stage least squares methods to estimate the relationship between improvements in life expectancy (and predicted mortality) and economic growth (measured through Gross Domestic Product (GDP)/capita), controlling for country fixed effects. Their OLS estimations show only a slight (but not statistically significant) downward trend between predicted mortality and GDP per capita, indicating that countries with greater declines in mortality (hence increased in life expectancy) may have a slight decrease in GDP per capita. Their two stage least squares (2SLS) estimation shows a slightly negative, but again not significant coefficient on the log life expectancy term predicting log GDP per capita. They use access to new chemicals, drugs, and other international interventions causing mortality from TB, pneumonia, malaria, and various other diseases combined with actual mortality rates from these diseases before and after these interventions as instruments in their analysis. There has been a recent debate on the reliability and consistency of these Acemoglu and Johnson's results (Acemoglu and Johnson 2009; Bloom, Canning and Fink 2009; Bleakley 2006). This debate and its relevance to the results shown below will be reviewed more in the discussion section.

Ashraf, Lester, and Weil (2008) come to similar conclusions as those of Acemoglu and Johnson (2006 and 2007). They use a simulation model to estimate the effect of health improvements on economic growth looking into the future. Their main results confirm that raising life expectancy at birth from 40 to 60 years does not cause an increase in income per capita in the long run.

Bleakley (2007) uses aggregated county units (State Economic Areas) to estimate the effect of certain eradication campaigns (hookworm and malaria) on school enrollment, school attendance and literacy rates in the American South. He uses a difference in difference approach combined with data on malaria and hookworm eradication efforts to set up a treatment/control design. He finds that school attendance rates are higher for areas that are exposed to more treatment for hookworm and malaria and those children with more exposure to eradication campaigns earned higher incomes as adults. Bleakey (2007a) repeats a similar analysis using data from the 1950s malaria-eradication campaigns in Brazil, Colombia, and Mexico finding that malarious areas that were recipients of malaria-eradication campaigns had higher incomes in the next generation.

Other analyses of economic growth at the subnational level in the US have been undertaken, but health is not included in these models. Young et al. (2006), for example, test heterogeneous convergence across 32 states, using data at the county level. The results show that economic growth is negatively correlated with initial income as well as the size of government. Educational attainment has a positive relationship with economic growth for high school degree and four years of college or more. The size of finance, insurance and real estate, and entertainment industries are positively correlated with growth. Barro and Sala-i-Martin (1995) examine convergence across states, also finding that poor states tend to grow faster than rich states. They include a measure of human capital in their model, but no measure of health.

The link between health and economic growth has been well established at the individual level. From a theoretical perspective, there are multiple channels through which life expectancy affects economic growth. First, healthier individuals increase their incomes by being more productive, physically more energetic and mentally more robust (Bloom and Canning 2000). A second mechanism for improved economic development is through increases in savings. As a population lives longer, they will want to invest more in their retirement. A 10 year increase in longevity has been shown to lead to a 4.5% rise in savings (Bloom, Canning and Sevilla 2004). Third, improved health can lead to increases in economic growth through increases in education levels. A healthier population will want to invest more in their skills in order to earn higher wages. A healthier child will be able to attend school, learn more and have higher cognition.

This can lead to higher wages in the long term (Sachs and Malaney 2002). More recently research has begun to focus on the link between health and nutrition in utero and in early childhood as predictors of future economic growth (Heckman 2007). Early nutrition (Fogel 1997 and 2003) and the in utero environment (Gluckman and Hanson 2005 and 2006; Barker 1998) have been shown to lead to improved adult health. Economists have begun to connect these individual improvements in health to individual wealth and economic growth (Hoddinott et al. 2008; Case Fertig and Paxon 2005; Behrman and Rosenzweig 2004)

The methods for the analysis in this chapter are novel in two ways. First, it is the first time to the author's knowledge that the relationship between health and economic growth has been examined at either the state or county level in the entire US. Secondly, due to data availability and policy in the United States, the analysis below is able to use an innovative instrument, tobacco tax, to measure an unbiased relationship between life expectancy and income per capita. The paper will first review the data and methods, present some background on the strength of the instrument, and then present the results using OLS and 2SLS. The discussion will review the goals of the paper and answer a number of questions that are raised by this analysis.

Data and Methods

Data from 50 states within the US plus District of Columbia, are assembled every ten years over the period 1970-2000 from several different data sets that are explained below. The data are assembled at the state level (50 states plus District of Columbia) as well as for 2,826 merged county units within 49 states plus the District of Columbia.[1]

Data on population and mortality are obtained from the Compressed Mortality File (CMF) from the National Center for Health Statistics (NCHS). This data set provides mortality and population data for each state and county for different age, sex and race categories.[2] Per capita net earnings data are extracted from the US Department of Commerce, Bureau of Economic Analysis (BEA), Regional Economic Accounts (www.bea.gov/regional/reis/) for the years 1970, 1980, 1990 and 2000. Years of schooling data are obtained from a US Department of Agriculture, Economic Research Service file (http://www.ers.usda.gov/Data/Education/) that are extracted from the Bureau of the Census, 1970, 1989, 1990, and 2000 Census of Population. State level tobacco tax rates and cigarette consumption per capita for 1970, 1980, 1990 and 2000 are obtained from the USDA's Tax Burden on Tobacco (Orzechowski and Walker 2006).

Next a brief description of the variables created using the above databases is provided. The following variables are described: merged county unit, per capita net earnings, life expectancy, years of schooling, race, age structure, tobacco tax, consumer price index, unemployment, and cigarette consumption.[3]

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[1] Alaska is eliminated from the county level analysis due to a considerable amount of missing data at the county level.
[2] There are six race-sex categories and 16 age categories that are collapsed to 12 age categories for life expectancy calculations.
[3] Although cigarette consumption is not included in the models in the analysis below it is described here because it is an important mediator in the pathway from tobacco tax to life expectancy.

Merged county unit: 3,051 counties for which there are data are merged into 2,826 merged county units in order to avoid small county populations and numbers of deaths. All 2,826 merged county units have a population size of at least 4,000 person years (male and female combined). 2,663 counties are not merged with other counties while the remaining 388 counties are merged together to form 163 merged county units. The 163 merged county units range from having 2 to 7 counties. 122 merged county units are made up of 2 counties; 27 merged county units have three counties; 10 merged county units have 4 counties; 2 merged county units have 5 counties and 2 merged county units have six and seven counties each.

Net earnings per capita: Using the BEA's Regional Economic Accounts, net earnings are obtained for all states and merged county units from 1969-2005. Net earnings for each state and merged county unit are the sum of wage and salary disbursements, employer contributions for employee pension and insurance funds and proprietor's income (farm and nonfarm) plus an adjustment to convert earnings by place of work to a place of residence basis.[4] The Census Bureau's midyear population estimates are used to calculate net earnings per capita. Net earnings per capita for 1970, 1980 and 1990 are adjusted for regional inflation to the 2000 US$ based on the US Department of Labor, Bureau of Labor Statistics, Consumer Price Index, Regional Estimates (http://www.bls.gov/cpi/). Net earnings per capita are also referred to as earnings per capita throughout the text.

Life expectancy: Using the population and mortality data from the CMF, life expectancy is calculated for each state and merged county unit for the years 1970, 1980, 1990 and 2000. For the merged county unit, life expectancy is calculated by summing deaths and population over

[4] The adjustment for residence can be positive or negative depending on the state or county.

five calendar years (the year of analysis and two years on each side) to reduce sensitivity to small numbers. Twelve age group categories are used in the life expectancy calculation (some spanning five years others ten). A standard life table calculation is used to calculate life expectancy for each state and merged county unit using a program created in Stata.

Years of schooling: The data on state and county education levels in the form of percent of persons 25 years and older who completed different levels of schooling are transformed into years of schooling completed using the conversion factors created by Jaeger (1997). Years of schooling is weighted by county population size for each decade to create a years of schooling value for each merged county unit.

Race: Percent Black and percent "other race" are used as proxies for race.[5] Percent black and percent "other race" for each state and merged county unit are calculated from the NCHS Compressed Mortality Files for the years 1970, 1980, 1990, and 2000.

Age Structure: The percent of the population in each state and each merged county unit between the ages 20-44 years, 45-64 years, and 65-85+ years is created using population totals for each county in the NCHS Compressed Mortality Files for the years 1970, 1980, 1990, and 2000. Age structure is included in order to test the model's sensitivity to age structure changes.

Tobacco Tax: State and federal excise tax per pack of cigarettes is used as an instrument for life expectancy. Tobacco tax is in dollars and is inflated to 2000 US$.

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[5] More detailed race data were available after 1980, but in order to be consistent this analysis uses only percent black and percent "other race".

Consumer Price Index: Income, tobacco tax for 1970, 1980 and 1990 are adjusted for regional inflation to the 2000 US$ based on the US Department of Labor, Bureau of Labor Statistics, Consumer Price Index, Regional Estimates (http://www.bls.gov/cpi/).

Cigarette Consumption: The data for cigarette consumption include per capita packs of tobacco consumption in each state for the years 1970, 1980, 1990, and 2000.

Unemployment: Unemployment data is collected from the Bureau of Labor Statistics Database for years 1980, 1990 and 2000. State unemployment is defined as the annual, not seasonally adjusted unemployment rate http://data.bls.gov/cgi-bin/dsrv. County unemployment rate is defined as the rate unemployed ages 16+ and is extracted from the Area Resource File database.

All available data are inputted into Stata version 10.0 by the author for analysis. The distribution of the variables is examined to determine normality and identify any outliers. The net earnings per capita as well as life expectancy are examined for normality and found to be slightly skewed. For this reason, both of these variables are log transformed in the analysis below.

The econometric model for the relationship between life expectancy and net earnings per capita, modeled as a difference in difference, is written as:

$$\Delta LogEarn/cap_{j,t-(t-1)} = \Delta \log LE_{j,t-(t-1)}\pi + \Delta X_{j,t-(t-1)}\beta + e_{j,t-(t-1)}$$

where $\Delta \log LE$ is the change in the log of life expectancy over a specified time period for either the county or the state and ΔX is a vector of differenced state or county characteristics that affect earnings including years of schooling, age structure, and race as well as initial log of net earnings per capita and initial log life expectancy. This equation is tested over the period 1970 to 2000 (long difference) as well as over three decades (1970-1980, 1980-1990, 1990-2000) at both the state and merged county unit (in the equation above j refers to state or merged county unit). Each method has a full set of year dummies[6] as well as robust standard errors adjusted for intrastate correlation.[7] Additional results include unemployment as well as state time trends as right hand side variables. The above model is tested using ordinary least squares (OLS) and two stage least squares (2SLS). The instrument in the 2SLS for the change in log life expectancy is the change in state tobacco tax over time.

$$\Delta \log LE_{j,t-(t-1)} = \alpha_0 + \alpha_1 \Delta TobaccoTax_{s,t-(t-1)} + e_{s,t}$$

The following traditional convergence model is also estimated:

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[6] A time dummy is included to capture natural fluctuations in income per capita.
[7] Adjusting for intrastate correlation addresses the problem that counties may be independent across states but are not necessarily independent within states.

$$\Delta LogEarn/\,cap_{j,t-(t-1)} = \Delta \log LE_{j,t-1}\pi + \Delta X_{j,(t-1)}\beta + e_{j,t-1}$$

Results are initially reported for the state and merged county unit. The equations above are also estimated using levels rather than differences (results can be requested from the author).

Tobacco Tax

The first federal tobacco tax was implemented in 1794. In 1921, beginning with Iowa, states also began to tax cigarettes. By 1950, 40 states plus the District of Colombia had a state cigarette tax. The final state to impose a cigarette tax was North Carolina (2 cents in 1969 (http://www.druglibrary.org/Schaffer/LIBRARY/studies/nc/nc2b.htm). The mean tobacco tax (federal plus state) for this data set was 18 cents in 1970, 21 cents in 1980, 38 cents in 1990, and 75 cents in 2000. Tobacco tax rate (federal plus state) ranged from a low of 10 cents in 1970 (North Carolina) to $1.45 in the year 2000 (New York). After inflating tobacco tax rates to 2000 US$ using regional CPI, mean tobacco tax was 79 cents in 1970, 43 cents in 1980, 50 cents in 1990 and 75 cents in 2000.

The next section reviews all the possible pathways through which tobacco tax can influence life expectancy and income.

Price and Cigarette Consumption

Many published studies have shown that increasing the price of cigarettes has an effect on cigarette consumption. Price elasticity for the adult population ranges from -0.2 to -0.6, indicating that a 10% increase in cigarette price will decrease consumption between 2% and 6% (Becker et al. 1994; NCI 1994; Chaloupka and Weshler 1997; CDC, MMWR 1998; Chaloupka and Warner 1999; Kaplan 2001). The mechanism works in two ways: encouraging current smokers to quit smoking and preventing non-smokers, mostly youth, from beginning to smoke. This range includes both short-run and long-run effects; short-run effects having lower elasticity than long run effects. The price elasticity that estimated with the dataset used in this paper is -0.99.[8]

Tobacco Taxes and Cigarette Consumption

Empirical evidence shows a negative relationship between tobacco tax and consumption, although not as strong as with price and consumption. These estimates suggest that a 75 cent increase in tobacco tax would cut overall smoking rates by one half (Chaloupka and Weshler 1997). Anecdotal evidence suggests that the impact on cigarette consumption from tobacco tax is immediate and then lessens over time (three years).[9] Using the data from the analysis below, an elasticity of -0.46 is estimated between tobacco tax and per capita sales of cigarettes.

Cigarette Consumption and Mortality

Research on smoking and mortality dates back to the 1940s when Richard Doll began investigating the reason for large increases in lung cancer in Britain, especially among men. Doll's landmark 1948 "case-control" study showed that the only difference between male doctors that had lung cancer and those that did not was smoking levels (Doll and Hill 1950). At this same time, a study in the United States also came to the same conclusions on the relationship

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[8] This price elasticity is estimated over a three decade panel (1970-2000) at the state level controlling for education, age structure, and race.
[9] Communications with Greg Connolly, SHDH, HSPH

between smoking and lung cancer (Wynder and Graham 1950). Prospective studies over the next decade corroborated these initial results and also demonstrated that smoking was responsible for deaths from respiratory disease (chronic bronchitis) and vascular disease (heart attacks) (Doll and Hill 1966; Doll and Hill 1964). The results from these prospective studies showed death rates from all causes were two and three times as great in smokers as in non-smokers (Doll et al. 2004; Doll et al. 1994).

Smoking Cessation and Health

Just as cigarette smoking leads to increases in mortality, decreases in cigarette smoking lead to subsequent declines in mortality. Data from the UK have shown that as smoking rates began to fall around 1970 for men and women, mortality from lung cancer began to fall several years later (Cancer Research UK 2005). Quitting smoking before age 50 cuts in half the risk of dying over the next 15 years in half (US Department of Health and Human Services 1990). More recently, it has been estimated that quitting smoking can lead to gains in life expectancy even sooner: 3 years gained for quitting at age 60; 6 years gained for quitting at age 50; 9 years gained for quitting at age 40; 10 years gained for quitting at age 30 (Doll et al. 2004).

More immediate gains in health have been found examining specific causes of death. The effects of quitting on nonfatal myocardial infarction has been shown to be as early as 1 year after quitting and reaching the levels of nonsmokers within 3 years (Rosenberg, Pamler and Shapiro 1990; Rosenberg et al. 1985). Cardiovascular death among women who stopped smoking was reduced by 24% in 2 years (Kawachi et al. 1993). The American Cancer Society’s 50 state study found that standard mortality ratios for lung cancer among former smokers compared to current smokers (with no history of chronic disease) dropped as quickly as one year after cessation and continued to drop up until 16 years after cessation (US Department of Health and Human Services 1990; Shopland 1995).

Taxes and Health

Several studies examine the link between tobacco tax increases and subsequent changes in mortality and life expectancy. One study showed that in New Zealand there is actually a burden from tobacco tax on life expectancy leading to a decrease of between 0.005 years to 0.027 years. Although this study does show harm from tobacco tax, this harm is much less than the harm from smoking. Loss of life expectancy attributable to smoking was 42 to 257 times greater than the loss of life expectancy from tobacco tax (Wilson et al. 2004). Moore (1996) uses state level tobacco tax rates over the period 1954-1988 to estimate the impact on mortality, finding a significant impact of tobacco taxes on decreased lung, mouth and throat cancer and cardiovascular disease. Other studies have used modeling techniques to determine how mortality and other aspects of population health would change if a tobacco tax was implemented. A study using data from the state of California concluded that tobacco tax increases are beneficial to population health while also increasing state revenues. This study modeled Quality Adjusted Life Years (QALYs) under several different tobacco tax, consumption elasticity and time scenarios to conclude that 8359 QALYs would be saved in the first year of a tobacco tax increase and after 75 years 52,136 QALYs would be saved per year (Kaplan et al. 2001). Another study using data from the Netherlands and a chronic disease model to describe the morbidity and mortality from smoking, found that a tax increase causes a gain in life years and QALYs over a 100 year period. The largest gains in both life years and QALYs are between 30 and 40 years after the tax increase (van Baal 2007). Other studies have come to similar conclusions on the link between tobacco tax and QALYs (Emery et al. 2001; Ahmad 2005). Levy et al. (2000) find decreases in deaths attributable to smoking within the first year of a tax increase (1.2% decrease for a $0.20 tax increase and 4.0% decrease for a $1.00 tax increase) and continuing up until 40 years in the future (8.5% decrease for a $0.20 tax increase and 17.4% decrease for a $1.00 tax increase). Most recently, models that take into consideration different cigarette tax rates as well as price elasticity for cigarettes have demonstrated the effect on the population health (measured in Quality Adjusted Life Years) can occur as early as the first year of tax implementation (Kaplan 2007).

Mechanism to Earnings per Capita

The traditional mechanisms that are usually discussed when describing how health impacts economic growth are increases in savings, education, and changes in the population age structure. With extended life expectancy, populations live longer, saving more into their retirement, investing more in their education and with a large percent of the population in the working age range this can lead to large improvements in economic growth (Bloom and Canning 2000). Since the model used in this paper controls for education and age structure, the contribution from life expectancy to earnings per capita measured below is not based on either of these mechanisms. Rather, the mechanism proposed in the analysis to follow is related to morbidity and worker productivity. Life expectancy, instrumented with tobacco tax, is predicted to increase the morbidity associated with diseases related to smoking such as cardiovascular disease, cancers, and respiratory diseases. Although this mechanism has not been well researched, the author plans to investigate at the individual level the effect on worker productivity and morbidity on income levels using the Mincer wage equation and available data that contain smoking levels, wage data, as well as health and morbidity data. This mechanism is measured at the county and state level in the United States in the analysis that follows.

Tobacco Tax as an Instrumental Variable

Due to its potential impact on life expectancy, tobacco tax at the state level is chosen as an instrument for life expectancy in the analysis below. Two assumptions are made when using tobacco tax as an instrument. The first assumption is that tobacco tax is distributed independently of the error process. The author argues that regulation at the state level is not directly related to or somehow in anticipation of future growth at the state or county level and can then be taken to be exogenous in this model and random with respect to the error term. The second assumption is that tobacco tax is sufficiently correlated with the endogenous regressor, life expectancy. An examination of the first stage regressions allows us to determine the strength of the relationship between tobacco tax and life expectancy. Two tests are used to test the strength of our instrument. First stage regressions are examined and tobacco tax is considered sufficiently strong if the first stage F statistic is above 10.0 (Staiger and Stock 1997). Secondly, the F statistic is examined in comparison to the Stock and Yogo's (2005) critical values for a weak instrument test and it is concluded that tobacco tax explains a reasonable fraction of the variability of life expectancy if the F statistic is larger than Stock-Yogo's critical values for 10% of the maximal IV size. Figure 1 visually shows those states that had larger increases in tobacco tax over the last three decades had the largest gains in life expectancy.

Figure 1. Y-axis: Change in life expectancy (years), 1970 to 2000; X-axis: Change in tobacco tax (federal plus state) (2000 US¢), 1970 to 2000

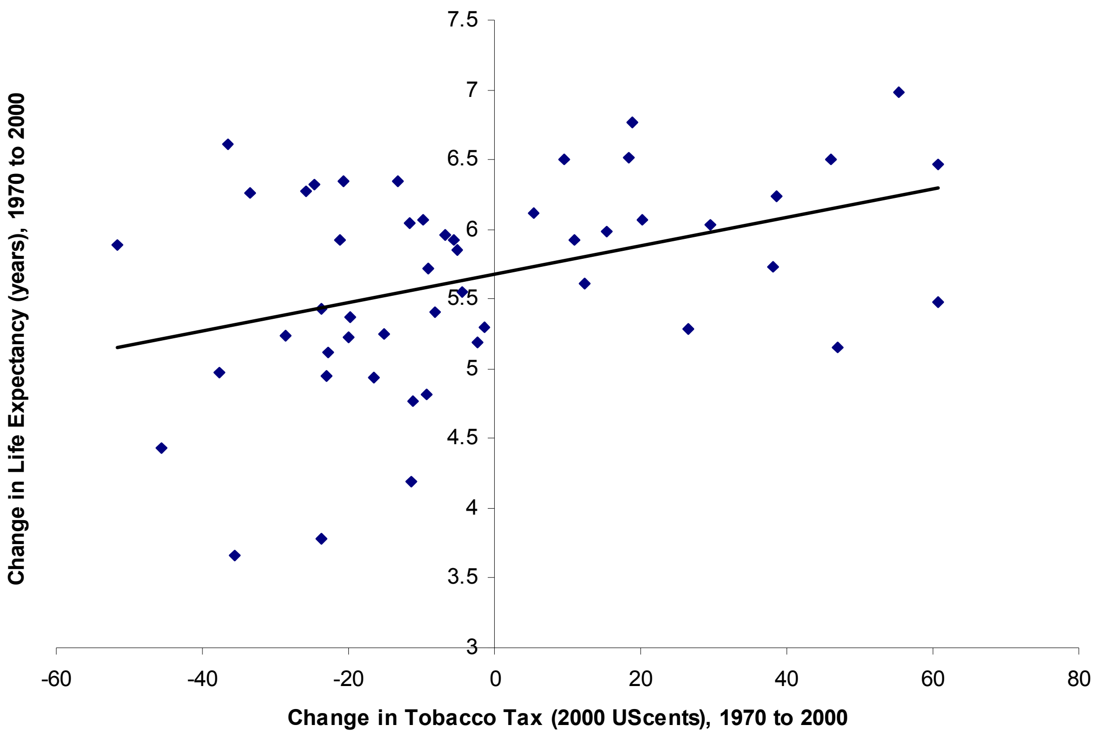


Figure 2 visually shows the relationship between life expectancy and tobacco tax using data over each decade (1970-1980, 1980-1990, 1990-2000, and 1970-2000). Those states that had larger increases in tobacco tax over the decades 1970-1980 and 1990-2000 had the largest gains in life expectancy. Over the period 1980-1990 the relationship between the change in tobacco tax and change in life expectancy is slightly negative.

Figure 2. Y-axis: Change in life expectancy (years), 1970 to 2000; X-axis: Change in tobacco tax (federal plus state) (2000 US¢), 1970 to 2000

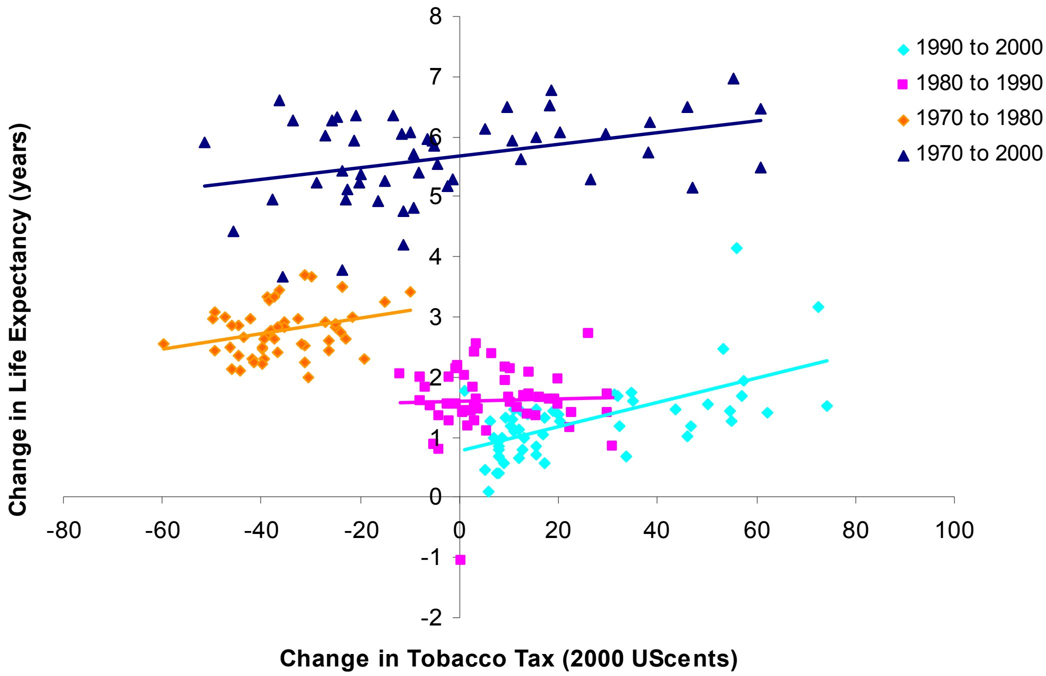


Figure 3 shows that there is negative correlation between changes in tobacco taxes and changes in net earnings at the state level.

Figure 3. Y-axis: Change in log net earnings per capita (2000 US$), 1970 to 2000; X-axis: Change in tobacco tax (federal plus state) (2000 US¢), 1970 to 2000

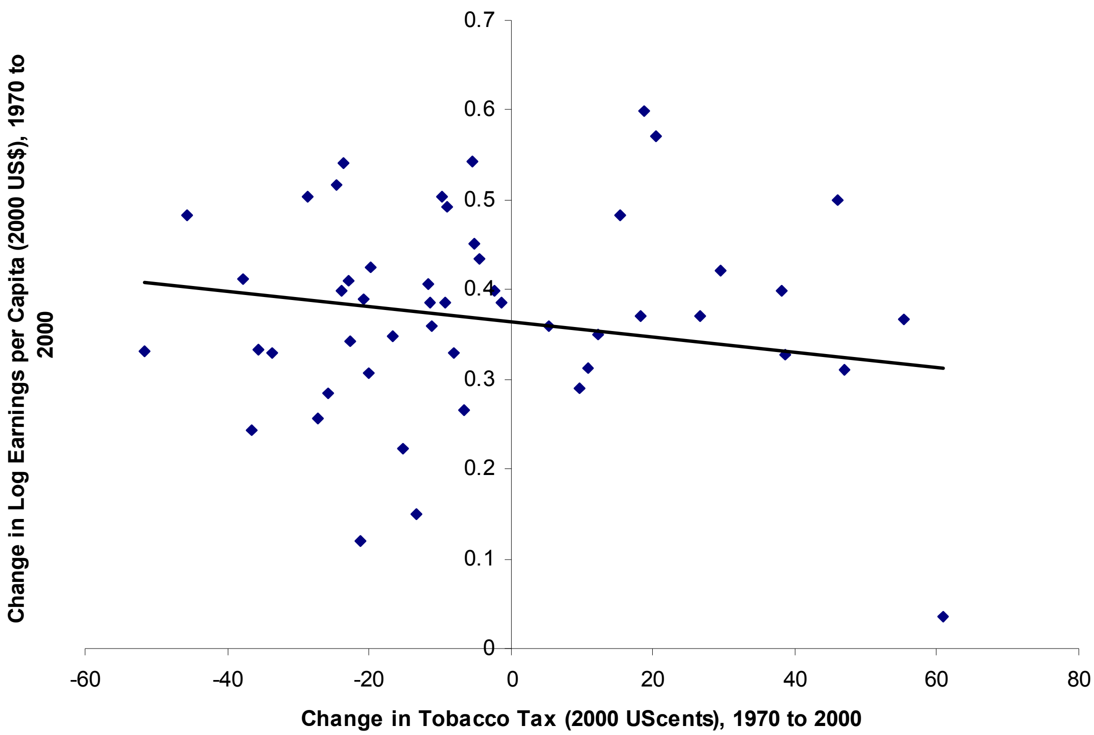


Figure 4 shows that in the mid years, from 1980 to 1990, those states that made the largest increases in tobacco taxes were actually the states that had the lowest growth in net earnings per capita.

Figure 4. Y-axis: Change in log net earnings per capita (2000 US$), panel 1970-1980, 1980-1990, 1990-2000; X-axis: Change in tobacco tax (federal plus state) (2000 US¢), panel 1970-1980, 1980-1990, 1990-2000

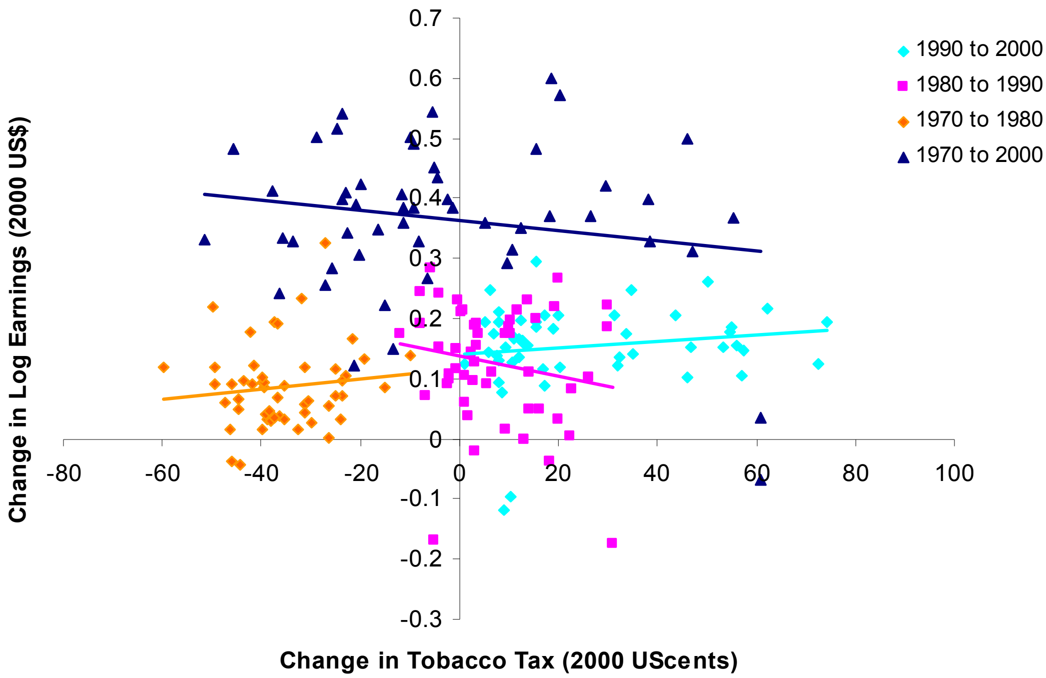
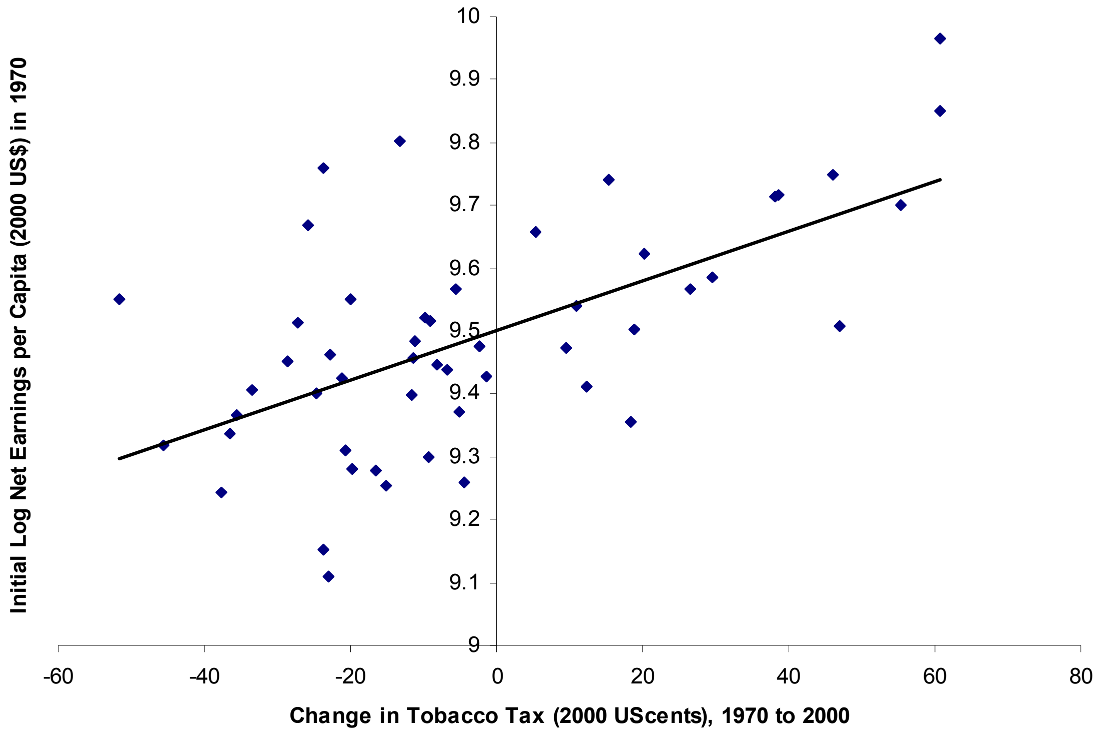


Figure 5 shows that there is also a positive correlation between initial levels of net earnings in 1970 and subsequent increases in tobacco tax. Those states that had higher net earnings in 1970 were the ones that increased tobacco taxes the most over the period 1970 to 2000.

Figure 5. Y-axis: Initial log net earnings per capita (2000 US$), 1970; X-axis: Change in tobacco tax (federal plus state) (2000 US¢), 1970 to 2000



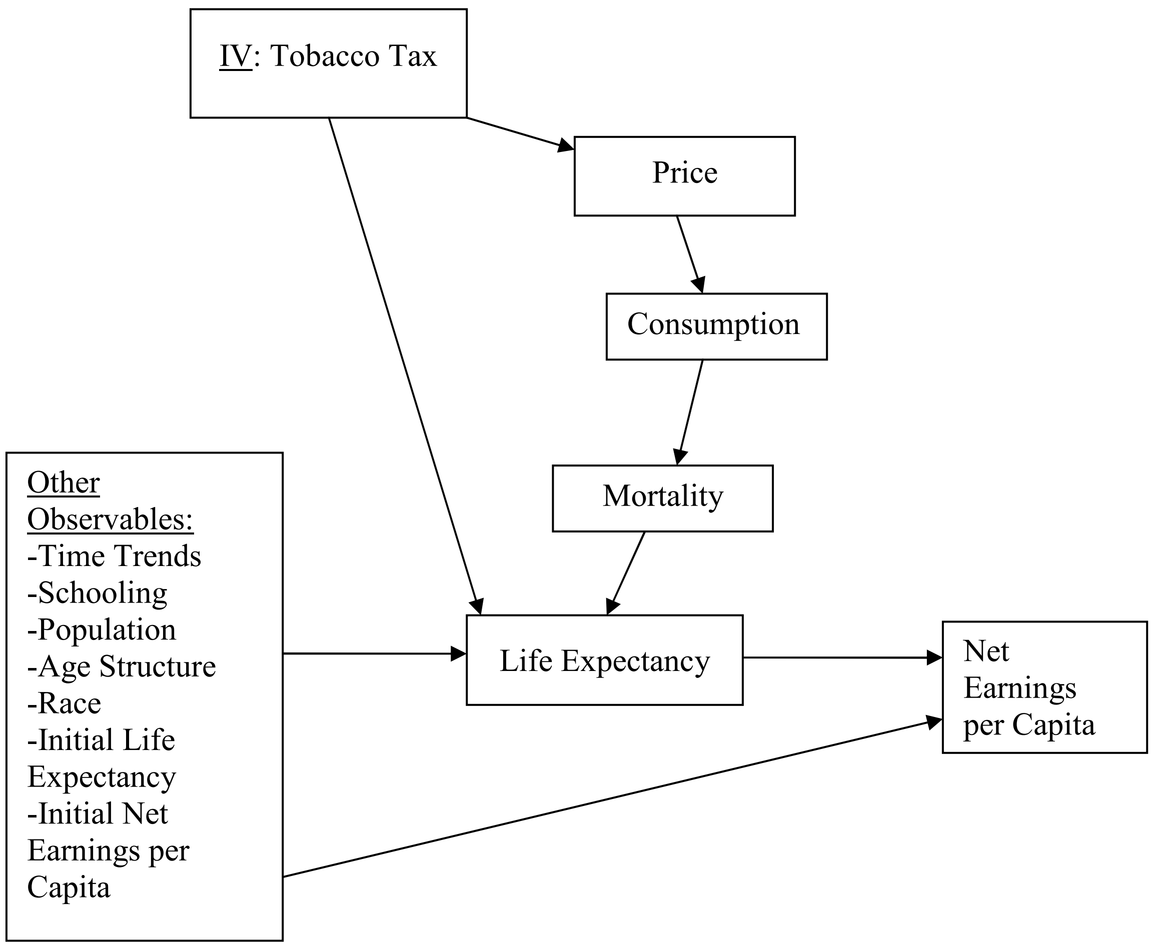
This positive correlation between tobacco tax and net earnings supports the argument for tobacco tax as an instrument. Since it is the richer states that are increasing their tobacco taxes the most, one can assume that they are not increasing tobacco taxes to further boost their economy. If this were the case, there may be evidence for reverse causality from income levels to tobacco tax. On the contrary, since the richer states are increasing tobacco taxes the most they must be making these increases for health reasons and are more likely to be using these tax funds to invest in health promoting activities, rather than balancing their budgets. This supports the argument that increases in tobacco tax are associated with increases in earnings per capita, but mainly through life expectancy.

Moreover, the reason for the larger increases in tobacco taxes, especially after 1990 was mainly due to the large external shock from the Master Settlement Agreement between state attorneys general and major US tobacco companies (Philip Morris, RJ Reynolds Tobacco Company, Brown & Williamson Tobacco Company, and Lorillard) in 1998. Although the MSA was not settled until 1998, earlier in the 1990s states began contemplating how to begin to curb levels of smoking in response to a CDC Report on Projected Smoking-Related Deaths among Youth in the United States (CDC 1996).

As of the year 2008, taxes on tobacco products accounted for only 2% of all state government tax collections. Even if some of this 2% did flow down to the county level it would not significantly impact county earnings.

Much of the tobacco tax is used directly for health related programs. In California for example, as of 2009, 31% of the tobacco tax is used for tobacco related programs and research, breast cancer research and fire prevention, 63% if used for programs to encourage proper childhood development, and the remaining 6% goes to the state's General Fund (Board of Equalization 2009).

The following diagram captures the different pathways through which tobacco tax operates as an instrument between life expectancy and income per capita.


IV: Tobacco Tax
Price
Consumption
Mortality
Other Observables:
-Time Trends
-Schooling
-Population
-Age Structure
-Race
-Initial Life Expectancy
-Initial Net Earnings per Capita
Life Expectancy
Net Earnings per Capita

Results

Table 1 shows the initial descriptive statistics for the 50 States plus the District of Columbia in the United States. Both net earnings per capita and life expectancy have increased in the US over the period 1970 to 2000. Income increased by 44.5% from 1970 to 2000 while life expectancy increased by 8.0%. Years of schooling increased by two years. Cigarette consumption decreased from 121.5 packs per person per year in 1970 to 83.8 packs per person per year in 2000. In 1970, average tobacco tax rate, in nominal terms, was 18 cents. By the year 2000, average tobacco tax rate increased to 76 cents. The percent of the population in the oldest age category (65-85+) increased from 9.6% in 1970 to 12.5% in the year 2000. The percent black in each merged county unit increased slightly over time from 10.0% to 11.4%.

Table 1. Means for 51 States; 1970, 1980, 1990 and 2000

	1970	1980	1990	2000
Per Capita Net Earnings (2000 US $)	13,439 (2,528)	14,673 (2,942)	16,620 (3,204)	19,426 (3,858)
Life Expectancy	71.4 (1.5)	74.2 (1.3)	75.8 (1.6)	77.0 (1.6)
Years of Schooling	10.4 (0.46)	11.3 (0.47)	11.9 (0.40)	12.4 (0.34)
Tobacco Tax (2000 US cents)	79 (16)	43 (10)	51 (13)	76 (28)
Tobacco Tax (Nominal US cents)	18 (4)	21 (4)	38 (10)	76 (28)
Cigarette Consumption	121.5 (32.1)	134.9 (27.5)	102.4 (22.6)	83.8 (26.1)
Percent Age 20-44 Years Old	31.6 (2.3)	37.3 (2.4)	39.7 (2.4)	36.5 (1.6)
Percent Age 45-64 Years Old	20.0 (1.6)	19.0 (1.6)	18.4 (1.1)	22.4 (1.3)
Percent Age 65-85+ Years Old	9.6 (2.0)	11.0 (2.1)	12.4 (2.1)	12.5 (1.9)
Percent Black	10.0 (12.7)	10.4 (12.7)	10.8 (12.1)	11.4 (12.0)
Percent Other Race	2.7 (8.7)	3.4 (8.9)	4.4 (9.1)	5.6 (9.7)

Income estimates are adjusted to 2000 US$ using regional inflation rates; Standard Deviation in parenthesis

Table 2 reports ordinary least squares (OLS) regressions of long difference in difference equation with the difference in log of net earnings per capita at the state level as the dependent variable. All regressions in this table include data for only years 1970 and 2000. Column 1 includes log life expectancy as the only independent variable. Although not significant, the results in the first column indicate that a 1% increase in life expectancy at birth (measured in years) is associated with a 0.836% decrease in net earnings per capita. Column 2 adds years of schooling to the model. The relationship between life expectancy and net earnings per capita becomes positive and insignificant. The coefficient on years of schooling in Column 2 estimates a one year increase in education is associated with a 27.9% increase in net earnings per capita. In Column 3 age structure is added to the model, indicating that being in the age group 20-44 years old increases net earnings per capita at the state level and being over age 45 has no significant impact on earnings. Percent black and other race in each state is not predictive of changes in earnings. Column 5 shows that neither the change in life expectancy over time and initial levels of life expectancy are correlated with earnings. Column 6 shows that initial level of earnings per capita is a positive, significant predictor of increases in earning per capita.

Table 2. OLS: Dependent variable: Long difference in log net earnings per capita (just 1970 and 2000); Independent variables: Long Difference (just 1970 and 2000); State Level

	1	2	3	4	5	6
Δ Log Life Expectancy	-0.836 (1.708)	0.002 (1.245)	1.755 (0.978)	1.515 (1.015)	1.473 (1.132)	-0.326 (1.335)
Δ Years of Schooling	---	0.279 (0.062)**	0.206 (0.044)**	0.224 (0.040)**	0.223 (0.043)**	0.225 (0.042)**
Log Life Expectancy 1970	---	---	---	---	-0.056 (0.574)	-0.245 (0.474)
Log Earnings/cap 1970	---	---	---	---	---	0.247 (0.100)*
Δ % 20-44 years old		---	0.033 (0.013)*	0.042 (0.014)**	0.042 (0.015)**	0.065 (0.015)**
Δ % 45-64 years old	---	---	-0.007 (0.011)	-0.001 (0.012)	-0.001 (0.012)	0.011 (0.011)
Δ % 65-85 years old	---	---	-0.019 (0.010)	-0.015 (0.010)	-0.015 (0.010)	-0.008 (0.011)
Δ % Black	---	---	---	-0.001 (0.004)	-0.001 (0.004)	-0.004 (0.002)
Δ % Other Race	---	---	---	0.012 (0.005)*	0.012 (0.006)*	0.008 (0.006)
Constant	0.430 (0.122)**	-0.195 (0.152)	-0.271 (0.096)**	-0.393 (0.123)**	-0.152 (2.480)	-1.703 (2.478)
2000	---	---	---	---	---	---
Number of Observations	51	51	51	51	51	51
Number of counties	51	51	51	51	51	51

OLS regressions with robust standard errors in parentheses; * significant at 5%; ** significant at 1%

Table 3 reports the difference in difference regressions of the change in the log of net earnings per capita at the state level as the dependent variable. The data are differenced over four time periods (1970 to 2000) leaving three differenced time points (1970 - 1980, 1980 - 1990, and 1990 - 2000). The results indicate a negative, mostly insignificant relationship between life expectancy and earnings per capita. Years of schooling is the only variable that is positively and significantly correlated with increased earnings per capita. Equivalent county level OLS regressions are shown Tables 4 and 5.

Table 3. OLS: Dependent variable: Difference in log net earnings per capita (Panel, 1970 to 2000); Independent variables: Differenced (Panel, 1970 to 2000); State Level

	1	2	3	4	5	6
Δ Log Life Expectancy	-2.214 (0.981)*	-1.244 (0.747)	-0.566 (0.707)	-0.612 (0.742)	-0.465 (0.799)	-0.568 (0.733)
Δ Years of Schooling	---	0.309 (0.074)**	0.211 (0.053)**	0.211 (0.057)**	0.216 (0.058)**	0.220 (0.054)**
Initial Log Life Expectancy	---	---	---	---	0.215 (0.219)	0.245 (0.311)
Initial Log Earnings/cap	---	---	---	---	---	0.036 (0.047)
Δ % 20-44 years old	---	---	0.011 (0.006)	0.009 (0.006)	0.009 (0.006)	0.009 (0.006)
Δ % 45-64 years old	---	---	-0.011 (0.007)	-0.014 (0.008)	-0.014 (0.008)	-0.014 (0.008)
Δ % 65-85 years old	---	---	-0.021 (0.007)**	-0.021 (0.008)**	-0.020 (0.008)**	-0.020 (0.008)*
Δ % Black	---	---	---	-0.009 (0.005)	-0.010 (0.005)	-0.012 (0.005)*
Δ % Other Race	---	---	---	-0.007 (0.010)	-0.008 (0.011)	-0.012 (0.011)
Constant	0.171 (0.042)**	-0.153 (0.063)*	-0.132 (0.058)*	-0.114 (0.065)	-1.039 (0.964)	-1.511 (1.383)
1980	---	---	---	---	---	---
1990	0.002 (0.033)	0.108 (0.024)**	0.133 (0.020)**	0.128 (0.021)**	0.124 (0.022)**	0.122 (0.024)**
2000	0.022 (0.032)	0.192 (0.030)**	0.284 (0.060)**	0.284 (0.061)**	0.279 (0.059)**	0.277 (0.070)**
Number of Observations	153	153	153	153	153	153
Number of counties	51	51	51	51	51	51

OLS regressions with year dummies. Robust standard errors, adjusted for clustering within state, in parentheses; * significant at 5%; ** significant at 1%

Table 4 reports ordinary least squares regressions of long difference in difference equation with the difference log of net earnings per capita at the merged county unit as the dependent variable.

All regressions in this table include data for only years 1970 and 2000. Column 1 includes log life expectancy as the only independent variable. Although not significant, the results in the first column indicate that a 1% increase in life expectancy at birth (measured in years) is associated with a 0.399% increase in earnings per capita. After including all other variables in the model, in Column 6, the results show that a 1% increase in life expectancy is significantly correlated with a 1% increase in net earnings per capita.

Table 4. OLS: Dependent variable: Long difference in log net earnings per capita (just 1970 and 2000); Independent variables: Long Difference (just 1970 and 2000); County Level

	1	**2**	**3**	**4**	**5**	**6**
Δ Log Life Expectancy	0.399 (0.411)	-0.149 (0.276)	-0.086 (0.201)	-0.119 (0.193)	0.396 (0.229)	1.008 (0.281)**
Δ Years of Schooling	---	0.272 (0.013)**	0.220 (0.013)**	0.216 (0.014)**	0.216 (0.014)**	0.205 (0.014)**
Log Life Expectancy 1970	---	---	---	---	1.034 (0.311)**	1.584 (0.309)**
Log Net Earnings/cap 1970	---	---	---	---	---	-0.141 (0.032)**
Δ % 20-44 years old		---	0.009 (0.004)*	0.009 (0.004)*	0.012 (0.004)**	0.009 (0.004)*
Δ % 45-64 years old	---	---	0.022 (0.003)**	0.022 (0.003)**	0.023 (0.003)**	0.023 (0.003)**
Δ % 65-85 years old	---	---	-0.018 (0.003)**	-0.018 (0.003)**	-0.017 (0.003)**	-0.017 (0.003)**
Δ % Black	---	---	---	-0.001 (0.001)	-0.002 (0.001)	-0.001 (0.001)
Δ % Other Race	---	---	---	0.001 (0.004)	0.002 (0.004)	0.003 (0.004)
Constant	0.272 (0.029)**	-0.244 (0.028)**	-0.182 (0.039)**	-0.174 (0.042)**	-4.643 (1.360)**	-5.690 (1.309)**
2000	---	---	---	---	---	---
Number of Observations	2826	2826	2826	2826	2826	2826
Number of counties	2826	2826	2826	2826	2826	2826

OLS regressions with robust standard errors, adjusted for clustering within state, in parenthesis; * significant at 5%; ** significant at 1%

Table 5 reports the difference in difference regressions of the change in the log of net earnings per capita at the merged county unit as the dependent variable. The data are differenced over four time periods (1970 to 2000) leaving three differenced time points (1970 - 1980, 1980 - 1990, and 1990 - 2000). The results indicate a negative, insignificant relationship between life expectancy and net earnings per capita except for Column 6 where a positive, insignificant relationship is shown.

Table 5. OLS: Dependent variable: Difference in log net earnings per capita (Panel, 1970 to 2000); Independent variables: Differenced (Panel, 1970 to 2000); County Level

	1	**2**	**3**	**4**	**5**	**6**
Δ Log Life Expectancy	-0.397 (0.296)	-0.381 (0.303)	-0.253 (0.321)	-0.318 (0.324)	-0.151 (0.340)	0.459 (0.393)
Δ Years of Schooling	---	0.200 (0.016)**	0.172 (0.016)**	0.157 (0.019)**	0.156 (0.019)**	0.158 (0.019)**
Initial Log Life Expectancy	---	---	---	---	0.308 (0.132)*	0.961 (0.155)**
Initial Log Earnings/cap	---	---	---	---	---	-0.161 (0.033)**
Δ % 20-44 years old	---	---	0.002 (0.003)	0.002 (0.003)	0.003 (0.003)	0.001 (0.003)
Δ % 45-64 years old	---	---	0.002 (0.003)	0.001 (0.003)	0.002 (0.003)	0.004 (0.003)
Δ % 65-85 years old	---	---	-0.015 (0.004)**	-0.015 (0.004)**	-0.014 (0.004)**	-0.015 (0.004)**
Δ % Black	---	---	---	-0.007 (0.002)**	-0.007 (0.002)**	-0.004 (0.002)
Δ % Other Race	---	---	---	-0.003 (0.004)	-0.002 (0.004)	0.003 (0.005)
Constant	0.061 (0.022)**	-0.114 (0.029)**	-0.083 (0.027)**	-0.070 (0.026)**	-1.397 (0.572)*	-2.705 (0.577)**
1980	---	---	---	---	---	---
1990	0.070 (0.031)*	0.116 (0.033)**	0.121 (0.033)**	0.121 (0.032)**	0.115 (0.032)**	0.099 (0.030)**
2000	0.075 (0.021)**	0.146 (0.022)**	0.123 (0.028)**	0.125 (0.028)**	0.118 (0.026)**	0.097 (0.024)**
Number of Observations	8476	8476	8476	8476	8476	8476
Number of counties	2826	2826	2826	2826	2826	2826

OLS regressions with year dummies. Robust standard errors, adjusted for clustering within state, in parentheses; * significant at 5%; ** significant at 1%; 2 observations are missing from the analysis because 1 counties in North Dakota had negative net earnings in 1980 causing this county to lose 2 differenced time points (1970-1980 and 1980-1990) (La Moure, ND)

Table 6 reports a long difference regression with the change in the log of net earnings per capita at the state level as the dependent variable. Log of net earnings per capita is differenced over two time periods (1970 to 2000). The independent variables in each regression are initial levels of each variable in the year 1970. Table 6 captures the long term impact (rather than contemporaneous effect) of health improvement on earnings per capita. The results indicate that initial levels of life expectancy in 1970 mostly lead to improvements in earnings per capita over the period 1970 to 2000 with a significant result in the final column. The final column shows that a 1% increase in life expectancy in the year 1970 leads to a 6.047% increase in net earnings per capita at the state level over the 30 year period 1970 to 2000. Interestingly, initial levels of years of schooling in 1970 do not lead to higher levels of earnings per capita. Race in 1970 is important showing that a 1% increase in percent black in each state is significantly correlated with a 0.78% increase in net earnings over the 30 year period.

In Columns 3, 4 and 5, initial income per capita is added to the model in order to estimate a standard conditional convergence model. Initial levels of life expectancy significantly predict changes in earnings per capita. Some might argue that the results with only initial levels of life expectancy are biased due to omitted variables. However, including initial levels of education and income should control for many of these omitted variables and the coefficient on life expectancy becomes larger and more significant. Table 6 shows that the long term impact on earnings per capita from initial levels of health at the state level is positive and significant.

Table 6. OLS: Dependent variable: Difference in log net earnings per capita (Panel, 1970 to 2000); Independent variables: Initial Levels 1970; State Level

	1	**2**	**3**	**4**	**5**
Log Life Expectancy 1970	-0.183 (0.997)	0.750 (1.479)	0.622 (1.528)	0.028 (1.428)	6.047 (1.256)**
Years of Schooling 1970	---	-0.094 (0.060)	-0.074 (0.065)	-0.046 (0.071)	-0.048 (0.044)
Log Earnings/cap 1970	---	---	-0.067 (0.164)	-0.063 (0.274)	-0.145 (0.164)
% 20-44 years old 1970	---	---	---	0.011 (0.020)	0.020 (0.013)
% 45-64 years old 1970	---	---	---	0.007 (0.029)	0.012 (0.018)
% 65-85 years old 1970	---	---	---	0.026 (0.021)	-0.0001 (0.015)
% Black 1970	---	---	---	---	0.008 (0.002)**
% Other Race 1970	---	---	---	---	-0.010 (0.001)**
Constant	1.149 (4.253)	-1.860 (5.902)	-0.885 (6.597)	0.590 (5.798)	-24.512 (4.957)**
1980	---	---	---	---	---
1990	---	---	---	---	---
2000	---	---	---	---	---
Number of Observations	51	51	51	51	51
Number of states	51	51	51	51	51

OLS regressions; robust standard errors in parentheses; * significant at 5%; ** significant at 1%

Table 7 reports a long difference regression with the change in the log of net earnings per capita at the merged county unit as the dependent variable. Log of net earnings per capita is differenced over two time periods (1970 to 2000). The independent variables in each regression are initial levels of each variable in the year 1970. Table 7 captures the long term impact (rather than contemporaneous effect) of health improvement on earnings per capita. The results indicate that initial levels of life expectancy in 1970 mostly lead to improvements in earnings per capita over the period 1970 to 2000 with a significant result in the final column. The final column shows that a 1% increase in life expectancy in the year 1970 leads to a 1.935% increase in net earnings per capita at the merged county unit level over the 30 year period 1970 to 2000. Interestingly, initial levels of years of schooling in 1970 do not lead to higher levels of earnings per capita. As in the state level results, being black in 1970 is positively correlated with earnings per capita over the next 30 years. A 1% increase in percent black in each county is significantly correlated with a 0.3% increase in net earnings per capita over the 30 year period.

Table 7. OLS: Dependent variable: Difference in log net earnings per capita (Panel, 1970 to 2000); Independent variables: Differenced (Panel, 1970 to 2000); County Level

	1	**2**	**3**	**4**	**5**
Initial Log Life Expectancy	0.161 (0.330)	0.796 (0.324)*	0.831 (0.325)*	1.070 (0.371)**	1.935 (0.269)**
Initial Years of Schooling	---	-0.049 (0.014)**	-0.000 (0.019)	-0.023 (0.016)	-0.006 (0.016)
Initial Log Earnings/cap	---	---	-0.209 (0.044)**	-0.283 (0.043)**	-0.294 (0.043)**
Initial % 20-44 years old	---	---	---	0.017 (0.004)**	0.018 (0.004)**
Initial % 45-64 years old	---	---	---	-0.007 (0.004)	-0.002 (0.004)
Initial % 65-85 years old	---	---	---	0.005 (0.006)	0.004 (0.005)
Initial % Black	---	---	---	---	0.003 (0.001)**
Initial % Other Race	---	---	---	---	-0.002 (0.001)
Constant	-0.385 (1.411)	-2.615 (1.340)	-1.303 (1.316)	-1.832 (1.358)	-5.719 (1.110)**
1980	---	---	---	---	---
1990	---	---	---	---	---
2000	---	---	---	---	---
Number of Observations	2826	2826	2826	2826	2826
Number of counties	2826	2826	2826	2826	2826

OLS regressions; robust standard errors, adjusted for clustering within state, in parentheses; * significant at 5%; ** significant at 1%

Table 8 reports the 2SLS estimates of the difference in difference equation with log of earnings per capita at the state level as the dependent variable. All regressions in Table 8 include data differenced over the period 1970 through 2000. Results for the all six 2SLS estimates in Table 8 indicate a negative, null relationship between life expectancy and earnings per capita. Education levels continue to have an important impact on earnings per capita with one extra year of schooling associated with an increase in earnings per capita in the range of 21.1% and 27.0%. The percent of 20-44 year olds in a state, as compared to the other population categories, is most predictive of earnings per capita. After including initial levels of life expectancy and initial levels of net earnings in the year 1970, nothing in the model predicts earnings per capita. Tobacco tax difference over the long period 1970-2000 is not a strong instrument as none of the F statistics have values greater than 10.0. First stage results can be requested from the author.

Table 8. 2SLS: Dependent variable: Long difference in log net earnings per capita (just 1970 to 2000); Independent variables: Long differenced (just 1970 to 2000); State Level

	1	**2**	**3**	**4**	**5**	**6**
Δ Log Life Expectancy	-7.009 (8.384)	-2.070 (6.240)	1.968 (2.903)	-0.665 (3.681)	-0.633 (3.464)	-29.418 (47.929)
Δ Years of Schooling	---	0.270 (0.051)**	0.207 (0.041)**	0.216 (0.044)**	0.211 (0.045)**	0.103 (0.249)
Log Life Expectancy 1970	---	---	---	---	-0.449 (0.673)	-5.015 (8.218)
Initial Log Earnings/cap	---	---	---	---	---	1.361 (1.735)
Δ % 20-44 years old	---	---	0.033 (0.012)**	0.045 (0.013)**	0.046 (0.014)**	0.202 (0.218)
Δ % 45-64 years old	---	---	-0.008 (0.011)	0.003 (0.013)	0.003 (0.012)	0.102 (0.148)
Δ % 65-85 years old	---	---	-0.020 (0.011)	-0.011 (0.012)	-0.012 (0.011)	0.057 (0.109)
Δ % Black	---	---	---	-0.001 (0.005)	-0.000 (0.004)	-0.007 (0.014)
Δ % Other Race	---	---	---	0.013 (0.006)*	0.014 (0.007)*	0.016 (0.029)
Constant	0.901 (0.630)	-0.019 (0.462)	-0.287 (0.220)	-0.250 (0.260)	1.670 (3.046)	9.453 (21.934)
2000	---	---	---	---	---	---
Number of Observations	51	51	51	51	51	51
Number of counties	51	51	51	51	51	51
F statistic	5.119	4.358	3.634	3.041	3.758	0.305

2SLS regressions with robust standard errors in parentheses; * significant at 5%; ** significant at 1%, IV for the difference in log life expectancy is the long difference in state level tobacco tax

Table 9 reports the 2SLS difference in difference estimations with the change in the log earnings per capita at the state level as the dependent variable. Each independent variable is also differenced. The data are differenced over four time periods (1970 to 2000) leaving three differenced time points in the analysis (1970 - 1980, 1980 - 1990, and 1990 - 2000). The results from Table 9 indicate a null relationship between life expectancy and contemporaneous earnings per capita at the state level. In this model, neither initial levels of life expectancy nor initial levels of earnings per capita are significant predictors of future earnings per capita. Although state tobacco tax differenced over each decade is a stronger instrument than state tobacco tax differenced over the period 1970 to 2000 the first stage results do not show F statistics greater than 10.0. First stage results can be requested from the author.

Table 9. 2SLS: Dependent variable: Difference in log net earnings per capita (Panel 1970 to 2000); Independent variables: Differenced (Panel 1970 to 2000); State Level

	1	**2**	**3**	**4**	**5**	**6**
Δ Log Life Expectancy	-4.059 (3.399)	-0.590 (2.417)	0.695 (2.322)	1.415 (2.202)	1.468 (2.049)	1.068 (2.287)
Δ Years of Schooling	---	0.319 (0.069)**	0.214 (0.051)**	0.213 (0.059)**	0.222 (0.060)**	0.224 (0.057)**
Initial Log Life Expectancy	---	---	---	---	0.405 (0.222)	0.395 (0.211)
Initial Log Earnings/cap	---	---	---	---	---	0.027 (0.034)
Δ % 20-44 years old	---	---	0.014 (0.009)	0.014 (0.008)	0.014 (0.008)	0.013 (0.008)
Δ % 45-64 years old	---	---	-0.009 (0.008)	-0.010 (0.008)	-0.011 (0.007)	-0.011 (0.008)
Δ % 65-85 years old	---	---	-0.020 (0.013)	-0.019 (0.007)**	-0.019 (0.007)**	-0.019 (0.007)**
Δ % Black	---	---	---	-0.008 (0.004)	-0.010 (0.005)*	-0.011 (0.005)*
Δ % Other Race	---	---	---	-0.008 (0.010)	-0.010 (0.011)	-0.013 (0.011)
Constant	0.241 (0.131)	-0.187 (0.110)	-0.202 (0.150)	-0.222 (0.123)	-1.956 (1.028)	-2.148 (0.935)*
1980	---	---	---	---	---	---
1990	-0.029 (0.063)	0.121 (0.044)**	0.165 (0.063)**	0.179 (0.056)**	0.166 (0.049)**	0.157 (0.055)**
2000	-0.018 (0.081)	0.210 (0.061)**	0.333 (0.125)**	0.362 (0.099)**	0.343 (0.088)**	0.330 (0.097)**
Number of Observations	153	153	153	153	153	153
Number of counties	51	51	51	51	51	51
F statistic	11.292	7.129	5.681	5.697	7.764	6.868

2SLS regressions with a full set of year dummies. Robust standard errors, adjusted for clustering within state, in parentheses; * significant at 5%; ** significant at 1%, IV for log life expectancy is differenced state level tobacco tax

The 2SLS difference in difference models are re-estimated using data at the county level for 2,826 merged county units. All regressions in Table 10 include data differenced over the period

1970 through 2000. Results for the all six 2SLS estimates in Table 10 indicate a negative, null relationship between life expectancy and earnings per capita. Education levels continue to have an important impact on earnings per capita with one extra year of schooling associated with an increase in income per capita in the range of 22.4% and 28.7%. First stage results can be requested from the author.

Table 10. 2SLS: Dependent variable: Long difference in log net earnings per capita (just 1970 to 2000); Independent variables: Long differenced (just 1970 to 2000); County Level

	1	**2**	**3**	**4**	**5**	**6**
Δ Log Life Expectancy	-5.879 (3.951)	-2.318 (2.154)	-2.669 (2.067)	-2.430 (2.007)	-2.589 (1.380)	-2.262 (1.969)
Δ Years of Schooling	---	0.287 (0.020)**	0.235 (0.019)**	0.226 (0.017)**	0.227 (0.016)**	0.224 (0.019)**
Log Life Expectancy 1970	---	---	---	---	0.115 (0.534)	0.303 (0.834)
Log Earnings/cap 1970	---	---	---	---	---	-0.034 (0.072)
Δ % 20-44 years old	---	---	0.014 (0.005)*	0.013 (0.005)*	0.014 (0.004)**	0.013 (0.005)**
Δ % 45-64 years old	---	---	0.025 (0.005)**	0.025 (0.005)**	0.025 (0.004)**	0.025 (0.004)**
Δ % 65-85 years old	---	---	-0.012 (0.006)*	-0.013 (0.005)*	-0.012 (0.004)**	-0.012 (0.004)**
Δ % Black	---	---	---	-0.002 (0.001)	-0.003 (0.001)**	-0.002 (0.001)
Δ % Other Race	---	---	---	0.002 (0.005)	0.002 (0.004)	0.002 (0.004)
Constant	0.721 (0.287)*	-0.118 (0.125)	-0.079 (0.091)	-0.077 (0.092)	-0.565 (2.350)	-1.062 (3.096)
2000	---	---	---	---	---	---
Number of Observations	2826	2826	2826	2826	2826	2826
Number of counties	2826	2826	2826	2826	2826	2826
F statistic	6.498	7.846	9.130	9.740	19.177	15.334

2SLS regressions with robust standard errors, adjusted for clustering within state, in parentheses; * significant at 5%; ** significant at 1%, IV for the difference in log life expectancy is the long difference in state level tobacco tax

Table 11 reports the 2SLS difference in difference estimations with the change in the log of net earnings per capita at the merged county unit as the dependent variable. Each independent variable is also differenced. The data are differenced over four time periods (1970 to 2000) leaving three differenced time points in the analysis (1970 - 1980, 1980 - 1990, and 1990 - 2000). The results from Table 11 indicate a mostly null relationship between life expectancy and contemporaneous earnings per capita at the county level except for the last column where a significant relationship is shown. In the last column the data show a 1% increase in life expectancy leads to a 4% increase in net earnings per capita. First stage results can be requested from the author.

Table 11. 2SLS: Dependent variable: Difference in log net earnings per capita (Panel 1970 to 2000); Independent variables: Differenced (Panel 1970 to 2000); County Level

	1	2	3	4	5	6
Δ Log Life Expectancy	0.576 (2.539)	2.922 (2.275)	3.245 (2.309)	3.474 (2.299)	2.603 (1.922)	3.931 (1.981)*
Δ Years of Schooling	---	0.202 (0.017)**	0.168 (0.018)**	0.158 (0.021)**	0.156 (0.021)**	0.159 (0.022)**
Initial Log Life Expectancy	---	---	---	---	0.823 (0.364)*	1.745 (0.462)**
Initial Log Earnings/cap	---	---	---	---	---	-0.202 (0.043)**
Δ % 20-44 years old	---	---	0.001 (0.003)	0.001 (0.003)	0.004 (0.003)	0.002 (0.003)
Δ % 45-64 years old	---	---	0.001 (0.003)	0.0003 (0.003)	0.002 (0.003)	0.005 (0.003)*
Δ % 65-85 years old	---	---	-0.019 (0.005)**	-0.020 (0.006)**	-0.017 (0.005)**	-0.018 (0.005)**
Δ % Black	---	---	---	-0.004 (0.003)	-0.006 (0.003)*	-0.002 (0.003)
Δ % Other Race	---	---	---	-0.004 (0.004)	-0.002 (0.003)	0.004 (0.005)
Constant	0.020 (0.112)	-0.257 (0.102)*	-0.220 (0.094)*	-0.220 (0.093)*	-3.711 (1.629)*	-5.823 (1.749)**
1980	---	---	---	---	---	---
1990	0.095 (0.074)	0.201 (0.070)**	0.209 (0.072)**	0.215 (0.070)**	0.166 (0.053)**	0.157 (0.049)**
2000	0.105 (0.084)	0.251 (0.075)**	0.223 (0.078)**	0.232 (0.077)**	0.174 (0.053)**	0.160 (0.047)**
Number of Observations	8476	8476	8476	8476	8476	8476
Number of counties	2826	2826	2826	2826	2826	2826
F statistic	41.237	39.644	40.845	42.885	51.288	58.589

2SLS regressions with a full set of year dummies. Robust standard errors, adjusted for clustering within state, in parentheses; * significant at 5%; ** significant at 1%, IV for log life expectancy is differenced state level tobacco tax; 2 observations are missing from the analysis because 1 county in North Dakota had negative net earnings in 1980 causing this county to lose 2 differenced time points (1970-1980 and 1980-1990) (La Moure, ND).

The results above show mixed results when examining the relationship between life expectancy and net earnings per capita at the state and county level. At the state level, when using OLS, the relationship between life expectancy and earnings per capita remains negative and insignificant using both the long difference and panel differenced models. The county level OLS shows a positive relationship between life expectancy and net earnings per capita and is even significant in the long difference model. The results are more consistent between the state and county levels using 2SLS where both the state and county level panel differenced models (over three decades) show a positive and even significant relationship between life expectancy and net earnings per capita (a significant relationship is found in the panel, differenced, county level model). Although not strong, the results above demonstrate some evidence in the US for a link between health and net earnings per capita.

Discussion

This paper examines the link from health to economic growth, measured with earnings per capita, at the state and county level in the United States (US). The analysis is important because to the author's knowledge this is the first time the relationship between health and economic growth has been examined at either level in the entire United States and because the results provide some evidence, although not consistently in all models, of a possible positive contemporaneous effect of health on earnings per capita, even after controlling for initial levels of life expectancy and net earnings per capita.

In Bloom, Canning and Fink's (2009) critique of Acemoglu and Johnson's (2007) results, they show that the negative sign on Acemoglu and Johnson's (2007) life expectancy coefficient can be reversed by including omitted variables such as initial levels of life expectancy and income per capita. Bloom, Canning and Fink (2009) argue that the negative relationship captured by Acemoglu and Johnson, besides being instrumented poorly, is measuring a contemporaneous relationship between health and economic growth which should be negative, as it is hard to argue that health has an immediate impact on life expectancy. They demonstrate that a positive and significant impact on income from health improvement is modeled most effectively using a lagged measure of health. They find that Acemoglu and Johnson's instrument loses all predictive power after including initial levels of life expectancy and GDP/capita.

Including initial levels of life expectancy and net earnings per capita does not change the contemporaneous relationship between life expectancy and net earnings per capita at the state or county level in the analysis above. After including lagged levels of health and net earnings per capita in the differenced panel 2SLS model estimations for both the state and the county, the sign on the coefficient of the change in life expectancy term remains positive (see last columns of Tables 9 and 11). The strength of the instrument used in the analysis above, tobacco tax, remains strong after including initial levels of life expectancy and net earnings per capita for the county level analysis, with F statistics above 10.0. In the state level analysis, after including lagged levels of health and net earnings per capita the instrument does lose some strength.

The ordinary least squares and two stage least squares models are re-estimated using levels, rather than differenced, data (results can be requested from the author). A similar pattern is observed using levels data: a stronger, more relationship between life expectancy and net earnings when other variables (education, age structure and race) as well as initial levels of life expectancy and net earnings are added to the model. However, the levels analysis does not show a significant relationship in the county panel model, as is seen in the county differenced panel model. Tobacco tax retains its strength as an instrument in the levels analysis at the county level.

Another question that is raised by the analysis above is the effect of population growth on income levels. Acemoglu and Johnson's main argument for the negative relationship seen between health and economic growth is that population size is growing faster than GDP. They argue that the "positive effect on population size [from increases in life expectancy] outweighs the increase in GDP" (Acemoglu and Johnson 2006; pg. 17). They support this statement by modeling their data with GDP as the dependent variable rather than GDP per capita, showing that when GDP (not per capita) is used as the dependent variable, a positive relationship between life expectancy and GDP is seen. The state level models are rerun in a similar manner with net earnings at the state and county levels as the dependent variable, rather than net earnings per capita (results can be requested from the author). The 2SLS regression results, after including initial levels of life expectancy and initial levels of net earnings, indicate a positive, insignificant elasticity between life expectancy and net earnings at both the state and county levels. These results show that in the US population size may not be outweighing the increase in income as positive results are seen without using per capita estimates for income but these results are not significant.

The impact of improvements in life expectancy on population size is also tested. Unlike the results by Acemoglu and Johnson, where life expectancy increases as population size increases the results at the state and county level in the US show a negative, insignificant relationship between life expectancy and population size. The 2SLS results show that neither estimates at the state or county level lead to a consistent positive or negative relationship between life expectancy and population size. This is interesting considering in cross country analyses life expectancy is significantly correlated with population growth. In the US, life expectancy is not driving population growth. Results can be requested from the author.

It might also be argued that tobacco tax is a weak instrument because there may be some other variables (apart from initial levels of life expectancy and income) omitted from the analysis that are biasing the results seen between tobacco taxes and income levels and tobacco taxes and life expectancy. In other words, it may be that certain states have increased their tobacco taxes in order to stimulate the economy and increase revenues regardless of the health status of their population. For example, places with high unemployment may be more likely to attempt to stimulate their economies with increases in tobacco taxes. The models are tested including unemployment rates at the state and county level in order to test if places with higher unemployment rates are biasing the relationship between tobacco tax and income and hence life expectancy and income per capita. There is some evidence at the state level for omitted variable bias due to unemployment as after including unemployment our instrument is not as strong at the state level. At the county level, tobacco tax remains a strong instrument after including county level unemployment and after including unemployment the relationship between life expectancy and income remains positive, although still not significant. Results can be requested from the author.

The results above estimate high returns to education, in the range of 15.6% to 30.9%. This figure is higher than has been estimated to higher education for the developing countries, 13%, but more similar to the return to higher education for Africa (28%), Asia (7%) and Latin America (26%). Card (1999) reviews the literature and shows that levels of individual schooling lead to between a 6-11% increase in levels of individual wages (Sianesi and Van Reenen 2003). The figure estimated in the results above may be higher than those found in the literature for three reasons. First, the estimations examine the link between years of schooling and wages and do not adjust for potential social costs to educating students at different levels (such as opportunity costs of teachers' time and other inputs) (Birdsall 1996). Secondly, the estimation in this paper uses aggregated figures of both years of schooling and wages at the state and county level not estimates of individual schooling and individual wages. Finally, education is not instrumented in the above estimation which may lead to higher returns to schooling due to omitted variable bias and potential reverse causality. Education is included in the models as a control factor and the results of the coefficient on education are not the main focus of this paper.

Ecological fallacy may be causing some of the results shown above. The relationship between life expectancy and net earnings per capita at the county level is instrumented by tobacco tax which is a state level variable. Using an instrument that is aggregated to a different level than the outcome is not a new concept and has been used in several well known instrumental variable analyses (Cawley et al. 2006). The precision of the estimates in the multi-level structured model are accounted for by clustering the standard errors within each state. Confounding at the county level is accounted for through differencing and other control factors, such as initial levels of earnings per capita and life expectancy. Confounding at the state level also needs to be accounted for. In order to account for this potential confounding at the state level, the 2SLS regressions are re-estimated to include a state time trend in order to control changes over time at the state level that might be impacting the relationship between life expectancy and net earnings. The 2SLS regressions including state time trends (results can be requested from the author) follow a similar pattern to the 2SLS results shown in Tables 10 and 11, where the differenced, county panel model remains significant at a 10% significance level.

Interestingly, the traditional conditional convergence models in Tables 6 and 7 predict a large and significant impact of life expectancy on net earnings per capita at both the county and state level. These results are comparable to that of Bloom, Canning, Sevilla (2004) who find using data from a over 100 countries and spanning the years 1960 to 2000 that a one-year increase in life expectancy increases output (Gross Domestic Product) by 4%. The results above find a 1%

increase in life expectancy over 10 years increases net earnings per capita by 1.9% at the county level and 6.0% at the state level.

This paper addresses a major question in the literature on health and economic growth: do the positive results realized when looking at health and economic growth across countries hold for data within a country, specifically the United States? Due to data availability, this question can be answered using data from 51 states in the US and 2,826 merged county units in the 51 states. The results indicate that the pattern between life expectancy and net earnings per capita is not as strong within the US as is seen across countries. Many of the estimations shown above show a null, even negative relationship between life expectancy and net earnings per capita in the US. Only after controlling for initial levels of life expectancy and initial levels of net earnings per capita is a slight positive, significant result demonstrated between life expectancy and net earnings per capita. This positive result is stronger using county level data than when using state level data.

References

Acemoglu, Daron, and Simon Johnson. Disease and Development: A Reply to Bloom, Canning, and Fink. MIT, September 2009.

Acemoglu, Daron, and Simon Johnson. "Disease and Development: The Effect of Life Expectancy on Economic Growth." Journal of Political Economy 115.6 (2007): 925-85.

---. "Disease and Development: The Effect of Life Expectancy on Economic Growth." National Bureau of Economic Research Working Paper Series No. 12269 (2006).

Ahmad, Sajjad. "Increasing Excise Taxes on Cigarettes in California: A Dynamic Simulation of Health and Economic Impacts." Preventive medicine 41.1 (2005): 276-83.

Andrews, D. W. K., and Stock J.H. "Testing for Weak Instruments in Linear IV Regression." Identification and Inference for Econometric Models: Essays in Honor of Thomas Rothenberg. Cambridge: Cambridge University Press, 2005.

Ashraf, Quamrul H., Ashley Lester, and David N. Weil. "When does Improving Health Raise GDP?" National Bureau of Economic Research Working Paper Series No. 14449 (2008).

Barker, DJP. Mothers, Babies and Health in Later Life. 2nd edition ed. Edinburgh, UK: Churchill Livingstone, 1998.

Barro, Robert J., and Xavier Sala-i-Martin. "Economic Growth and Convergence Across the United States." National Bureau of Economic Research Working Paper Series No. 3419 (1990).

Becker, Gary S., Michael Grossman, and Kevin M. Murphy. "An Empirical Analysis of Cigarette Addiction." American Economic Review 84.3 (1994): 396.

Beer Institute. Brewers Almanac., 2008.

Behrman, Jere R., and Mark R. Rosenzweig. "Returns to Birthweight." Review of Economics & Statistics 86.2 (2004): 586-601.

Bhargava, Alok, et al. "Modeling the Effects of Health on Economic Growth." Journal of health economics 20.3 (2001): 423-40.

Birdsall, Nancy. "Public Spending on Higher Education in Developing Countries: Too Much Or Too Little?" Economics of Education Review 15.4 (1996): 407-19.

Bleakley, Hoyt. Disease and Development: Comments on Acemoglu and Johnson., 2006.

---. Malaria Eradication in the Americas: A Retrospective Analysis of Childhood Exposure. Vol. Working Paper, CEDE/Los Andes, September 2006., 2007a.

Bleakley, Hoyt. "Disease and Development: Evidence from Hookworm Eradication in the American South." Quarterly Journal of Economics 122.1 (2007): 73-117.

Bloom, David E., David Canning, and Pia N. Malaney. Demographic Change and Economic Growth in Asia. Vol. CID Working Paper No. 015. Center for International Development at Harvard University:, May 1999.

Bloom, David E., David Canning, and Günther Fink. "Disease and Development Revisited." National Bureau of Economic Research Working Paper Series No. 15137 (2009).

Bloom, David E., David Canning, and Jaypee Sevilla. "The Effect of Health on Economic Growth: A Production Function Approach." World Development 32.1 (2004): 1-13.

Bloom, David E., and David Canning. "The Health and Wealth of Nations." Science 287.5456 (2000): 1207.

Bloom, David E., and Pia N. Malaney. "Macroeconomic Consequences of the Russian Mortality Crisis." World Development 26.11 (1998): 2073-85.

Bloom, David E., and Jeffrey G. Williamson. "Demographic Transitions and Economic Miracles in Emerging Asia." The World Bank Economic Review 12.3 (1998): 419-55.

Board of Equalization. "Cigarette and Tobacco Product Taxes." California State Board of Equalization Publication 93 (2009).

Bureau of Economic Analysis. Local Area Personal Income and Employment Methodology. US Department of Commerce:, 2008.

Cancer Research UK. "Lung Cancer Incidence and Smoking Trends, Great Britain, by sex, 1948-2005." <http://info.cancerresearchuk.org/images/gpimages/cs_lungproj_f4.1>.

Card, David. "The Causal Effect of Education on Earnings." Handbook of Labor Economics. Ed. O. Ashenfelter and Card D., 1999.

Case, Anne, Angela Fertig, and Christina Paxson. "The Lasting Impact of Childhood Health and Circumstance." Journal of health economics 24.2 (2005): 365-89.

Cawley, John, David C. Grabowski, and Richard A. Hirth. "Factor Substitution in Nursing Homes." Journal of health economics 25.2 (2006): 234-47.

Chaloupka, Frank J., and Rosalie Liccardo Pacula. "Sex and Race Differences in Young People's Responsiveness to Price and Tobacco Control Policies." Tobacco control 8.4 (1999): 373-7.

Chaloupka, Frank J., and KE Warner. "The Economics of Smoking." The Handbook of Economics. Ed. J. Newhouse and A. Culyer. Amsterdam, The Netherlands: Elsevier Science, 1999.

Chaloupka, Frank J., and Henry Wechsler. "Price, Tobacco Control Policies and Smoking among Young Adults." Journal of health economics 16.3 (1997): 359-73.

Cosby, Arthur, et al. *Racial Disparities in the Cardiovascular Health of Mississippians 2005* . Social Science Research Center, Mississippi State University, 2005.

Doll, R., and AB Hill. "Mortality of British Doctors in Relation to Smoking: Observation on Coronary Thrombosis." National Cancer Institute Monographs 19 (1966): 205--68.

Doll, R., et al. "Mortality in Relation to Consumption of Alcohol: 13 Years' Observations on Male British Doctors." BMJ 309.6959 (1994): 911-8.

Doll, Richard, and A. B. Hill. "Smoking and Carcinoma of the Lung." Br Med J 2.4682 (1950): 739-48.

Doll, Richard, and Austin Bradford Hill. "Mortality in Relation to Smoking: Ten Years' Observations of British Doctors." Br Med J 1.5396 (1964): 1460-7.

Doll, Richard, et al. "Mortality in Relation to Smoking: 50 Years' Observations on Male British Doctors." BMJ 328.7455 (2004): 1519.

Emery, Sherry, et al. "Simulated Effect of Tobacco Tax Variation on Latino Health in California." American Journal of Preventive Medicine 21.4 (2001): 278-83.

Fogel, RW. The Escape from Hunger and Premature Death, 1700-2100: Europe, America and the Third World. Cambridge, UK: Cambridge University Press, 2003.

---. "In Handbook of Population and Family Economics." Handbook of Population and Family Economics. Ed. MR Rosenzweig and O. Stark. Vol 1A ed. Amsterdam: Elsevier Science, 1997. 433-481.

Gluckman P, and Hanson M. Mismatch: Why our World no Longer Fits our Bodies. Oxford: Oxford University Press, 2006.

Gluckman, PD, and Hanson M. The Fetal Matrix: Evolution, Development, and Disease. Cambridge, UK: Cambridge University Press, 2005.

Heckman, James J. "The Economics, Technology, and Neuroscience of Human Capability Formation." Proceedings of the National Academy of Sciences 104.33 (2007): 13250-5.

Hoddinott, John, et al. "Effect of a Nutrition Intervention during Early Childhood on Economic Productivity in Guatemalan Adults." Lancet 371.9610 (2008): 411-6.

Jaeger, David A. "Reconciling the Old and the New Census Education Questions: Recommendations for Researchers " Journal of Business and Economic Statistics 15.3 (1997): 300.

Jamison, DT, LJ Lau, and J. Wang. "Health's Contribution to Economic Growth in an Environment of Partially Endogenous Technical Progress." *Health and Economic Growth: Findings and Policy Implications*. Ed. G. Lopez-Casasnovas and Rivera, B, Currais, L. Cambridge, MA: MIT Press, 2005. 67-91.

Kaplan, Robert M., et al. "Simulated Effect of Tobacco Tax Variation on Population Health in California." American Journal of Public Health 91.2 (2001): 239-44.

---. "Simulated Effect of Tobacco Tax Variation on Population Health in California." American Journal of Public Health 91.2 (2001): 239-44.

Kaplan, Robert M., John P. Anderson, and Cameron M. Kaplan. "Modeling Quality-Adjusted Life Expectancy Loss Resulting from Tobacco use in the United States." Social Indicators Research 81.1 (2007): 51.

Kawachi, Ichiro, et al. "Smoking Cessation in Relation to Total Mortality Rates in Women: A Prospective Cohort Study." Annals of Internal Medicine 119.10 (1993): 992-1000.

Levy, David T., K. Michael Cummings, and Andrew Hyland. "Increasing Taxes as a Strategy to Reduce Cigarette use and Deaths: Results of a Simulation Model." Preventive medicine 31.3 (2000): 279-86.

Moore, Michael J. "Death and Tobacco Taxes." RAND Journal of Economics 27.2 (1996): 415-28.

Murray, Christopher J. L., et al. "Eight Americas: Investigating Mortality Disparities Across Races, Counties, and Race-Counties in the United States." PLoS Med 3.9 (2006): e260.

National Cancer Institute. The Impact of Cigarette Excise Taxes on Smoking among Children and Adults: Summary Report of a National Cancer Institute Expert Panel. Proceedings of the an- Nual Information Exchange Conference of ASSIST (America Stop Smoking Intervention Study). San Francisco, CA:, 1994.

National Center for Health Statistics, Centers for Disease Control, and US Department of Health and Human Services. Health, United States, 2006 ., 2006.

National Center for Health Statistics. Compressed Mortality File, 1999-2004 (Machine Readable Data File and Documentation, CD-ROM Series 20, no. 1A, 2E and 2J). Hyattsville, Maryland:, 2006.

Orzechowski, and Walker. *Tax Burden on Tobacco*

. US: Economic Research Service, USDA, 2006.

"Projected Smoking-Related Deaths among Young--United States." MMWR: Morbidity & Mortality Weekly Report 45.44 (1996): 971.

"Response to Increases in Cigarette Prices by race/ethnicity, Income, and Age Groups--United.." MMWR: Morbidity & Mortality Weekly Report 47.29 (1998): 605.

Rosenberg, L., et al. "The Risk of Myocardial Infarction After Quitting Smoking in Men Under 55 Years of Age." N Engl J Med 313.24 (1985): 1511-4.

Rosenberg, L., J. R. Palmer, and S. Shapiro. "Decline in the Risk of Myocardial Infarction among Women Who Stop Smoking." N Engl J Med 322.4 (1990): 213-7.

Ruser, John, Adrienne Pilot, and Charles Nelson. Alternative Measures of Household Income: BEA Personal Income, CPS Money Income, and Beyond . US Bureau of Economic Analysis and US Census Bureau:, 2004.

Sachs, Jeffrey D., and Andrew M. Warner. "Sources of Slow Growth in African Economies." Journal of African Economies 6.3 (1997): 335-76.

Sachs, Jeffrey, and Pia Malaney. "The Economic and Social Burden of Malaria." Nature 415.6872 (2002): 680.

Shopland, Donald R. "Tobacco use and its Contribution to Early Cancer Mortality with a Special Emphasis on Cigarette Smoking." Environmental health perspectives 103., Supplement 8 (1995): 131-42.

Sianesi, Barbara, and John Van Reenen. "The Returns to Education: Macroeconomics." Journal of Economic Surveys 17.2 (2003): 157-200.

Staiger, Douglas, and James H. Stock. "Instrumental Variables Regression with Weak Instruments." Econometrica 65.3 (1997): 557-86.

"Tobacco use-United States, 1990-1999." MMWR: Morbidity & Mortality Weekly Report 48.43 (1999): 986-93.

US Department of Health and Human Services, CDC, and Office on Smoking and Health. The Health Consequences of Smoking: A Report of the Surgeon General. US:, 2004.

US Department of Health and Human Services. The Health Benefits of Smoking Cessation: A Report of the US Surgeon General 1990., 1990.

van Baal, Pieter H. M., et al. "Increasing Tobacco Taxes: A Cheap Tool to Increase Public Health." Health Policy 82.2 (2007): 142-52.

Wilson, N., et al. "How Much Downside? Quantifying the Relative Harm from Tobacco Taxation." Journal of epidemiology and community health 58.6 (2004): 451-4.

Wynder, EL, and EA Graham. "Tobacco Smoking as a Possible Etiologic Factor in Bronchiogenic Carcinoma." JAMA 143 (1950): 329--36.

Young, Andrew T., Matthew J. Higgins, and Daniel Levy. Heterogeneous Convergence. Vol. Working Paper., 2006.