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Assessing the Productive Efficiency of US Health Care: Comparison of Analytical Methods

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Section I: Introduction

Recent health care policy reforms have prompted an increased interest in the efficiency of the US health care system. Comparing the US to 23 other Organisation for Economic Co-operation and Development (OECD) member countries at similar levels of development, one finds that the health expenditure of the US far exceeds that of its peers. In 2006, the US spent approximately 15.8% of its GDP on health care, more than any other OECD country and considerably larger than the 9.1% average of its peer nations (OECD Health Data, 2009). The important question to ask then is whether or not this additional expenditure pays off in higher health outcomes. Unfortunately, based on average life expectancies alone, this does not seem to be the case. The US had the lowest female and male life expectancies at birth of the same 24 OECD countries in 2006. The US female life expectancy at birth was 80.7 years (tied with Denmark), falling 2.1 years below the average of 82.8 years; the US male life expectancy at birth was 75.4 years, again, falling 2 years below the average of 77.4 years (OECD Health Data, 2009). This raw and partial evidence suggests that the US health care system may be performing inefficiently compared to its peer nations.

Of course, there are many factors outside of health care that effect life expectancy at birth such as lifestyle choices regarding the consumption of tobacco, alcohol, and in-nutritious foods, pollution levels, external causes of death from accidents or crime, and socioeconomic factors such as GDP per capita or average education levels (Joumard, Isabelle et al., 2008). It is therefore not correct to assume that inefficient health care is the sole cause of low life expectancies in the US without taking these other factors into account. Therefore, the purpose of my research is to analyze the efficiency of the US health care system factoring in these outside effects. I accomplish this through a panel data analysis of 24 OECD countries (including the US) spanning the years 1960 to 2006. I first use an Ordinary Least Squares (OLS) regression of a Cobb-Douglas production function to rank the countries based upon country dummy variable coefficients. I then extend upon my econometric methods by utilizing a time invariant frontier model to generate efficiency estimates. I improve upon previous estimates by utilizing the most recent data available, including better and more specific proxies for certain variables, and only including countries whose performance is truly comparable to that of the US by removing low performing outliers that fall into a separate efficiency and income bracket.

The format of my paper is as follows: Section II provides a review of previous literature on the topic of health care system efficiency, Section III summarizes the econometric methods utilized, Section IV outlines my data and empirical model, Section V reports my results, Section VI offers a summation of my findings and Section VII suggests potential avenues for further research.

Section II: Literature Review

Several studies have sought to compare the efficiency of health care systems of OECD countries in recent years. Most empirical studies have focused on assessing and comparing the efficiency of all OECD countries without specific attention to the relative performance of a particular nation. For this reason, most studies include all OECD countries for which the desired variables are available over the desired period. Looking at the efficiency of all OECD nations however, ignores differences in income and health outcomes that place certain nations in a separate peer group. GDP per capita among the OECD countries in 2006 ranged from a little over 7,000 US$ to a little over 72,000 US$. One cannot reasonably expect nations at such different levels of development to have comparable health outcomes.

A recent OECD working paper used several measures to analyze the efficiency of OECD nations and found that the countries could be separated into three different groups based on health outcome results. The lowest group included the Czech Republic, Hungary, Mexico, Poland, the Slovak Republic, and Turkey (Joumard et al., 2008). This group had average life expectancies at birth that were four to five years lower than the average of the second performance group and had over seven more infant mortalities per 1,000 live births on average than the second performance group (Joumard et al., 2008). The differences between the second and first performance groups were much less extreme with differences in average life expectancies of about two years and differences in average infant mortality rates of less than one death per 1,000 live births (Joumard et al., 2008). The results of this study confirm that not all OECD countries are comparable when considering health outcomes.

Health Care Outputs

A major matter of debate in health system efficiency analysis is what variable is best to use as the output of a health care production function. Most studies contend that health outcomes are better to use than measures of health care activity such as the number of physician visits or CT scans, etc. performed (Garber and Skinner, 2008; Joumard et al., 2008; Or, Wang, and Jamison, 2004). Or, Wang and Jamison suggest that focusing efficiency analysis on measures of health care activity doesn’t look at the goal of health care, which is to improve patient health (2004). There is also a general consensus that health care activity analysis leads to negative incentives of overuse in health care as countries try to increase the quantity rather than the quality of health care provided. Even though it is largely agreed upon that health outcomes are a more accurate and appropriate measure of health care outputs, the vast array of potential measures of health outcomes leads to questions of which measure is best to use.

Measures of mortality rates and average life expectancies are the most widely available measures of overall health outcomes to date. The main problem with these measures however is the lack of specificity as to the inputs that go into them. A person's life expectancy is determined by many factors outside of health care such as lifestyle choices, pollution, and external causes like accidents and murder. It is difficult to separate the effects of these non-health-care-related components from the effects of health care. Several studies have thus looked at specific case studies of survival rates after or treatment of specific diseases (Preston and Ho, 2009). While these measures provide strong data on the effectiveness of specific health care treatments across countries, they cannot be expected to provide information on the overall efficiency of a health care system (Joumard et al., 2008). Therefore, despite the over-inclusiveness of mortality measures, most studies find that they are the best proxies of health outcomes currently available (Joumard et al., 2008; Or, Wang, and Jamison, 2004). By controlling for as many of the non-health-care-related inputs to life expectancy as possible, one can hope to ascertain a fairly accurate picture of the specific effects of the health care industry on patient life expectancy.

Health Care System Inputs

Studies vary in their choices of medical inputs as well. Most use either the number of physicians, hospital beds, or CT scanners as physical measures of inputs or use total, public, or private health expenditure as monetary measures of inputs, but few have used both physical and monetary measures simultaneously. Physical and monetary input measures are generally seen as substitute proxies for health care inputs. For example, Wang, Jamison, and Or use the number of practicing physicians per 1,000 people because they did not feel that adequate measures of health expenditure were available (2004). Joumard et al. run separate regressions using the number of practicing physicians in one set of regressions and total health expenditure in the other set

(2008). Joumard et al. claim that increases in total health expenditure leads to more practicing physicians, but this statement only holds under the assumption that the wages paid to physicians are equal across countries, which is not the case. An increase in total expenditure of 155,000 US$ would buy Germany two more physicians while it would not even pay for one extra physician in the United States according to the average physician incomes reported by Garber and Skinner from the OECD 2007 Health Data (2008). It therefore seems acceptable to use the number of practicing physicians as a proxy for labor inputs and total health expenditure as a proxy for other health care inputs as well as for the emphasis placed on healthcare by each country.

Socioeconomic and Environmental Controls

The most common socioeconomic and environmental control variables used in recent studies have been pollution, education levels, and GDP per capita (Joumard et al., 2008; Or, Wang, and Jamison, 2004). Air pollution, particularly in the form of Nitrogen Oxide, Sulfur Oxide, and Carbon Monoxide, has been found to create respiratory and cardiovascular issues, sometimes resulting in serious ailments or even death, in high concentrations (Chen et al., 2007; Leslie et al., 1978). It is possible then, that low concentrations of these toxins associated with ambient levels of air pollution could also have negative effects. Unfortunately, measures of pollution levels of these chemicals have only been collected since 1990 which makes their utilization in a time series analysis difficult (OECD 2009 Health Data).

GDP per capita and average education levels have also been found in previous studies to have a significant impact on health outcomes. Although education has been found to have a positive correlation to average life expectancies, the direction of causation is currently under debate (Joumard et al., 2008). Measures of educational attainment are also not widely available over time limiting their use in panel data analyses. GDP per capita has been found to be positively linked to health outcomes as well (Joumard et al., 2008; Or, Wang, Jamison, 2004). Countries with higher GDP per capita levels can afford better medical technology and pharmaceuticals which contribute positively to health outcomes. Citizens of high income countries are also more likely to have access to sanitary living conditions such as clean water, plumbing, and waste disposal systems. These factors along with many others cause higher GDP per capita levels to be positively correlated to health outcomes and the long running collection of income data among developed countries make this variable useful in panel data analyses (OECD 2009 Health Data).

One demographic variable that has not been considered in many previous studies is the age dependency ratio of a nation. Age dependency is the number of individuals who are 14 and younger or 65 and older divided by the number of individuals who are 15 to 64 (OECD Health Data, 2009). It thus measures the number of people needing assistive care versus those who must provide that care. A high age dependency ratio could increase the burden on health care systems as individuals of dependent age tend to have lower immune systems and are therefore more susceptible to contracting diseases. It therefore seems likely that a country with a high age dependency ratio could experience lower levels of health and thus, lower life expectancies.

Lifestyle Controls

Common lifestyle controls utilized in previous literature are tobacco and alcohol consumption along with diet and exercise (Joumard et al., 2008; Or, Wang, and Jemison, 2004). A problem area in recent studies involves the proxies used for diet and exercise. Or, Wang, and Jamison completely neglect this variable in their study (2004) and Joumard et al. use the number of fruits and vegetables consumed as a proxy for diet and exercise (2008). However, Joumard et al. have problems with the significance and robustness of the variable due to time lag issues. Other studies have also found that Fruit and Vegetable intake has a significant effect on weight gain only when it can be lagged over a period longer than four years (Buijsse et al., 2009). A person's diet now is likely to have stronger effects on her future health than it does on her current health. An overweight and diabetic individual who has consumed unhealthy foods and exercised little throughout her life but has recently begun to improve her diet through the increased consumption of fruits and vegetables is unlikely to see a change in her health status for some time. Simply measuring the consumption of fruit and vegetables does not account for these lagged effects.

Obesity is a much better proxy for diet and exercise since it measures the current negative health effects of an extended period of poor diet and exercise. However, differences in measurement techniques among various nations make this variable unusable in current studies. Because the US has high obesity rates compared to the other nations for which the data are available (OECD 2009 Health Data), it is imperative to take diet and exercise into consideration in order to get an accurate measure for health care efficiency. Sugar consumption is not as commonly considered but could also have negative effects on health outcomes and may be a better proxy for overall eating habits than fruit and vegetable consumption. One study looks at the effects of consuming sugar-sweetened soft drinks on weight gain and finds some evidence for increased weight gain in women over extended periods of time from increased consumption (Nissinen et al., 2009). An individual with a high sugar intake may be more likely to have a poor diet overall, and a poor diet can lead to many negative health effects including diabetes and cardiovascular issues (Buijsse et al., 2009).

Section III: Methods

The Basic Model

I use a Cobb-Douglas production function to analyze the efficiency of the US health care system compared to its peer nations. A production function allows me to assess the efficiency with which a nation uses its health care inputs to produce health outputs. A Cobb-Douglas production function is of the generic form

$$Y = AL^{B_1}K^{B_2}$$

where Y represents output, L represents labor inputs, K represents capital inputs, and A is a technological parameter. In the context of health care efficiency, the theoretical model that I regress is

$$Health\ Outcomes = \alpha(L)^{\beta_1}(K)^{\beta_2}(socioeconomic\ controls)^{\beta_3}(lifestyle\ controls)^{\beta_4}$$

where socioeconomic controls include demographic information as well as institutional parameters and lifestyle controls include tobacco and alcohol use along with diet and exercise. Representing health outcomes as HO, socioeconomic controls as SC, and lifestyle controls as LC, and transposing the equation into log linear form for the sake of estimation, we have

$$\ln HO_{it} = \alpha + \beta_1 \ln L_{it} + \beta_2 \ln K_{it} + \beta_3 \ln SC_{it} + \beta_4 \ln LC_{it} + \varepsilon_{it}$$

where ε_{it} is the error term of country *i* in time *t*.

OLS Regressions with Country Dummy Coefficients

In my initial analysis, I run OLS regressions of the basic form above, including country dummy variables to pick up country-specific differences in health outcomes. In this analysis, the coefficients of the descriptive independent variables are not as important as the coefficients of the country dummy variables. These coefficients indicate the differences in health outcomes between countries that cannot be explained by variations in the control variables and can thus be used as estimates of efficiency.

By making the US the excluded country in the regressions, significant coefficients of the dummy variables can be taken to indicate differences in health outcomes from those of the US due to inefficiency. A positive significant coefficient for a given country dummy indicates that that country has higher health outcomes than those of the US holding all other factors in the model constant. Variables with negative significant coefficients experience lower health outcomes than those of the US holding other factors constant. Insignificant coefficients indicate that there is not a significant difference between the health outcomes of the given country and those of the US. The countries can then be ranked based on the magnitude and significance of their country dummy coefficients to indicate their level of productivity in health care. The highest ranked country is considered to be performing at maximum efficiency. It is then assumed that all countries lying below the highest in rank could improve their health outcomes while maintaining the same levels of inputs by increasing their productivity.

This form of analysis has the drawback that country dummy variables pick up all effects not controlled for in the model, not just inefficiency. To account for this, I try to include as many control variables as possible. I also conduct further analyses that are more technically sound in order to compare my results to those of the OLS regressions. The method I choose to enact for further analysis is a time invariant frontier model.

Stochastic Frontier Analysis

Most forms of econometric analysis look primarily at the size and significance of the coefficients of the independent variables in the model along with the ability of the model to explain changes in the dependent variable. The residual is usually only considered enough to ensure that it is normally distributed and not serially correlated. In Stochastic Frontier Analysis (SFA) however, the residual becomes the most important part of the regression process (Jacobs, Smith, and Street, 2006). SFA, which is primarily used to analyze production functions, assumes that all or part of the residual is due to inefficiency. The most basic form of this analysis, called corrected ordinary least squares (COLS), assumes that the entire residual is due to inefficiency rather than model error (Jacobs, Smith, and Street, 2006). The country with the largest positive residual is assumed to be performing at 100% efficiency. The line of best fit is then shifted up to run through this maximum efficiency country, generating a production frontier. The other countries will all be inside this frontier and can be ranked according to how far inside each country lies (Jacobs, Smith, and Street, 2006).

Because no econometric model is without error, the model residual should really not be considered to be entirely due to inefficiency. Therefore, several more advanced methods have been developed in order to adjust for random error. In advanced SFA, it is assumed that the residual has two main components, one due to random model error, and one due to inefficiency (STATAXT). There have been many methods developed to dissect the residual into these two components. In almost all cases, the components are broken down by assuming that the random error term is normally distributed and then by placing various constraints on the distribution of the inefficiency term.

Using panel data helps in the estimation of inefficiency by providing multiple data points for each country, thereby providing better estimates for both the inefficiency term and explanatory variables included in the model (Jacobs, Smith, and Street, 2006). One of the simplest advanced SFA methods available for panel data assumes that the inefficiency term does not vary over time (Jacobs, Smith, and Street, 2006). This assumption can be challenged since increases in technology over time often improve efficiency; however, further analyses are beyond the scope of this paper. Time invariant SFA assumes that the random component of the error term is normally distributed with zero mean and that the inefficiency term has a truncated normal distribution (STATAXT). Efficiency estimates are generated from the broken down inefficiency term, signifying each country's variation from the estimated production frontier. Countries can then be ranked based on their estimated levels of efficiency (Jacobs, Smith, and Street, 2006). SFA improves upon the OLS method because it does not rely upon country dummy variables to generate efficiency estimates and because it better utilizes the available panel data.

Section IV: Data

My data come from the OECD 2009 Health Data set. Table 1 lists the 30 OECD member countries ranked first by GDP per capita and then by average life expectancies of both females and males at birth. The countries in bold are the ones included in the study. I eliminate the six countries mentioned in Section II from my analysis since their performance has been found to be incomparable to that of the other nations included in the study. Table 1 also clearly displays that these nations are fundamentally different, both in their income levels and health outcomes, than the included nations. Furthermore, the average GDP per capita of the 24 OECD countries in the analysis was 40,188 US$ in 2006 which is comparable to the 43,904 US$ average GDP per capita of the US from the same year. This indicates that the nations included in the study represent countries at comparable development levels, in terms of GDP per capita, to that of the US (OECD 2009Health Data).

Table 1: OECD Countries Sorted by GDP, LEFB, and LEBM

Country	GDP per capita	LEFB	LEMB	Sorted by LEFB	Sorted by LEMB
NORW	72,282	82.9	78.2	**JAPAN**	**ICE**
LUX	67,932	81.9	76.8	**SPAIN**	**SWITZ**
ICE	54,672	83.0	79.4	**SWITZ**	**JAPAN**
IRE	52,354	82.2	77.4	**ITAL**	**AUS**
SWITZ	52,062	84.2	79.2	**FRAN**	**SWED**
DEN	50,366	80.7	76.1	**AUS**	**ITAL**
US	43,904	80.7	75.4	**FIN**	**CAND**
SWED	43,284	82.9	78.7	**ICE**	**NORW**
NETH	41,289	81.9	77.6	**CAND**	**NEW**
UK	40,403	81.7	77.3	**NORW**	**SPAIN**
FIN	39,636	83.1	75.9	**SWED**	**NETH**
CAND	39,315	83.0	78.4	**AUST**	**IRE**
AUST	38,833	82.7	77.1	**GERM**	**UK**
AUS	37,980	83.5	78.7	**KOR**	**FRAN**
BELG	37,733	82.3	76.6	**BELG**	**GERM**
FRAN	35,751	84.1	77.2	**PORT**	**AUST**
GERM	35,231	82.4	77.2	**IRE**	**GRE**
JAPAN	34,144	85.8	79.0	**NEW**	**LUX**
ITAL	31,774	84.2	78.5	**GRE**	**BELG**
SPAIN	27,863	84.4	77.7	**LUX**	**DEN**
NEW	25,742	82.2	78.0	**NETH**	**FIN**
GRE	23,904	82.0	77.1	**UK**	**KOR**
KOR	19,707	82.4	75.7	**DEN**	**PORT**
PORT	18,355	82.3	75.5	**US**	**US**
CZEC	13,880	79.9	73.5	CZEC	CZEC
HUN	11,226	77.4	69.0	POL	MEX
SLOV	10,364	78.2	70.4	SLOV	TURK
MEX	9,016	77.2	72.4	HUN	POL
POL	8,967	79.6	70.9	MEX	SLOV
TURK	7,268	75.3	71.1	TURK	HUN

Health Care Outputs

As a proxy for health outcomes, I run separate regressions using the average life expectancies of men and women both at birth and at age 60 since a large portion of health expenditure is spent on senior citizens (Joumard et al., 2008).

Health Care System Inputs

I use the number of practicing physicians as well as total health expenditure as measures of health care inputs for the reasons stated in the literature review. I run separate regressions using the number of practicing general practitioners and the total number of practicing physicians as the proxy for labor. I do this because of the growing international concerns that there will be shortages of general practitioners in the near future. It is possible that the ratio of general practitioners to specialists contributes significantly to improving the health outcomes as well as the cost effectiveness of a health care system. Thus, analyzing the effects of total physicians on health outcomes as opposed to the specific effects of the number of general practitioners could indicate what the more important factor in improving health outcomes is: increasing the total number of physicians without regard to whether they are general practitioners or specialists, or particularly increasing the number of general practitioners.

Socioeconomic and Environmental Controls

As socioeconomic controls, I include GDP per capita and educational attainment at the secondary level, both of which have been found to be significant in previous studies. I also include the age dependency ratio of each nation in order to compensate for demographic differences in the age distribution of various populations that could affect health outcomes. I do not include measures for institutional differences in health care systems because it is too difficult to disentangle the combinations of institutional frameworks enacted by individual countries (Joumard et al., 2008). As environmental controls, I utilize measures of ambient levels of air pollution in the form of sulfur oxide, nitrogen oxide, and carbon monoxide.

Lifestyle Controls

As lifestyle controls, I include tobacco, alcohol, and sugar consumption. To correct for missing data in tobacco consumption, linear regressions are run analyzing changes in consumption over time and the fitted values from the regressions were used in place of the actual data. The available measure of sugar consumption only takes into account the consumption of refined sugars and does not include artificial sweeteners or high fructose corn syrup. While this proxy neglects a large portion of sweetener consumption, at least in the US, that also has negative health effects; the consumption of refined sugar alone has been found to lead to numerous health issues, and so gives some indication of the negative health effects of a poor diet.

Empirical Model

My empirical model is as follows:

$$\ln LE_{it} = \alpha + \beta_1 \ln Phys_{it} + \beta_2 \ln HealthExp_{it} + \beta_3 \ln Tob_{it} + \beta_4 \ln Alc_{it} + \beta_5 \ln Sugar_{it} + \beta_6 \ln AgeDep_{it} + \beta_7 \ln Secondary_{it} + \beta_8 \ln Pollution_{it} + \beta_9 \ln GDP_{it} + \beta_{10} CountryDummies + \varepsilon_{it}$$

The variable *Phys* indicates the total number of practicing physicians and the number of practicing general practitioners in separate regressions. *LE* indicates life expectancy at birth and at age 60 for both men and women with separate regressions run for each. Pollution indicates separate variables for nitrogen oxide, sulfur oxide, and carbon monoxide. I run separate regressions including and excluding *Sugar* in order to assess the differences in the efficiency estimates of the US when taking diet and exercise into account. *CountryDummies* represents separate dummy variables for each country with the US as the excluded case. The brunt of my initial analysis will be formed from the values of these coefficients. Table 2 provides the descriptive statistics of my dependent and independent variables.

Table 2: Descriptive Statistics

Variable	Description	n	Mean	Std. Dev.	Min	Max
Dependent Variables						
LEFB	Life expectancy of females at birth (Years)	1010	78.293	3.4539	53.7	86.0
LEF60	Life expectancy of females at age 60 (Years)	991	22.078	2.0830	17.5	28.1
LEMB	Life expectancy of males at birth (Years)	1010	72.083	3.7486	51.1	79.7
LEM60	Life expectancy of males at age 60 (Years)	996	17.989	1.9989	12.7	22.6
Independent Variables						
Phys (+)	Total Practicing Physicians (Density per 1,000 people)	843	2.1845	.89337	.50	5.35
GenPrac (+)	Practicing General Practitioners (Density per 1,000 people)	592	.8839	.45347	.19	2.12
HealthExp (+)	Total expenditure on health (% of GDP)	961	7.150	2.1376	1.5	16.0
Nitrogen (-)	Total nitrogen oxide emissions (kg per capita)	383	40.65	22.634	12	115
Sulfur (-)	Total sulfur oxide emissions (kg per capita)	383	28.47	27.318	2	141
Carbon (-)	Total carbon monoxide emissions (kg per capita)	383	135.19	105.638	17	548
GDP (+)	GDP per capita (US$ exchange rate)	1097	14789.45	13400.25	276	82520
Second (+)	Ed. attainment at upper secondary level (% population)	234	41.09	12.615	10	64
AgeDep (-)	Age dependency ratio (Pop 0-14 & 65+ / Pop 15-64 yrs old, %)	1133	53.721	7.6283	38.8	88.8
Alcohol (-)	Alcohol consumption of those 15+ (liters per capita)	1018	10.421	3.6635	2.5	20.8
Tobacco (-)	Tobacco consumption (% population who smoke daily)	503	31.793	9.0686	14.5	61.0
Sugar (-)	Sugar consumption (kilos per capita)	989	41.972	11.4483	1.6	71.9

Section V.I: OLS Regression Results

The full results of the OLS regressions are listed in Tables A1 and A2 in the appendix. Greece, Japan, Korea, Luxembourg, and Spain are removed from the analysis due to data availability, leaving 19 OECD countries, including the US, in the data set.

The regressions including *LnPhys* as the variable for labor (Table A1) have less descriptive merit than those including *LnGenPract* (Table A2). The coefficients for sugar consumption (when included) and health expenditure in the regressions run with *LnPhys* were almost always found to be insignificant and/or to have the incorrect sign. The total number of physicians itself was also found to be insignificant or to have the wrong sign. These results support the hypothesis that the number of general practitioners has a more significant impact on patient health outcomes than the total number of physicians alone. For these reasons, the results from the regressions including *LnPhys* have been excluded from further analysis. The results can be seen in Table A2 in the appendix. The results discussed here only include results from the regressions run with *LnGenPract* as the indicator for labor.

The number of general practitioners has a positive significant impact on the life expectancies of females both at birth and at age 60. The number of general practitioners only has a significant impact on male life expectancies when sugar consumption is included in the model. As expected, total health expenditure has a significant positive impact on the life expectancies of both women and men at birth and at age 60. The significance of both variables suggests that it is acceptable to use the number of general practitioners as a proxy for labor along with total health expenditure as a proxy for other health inputs simultaneously.

GDP per capita has a positive impact on the life expectancies of females, but, surprisingly, is negatively correlated with the life expectancies of males. This could be explained by changes in diet and daily physical exertion that accompany increased income levels. Because white-collar jobs often pay higher wages than more labor intensive trades, it is possible that men with higher incomes are less active on a daily basis than those at lower income levels. Men with higher incomes are also able to hire workers to perform manual labor at home like construction projects and yard work, thus further decreasing activity levels. Increased income could also increase one's calorie intake as food becomes more readily affordable. On the other hand, because this study spans the years 1960 to 2008, it is likely that increases in GDP per capita signify increased activity for women as they began to work outside of the home, often while still maintaining their domestic activities.

Educational attainment as well as pollution levels are insignificant and interfere with the model. These variables are only available for a short period of time relative to the other variables in the study, so including them in the model greatly decreases the degrees of freedom which could be the cause of their insignificance. The short duration of the available data also make time lags for these variables impossible to implement. They have thus been dropped from the analysis.

Tobacco consumption has a significant negative impact on the life expectancies of both men and women at birth and at age 60. The coefficients of this variable are by far the largest of the descriptive independent variables in the model, implying that, if tobacco consumption could be decreased, the positive impact on health outcomes could be dramatic. Alcohol consumption has a significant negative impact on the life expectancies of women, but not on men. Given that men are larger than women on average and that alcohol tolerance is proportional to size, it is understandable that alcohol consumption would not have as big of an effect on the health outcomes of men as on those of women.

Separate regressions are run including and excluding sugar consumption in order to assess its effect on the efficiency estimates of the US. The regressions including *LnSugar* have more descriptive merit and, overall, the sizes of the coefficients of the other descriptive independent variables do not change drastically when the variable is included. Sugar consumption itself has a significant negative impact on all measures of life expectancy, supporting the hypothesis that poor diet, indicated by increased sugar consumption, contributes to poor health.

It is relevant to note that the coefficients for all of the descriptive independent variables are percent changes in life expectancy given a 1% change in the associated variable because the model has been transposed into natural log form. Given an average life expectancy of 80 years, a 5% change would increase life expectancy by 4 years. It is difficult to calculate the value of four extra years of life but, for most people, this difference would likely be considered rather large. If four years does not seem important, consider that there is a relatively small difference between life expectancies among developed nations to begin with. The difference between the highest and lowest values for female life expectancy at birth of the countries included in the study is only 4.1 years. Likewise the difference for male life expectancy at birth between the highest and lowest values is 3.9 years. The variance in life expectancy at age 60 is even smaller. Small coefficients are thus explained by the relatively small variance among developed nations in health outcomes.

Table 3 lists the country dummy variables in order of the magnitude and significance of their estimated coefficients. As stated in Section III, the US is the excluded case, so positive coefficients describe health outcomes above those of the US and negative coefficients describe health outcomes below those of the US. The US has therefore been placed in the rankings at the point between positive and negative coefficients. Countries that do not have a significant difference in health outcomes from that of the US are still ranked according to the magnitude of their coefficients, though these rankings are somewhat arbitrary. In each case, the US has been circled to highlight its placement.

Table 3: Country Ranks from OLS Regressions

LEFB		LEF60		LEMB		LEM60	
No Sugar	Sugar	No Sugar	Sugar	No Sugar	Sugar	No Sugar	Sugar
SWITZ***	SWITZ***	SWITZ***	SWITZ***	ICE***	ICE***	ICE***	ICE***
SWED***	SWED***	FRAN***	FRAN***	SWED***	SWED***	SWITZ***	SWITZ***
ITAL***	NETH***	ITAL***	NETH***	SWITZ***	SWITZ***	SWED***	SWED***
FRAN***	ICE***	SWED***	SWED***	NETH***	NETH***	CAND***	CAND***
NETH***	FRAN***	NETH***	ITAL***	ITAL***	NORW***	ITAL***	AUS*
ICE***	ITAL***	CAND***	CAND***	NORW***	AUS***	FRAN***	NEWZ
CAND***	CAND***	AUS***	NEWZ***	AUS***	CAND***	AUS***	NORW
FIN***	AUS***	NEWZ***	AUS***	CAND***	UK***	NORW***	ITAL
NORW***	NORW***	ICE***	ICE***	UK***	ITAL***	NEWZ**	FRAN
AUS***	NEWZ***	FIN***	NORW***	NEWZ***	NEWZ***	NETH	NETH
UK***	FIN***	NORW***	FIN***	IRE***	IRE***	US	US
NEWZ***	UK***	UK***	UK**	FRAN***	DEN***	UK	UK
IRE***	IRE***	IRE***	IRE	BELG***	FRAN**	AUST	AUST***
BELG***	BELG***	BELG**	BELG	GERM***	BELG**	BELG	DEN***
AUST***	AUST***	AUST*	AUST	DEN***	GERM	GERM*	BELG***
PORT***	GERM**	PORT	US	FIN***	AUST	FIN*	FIN***
GERM***	PORT	GERM	GERM	AUST***	FIN	IRE*	IRE***
DEN**	DEN	US	DEN	PORT	US	PORT*	GERM***
US	US	DEN	PORT	US	PORT**	DEN***	PORT***

*** Significant at .001 level
** Significant at .01 level
* Significant at .05 level

Some clear high and low performers stand out in these analyses. Switzerland and Sweden rank in the top five countries for all regressions run. The other frequently high performers include Iceland, Italy, the Netherlands, and France. For the health outcomes of females, Denmark, Germany, Portugal, and the US experience the lowest levels of efficiency. For male health outcomes, Finland and Portugal consistently rank near the bottom. While some of the differences in health outcomes may be statistically insignificant, the consistency of the rankings provides an indication of countries that are consistently performing well, and those that are not.

In almost all of the regressions, the rank of the US appears to be low; the one clear exception is in the life expectancy of males at age 60 in which the US ranks near the middle rather than at or near the bottom. The difference in health outcomes for males over 60 could be explained by the strength of the US health care system in diagnosing and treating cardio vascular issues as well as prostate cancer (Preston and Ho, 2009). Overall however, these results indicate that the US health care system may be performing inefficiently.

It is important to note that taking sugar consumption into consideration alters both the rank and significance of several of the countries included in the study. After taking sugar into account, the difference between the health outcomes of the US and its peers seems to grow smaller. These results support the hypothesis that the poor dietary habits regular in the US could be contributing to the lower life expectancies of its citizens rather than the entirety of the blame being placed on an inefficient health care system.

As mentioned in Section III, the main issue with using country dummy coefficients in an OLS regression to indicate health care efficiency is that the dummy variables pick up all effects not accounted for in the model. Because variables for education and pollution could not be included, these as well as other potential influences on life expectancy such as crime rates and natural disasters that are outside of the control of health care are absorbed into the efficiency estimates. It is therefore desirable to perform an analysis that does not rely on country dummy variables to generate efficiency estimates. This is done here through SFA and the results are given in the next section.

Section V.II: Stochastic Frontier Analysis (SFA) Results

As explained in the Section III, SFA breaks down the regression residuals into two components, one due to model error which is assumed to be normally distributed with zero mean, and one due to inefficiency which is assumed in this analysis to have a truncated normal distribution with mean μ. While the coefficients of the independent variables are again, not the most important factor in this analysis, the results are fairly consistent with their OLS counterparts. Again, the regressions including *LnPhys* as the proxy for labor do not provide as strong results as those using *LnGenPract* and so only the results with *LnGenPRact* are discussed below. Full results can be seen in tables A3 and A4 in the appendix.

While the signs and significance of most coefficients are consistent with those of the OLS regressions, there are a few variances in the coefficients of the independent variables for life expectancies of males. Alcohol consumption now has a significant negative impact on life expectancies both at birth and at age 60 and general practitioners no longer have a significant effect on life expectancies at birth. The sizes of the coefficients however are not largely different from their OLS counterparts, suggesting that the differences in significance could be due to the relatively small effect these variables have on health outcomes for men. Despite these slightly problematic results, the important part of this analysis involves the efficiency estimates derived from the model residuals. Table 4 lists the countries ranked in order of the efficiency estimates generated in the analysis.

Table 4: Efficiency Rankings from SFA Results

LEFB		LEF60		LEMB		LEM60	
No Sugar	Sugar	No Sugar	Sugar	No Sugar	Sugar	No Sugar	Sugar
SWITZ	SWITZ	SWITZ	SWITZ	ICE	ICE	ICE	ICE
ITAL	SWED	FRAN	FRAN	SWED	SWED	SWITZ	SWITZ
FRAN	ITAL	ITAL	ITAL	ITAL	SWITZ	SWED	SWED
SWED	FRAN	SWED	IRE	SWITZ	IRE	ITAL	ITAL
ICE	ICE	CAND	SWED	IRE	ITAL	CAND	CAND
FIN	IRE	IRE	ICE	NORW	NORW	FRAN	US
IRE	FIN	FIN	CAND	NETH	DEN	NORW	FRAN
NORW	NORW	ICE	FIN	CAND	GERM	US	IRE
NETH	NETH	NORW	US	GERM	NETH	IRE	NORW
CAND	GERM	NETH	GERM	FRAN	US	GERM	DEN
GERM	CAND	GERM	DEN	DEN	FRAN	AUS	GERM
UK	DEN	US	NETH	UK	CAND	DEN	FIN
AUS	US	DEN	NORW	AUS	FIN	FIN	NEW
DEN	NEW	NEW	NEW	FIN	UK	NEW	AUS
NEW	UK	AUS	AUS	NEW	NEW	PORT	NETH
PORT	AUS	PORT	UK	US	AUS	NETH	UK
BELG	BELG	UK	BELG	BELG	BELG	UK	BELG
US	PORT	BELG	PORT	PORT	PORT	BELG	PORT
AUST	AUST	AUST	AUST	AUST	AUST	AUST	AUST

Overall, the countries that rank in the top five for efficiency estimates are consistent with the results of the previous regressions. Italy, Switzerland, and Sweden rank in the top five countries for all regressions run. The other frequently high performers again include Iceland and France while the Netherlands has moved to a lower performance group. The lowest performers experience a slight change from the previous estimates, with Austria, Belgium, and Portugal in the lower quartile for all regressions. While the ranking of the high efficiency performers remained largely the same, the rank of the countries below the first quartile seems to have shifted.

There are a few important differences between the efficiency estimates generated through SFA and those generated from the OLS regressions; the most important difference being in the ranking of the US. In regressions including sugar consumption, the US ranks in the second highest quartile of the countries regressed for all life expectancy measures other than female life expectancy at birth. The difference in results between the SFA and OLS models suggest that differences in health outcomes for the US could be due more to excluded variable bias rather than inefficiency. This is further supported from the fact that taking sugar into account increases the rank of the US by two to six positions. The impact of sugar on efficiency estimates for the US health care system suggests that a portion of the difference in health outcomes between the US and its peers is because of the poor diet of its citizens which could be outweighing the benefits of its health care system.

The SFA efficiency estimates can be found in tables A5 and A6 in the appendix. The analysis assumes that most countries are performing efficiently so the efficiency estimates for life expectancy of females and males at birth only range from about 95% to above 99%; the estimates for life expectancy at age 60 range from about 90% to above 99%. The variation in efficiency among countries is therefore sometimes quite small. There is no indication of the significance level of these differences so some of the variation may be arbitrary, as in the previous regressions. Also, although the US is ranked much higher in these estimates, it is still not ranked at the top which is still an indication of inefficiency in comparison to its peers.

While time invariant SFA is more econometrically sound than relying on country dummy coefficients for estimates of efficiency, there are still drawbacks to this method. A key issue with the model is that it assumes that the efficiency estimates remain constant over time. This is unlikely given the large health benefits associated with increases in medical technology that occur over time. Despite this flaw, SFA seems to generate fairly accurate efficiency results as further displayed by the consistency between the OLS and SFA results.

Section VI: Conclusion

As a whole, the OLS regressions explain a large portion of the variation in health outcomes, as measured by life expectancy, among the OECD nations studied. The significance levels of my variables in both the OLS and SFA models as well as the R^2 values of the OLS regressions suggest that the results found here are fairly accurate. The consistency between the results of the OLS and SFA regressions also help confirm the validity of the models.

The number of practicing general practitioners is found to have a more significant positive effect on life expectancy than the total number of practicing physicians, suggesting that increasing the number of general practitioners relative to specialists would have a positive effect on health outcomes. It therefore seems that it would be beneficial for countries to create incentives for medical students to choose careers as general practitioners rather than specialists which may mean alterations in the salary levels of specialists relative to those of general practitioners.

Smoking is found to have the largest impact on health outcomes suggesting that the negative effects of smoking greatly decrease health outcomes, even when taking positive health care factors into consideration. This implies that stricter regulation on the contents of tobacco products as well as the ease of purchase of these products may be necessary to improve the health outcomes of a nation.

Sugar consumption is found to have a significant negative effect on health outcomes. Taking sugar consumption into account increases the efficiency of the US, drastically in SFA results for life expectancy at birth for males and females. This suggests that a portion of the poor health outcomes of the US is likely due to poor diet rather than health care system inefficiency. However, even when taking sugar consumption into account, the findings suggest that the US health care system is still performing inefficiently in comparison to some of its peers. While it is possible that taking more lifestyle controls into account may further increase the efficiency of the US, it is also possible given the results that some of the difference in US health outcomes is in fact due to inefficiency in the health care system.

The policy implications of these results are often considered unappealing in the political world as they involve increasing government regulation and programs in health care. If these results are correct, the US needs to analyze its productive efficiency in health care relative to that of other nations. It is likely that a change in the system to one that is more generally followed in other nations may be appropriate. While pollution and education levels, along with other outside effects are unaccounted for in my model, the variables that are accounted for do not absorb enough of the negative health outcomes experienced by the US relative to its peers to remove the entirety of the blame from an inefficient health care system.

Section VII: Avenues for Further Research

While the results found here are fairly consistent with high descriptive merit, there is still much to be improved upon in this field of research. There was not sufficient evidence to suggest diagnostic issues in the OLS regressions, but it is important to take into consideration that the US is an outlier among its peers in total health expenditure. Including the US in the analysis could therefore skew the estimated effects of health expenditure on life expectancy. Excluding the US from this analysis was not possible, given that the focus of the research was on the efficiency of the US health care system. Finding a way to generate efficiency estimates for the US without explicitly including it in the analysis could possibly generate more accurate results.

Other aspects of the research could be improved upon as well in order to generate more accurate estimates of efficiency. Finding proxies for other factors that affect health outcomes such as education, pollution, and external causes of death is imperative to this goal. Improving upon the econometric methods of the analysis could also help, particularly by relaxing the assumption of time-invariant efficiency in the SFA regressions.

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Appendix

Table A1: Regression Results with LnGenPract as an Independent Variable

	lnLEFB		lnLEF60		lnLEMB		lnLEM60	
Variable	No Sugar	Sugar	No Sugar	Sugar	No Sugar	Sugar	No Sugar	Sugar
(Constant)	4.600***	4.685***	3.694***	3.848***	4.722***	4.808***	4.065***	4.187***
LnGenPract	0.011***	0.012***	0.036***	0.044***	0.004	0.008*	0.008	0.022**
LnHealthExp	0.027***	0.030***	0.046***	0.057***	0.027***	0.030***	0.046***	0.057***
LnGDP	0.008***	0.006***	0.017***	0.014***	-0.002	-0.004**	-0.015***	-0.016***
LnAgeDep	-0.038***	-0.040***	-0.063***	-0.062***	-0.034***	-0.036***	-0.045*	-0.041*
LnAlcohol	-0.009**	-0.011**	-0.031***	-0.042***	-0.005	-0.007	-0.003	-0.014
LnTobacco	-0.052***	-0.054***	-0.137***	-0.130***	-0.115***	-0.114***	-0.325***	-0.307***
LnSugar	----	-0.016***	----	-0.040***	----	-0.018***	----	-0.045***
AUS	0.037***	0.033***	0.061***	0.051***	0.042***	0.035***	0.039***	0.023*
AUST	0.021***	0.014***	0.017*	0.002	0.017***	0.007	-0.011	-0.031***
BELG	0.024***	0.017***	0.025**	0.007	0.024***	0.013**	-0.015	-0.041***
CAND	0.038***	0.033***	0.067***	0.055***	0.041***	0.034***	0.051***	0.036***
DEN	0.010**	0.007	-0.011	-0.013	0.019***	0.016***	-0.036***	-0.039***
FIN	0.038***	0.029***	0.053***	0.028***	0.017***	0.007	-0.019*	-0.043***
FRAN	0.047***	0.038***	0.100***	0.079***	0.027***	0.014**	0.040***	0.012
GERM	0.020***	0.009**	0.012	-0.011	0.020***	0.007	-0.018*	-0.047***
ICE	0.042***	0.039***	0.056***	0.051***	0.065***	0.064***	0.092***	0.090***
IRE	0.033***	0.025***	0.036***	0.021	0.033***	0.023***	-0.025*	-0.045***
ITAL	0.048***	0.036***	0.086***	0.058***	0.046***	0.032***	0.043***	0.012
NETH	0.044***	0.041***	0.074***	0.072***	0.047***	0.043***	0.012	0.009
NEWZ	0.033***	0.029***	0.056***	0.051***	0.036***	0.030***	0.023**	0.013
NORW	0.037***	0.030***	0.048***	0.029***	0.044***	0.035***	0.037***	0.012
PORT	0.020***	0.007	0.014	-0.017	0.000	-0.018**	-0.026*	-0.065***
SWED	0.051***	0.046***	0.078***	0.069***	0.063***	0.058***	0.071***	0.063***
SWITZ	0.058***	0.057***	0.125***	0.128***	0.057***	0.056***	0.083***	0.088***
UK	0.034***	0.028***	0.037***	0.025**	0.041***	0.033***	-0.002	-0.019
R^2	.9606	.9611	.9649	.9666	.9715	.9705	.9680	.9686
n	484	414	458	404	469	414	458	404

*** Significant at .001 level

** Significant at .01 level

* Significant at .05 level

Table A2: Regression Results with LnPhys as an Independent Variable

	lnLEFB		lnLEF60		lnLEMB		lnLEM60	
Variable	No Sugar	Sugar	No Sugar	Sugar	No Sugar	Sugar	No Sugar	Sugar
(Constant)	4.658***	4.722***	3.650***	3.701***	4.913***	4.953***	4.496***	4.530***
LnPhys	0.005	0.005	0.042***	0.052***	-0.014**	-0.012*	-0.033*	-0.029*
LnHealthExp	0.016***	0.018***	0.033***	0.037***	0.009*	0.012**	-0.014	-0.002
LnGDP	0.010***	0.009***	0.022***	0.019***	0.000	-0.001	-0.003	-0.004
LnAgeDep	-0.041***	-0.044***	-0.058***	-0.057***	-0.054***	-0.056***	-0.072***	-0.071***
LnAlcohol	-0.027***	-0.028***	-0.074***	-0.077***	-0.025***	-0.025***	-0.084***	-0.091***
LnTobacco	-0.048***	-0.050***	-0.105***	-0.099***	-0.121***	-0.120***	-0.329***	-0.313***
LnSugar	----	-0.011**	----	-0.018*	----	-0.010*	----	-0.024*
AUS	0.039***	0.036***	0.077***	0.072***	0.039***	0.035***	0.030**	0.025*
AUST	0.026***	0.021***	0.035***	0.026**	0.020***	0.014***	0.004	-0.005
BELG	0.030***	0.025***	0.039***	0.028**	0.030***	0.025***	-0.002	-0.010
CAND	0.035***	0.031***	0.068***	0.064***	0.034***	0.030***	0.028***	0.023*
DEN	0.008*	0.005	-0.013	-0.018*	0.020***	0.016***	-0.029*	-0.033**
FIN	0.035***	0.027***	0.057***	0.034**	0.014**	0.007	-0.027*	-0.047**
FRAN	0.059***	0.053***	0.130***	0.118***	0.042***	0.035***	0.087***	0.078***
GERM	0.025***	0.018***	0.026***	0.013	0.026***	0.018***	0.000	-0.012
ICE	0.029***	0.027***	0.019*	0.012	0.055***	0.054***	0.060***	0.055***
IRE	0.027***	0.021***	0.023*	0.009	0.028***	0.020***	-0.038**	-0.055***
ITAL	0.044***	0.035***	0.066***	0.047***	0.046***	0.038***	0.042**	0.026
NETH	0.036***	0.034***	0.050***	0.047***	0.044***	0.040***	0.005	-0.002
NEWZ	0.029***	0.026***	0.055***	0.051***	0.028***	0.024***	0.001	-0.005
NORW	0.029***	0.025***	0.022**	0.013	0.041***	0.037***	0.006	-0.009
PORT	0.032***	0.022***	0.048***	0.030**	0.009	0.000	0.006	-0.008
SWED	0.032***	0.028***	0.029***	0.020**	0.052***	0.048***	0.036***	0.025*
SWITZ	0.046***	0.044***	0.083***	0.078***	0.054***	0.050***	0.085***	0.080***
UK	0.027***	0.022***	0.032***	0.026**	0.028***	0.023***	-0.038***	-0.050***
R^2	.9533	.9497	.9609	.9603	.9622	.9589	.9475	.9446
n	531	474	514	458	531	474	519	463

*** Significant at .001 level

** Significant at .01 level

* Significant at .05 level

Table A3: SFA Results with LnGenPract as an Independent Variable

	lnLEFB		lnLEF60		lnLEMB		lnLEM60	
Variable	No Sugar	Sugar	No Sugar	Sugar	No Sugar	Sugar	No Sugar	Sugar
(Constant)	4.667***	4.751***	3.833***	3.988***	4.790***	4.872***	4.152***	4.266***
LnGenPract	0.008*	0.009***	0.032***	0.039***	0.001	0.005	0.002	0.016*
LnHealthExp	0.027***	0.029***	0.046***	0.056***	0.026***	0.029***	0.045***	0.057***
LnGDP	0.008***	0.007***	0.017***	0.015***	-0.001	-0.003*	-0.013***	-0.014***
LnAgeDep	-0.040***	-0.040***	-0.065***	-0.064***	-0.033***	-0.035***	-0.042*	-0.039*
LnAlcohol	-0.010**	-0.012***	-0.033***	-0.044***	-0.008*	-0.010**	-0.011	-0.021*
LnTobacco	-0.052***	-0.055***	-0.138***	-0.132***	-0.115***	-0.114***	-0.324***	-0.306***
LnSugar	----	-0.016***	----	-0.040***	----	-0.017***	----	-0.043***

*** Significant at .001 level

** Significant at .01 level

* Significant at .05 level

Table A4: SFA Results with LnPhys as an Independent Variable

	lnLEFB		lnLEF60		lnLEMB		lnLEM60	
Variable	No Sugar	Sugar	No Sugar	Sugar	No Sugar	Sugar	No Sugar	Sugar
(Constant)	4.715***	4.775***	3.783***	3.822***	4.961***	4.988***	4.553***	4.562***
LnPhys	0.007	0.008	0.045***	0.055***	-0.012*	-0.010*	-0.025	-0.020
LnHealthExp	0.015***	0.017***	0.032***	0.037***	0.008	0.012**	-0.012	0.001
LnGDP	0.010***	0.009***	0.021***	0.018***	0.001	0.000	-0.004	-0.005
LnAgeDep	-0.041***	-0.043***	-0.059***	-0.057***	-0.053***	-0.054***	-0.070***	-0.070***
LnAlcohol	-0.026***	-0.027***	-0.071***	-0.074***	-0.027***	-0.027***	-0.084***	-0.091***
LnTobacco	-0.047***	-0.049***	-0.105***	-0.099***	-0.119***	-0.117***	-0.323***	-0.305***
LnSugar	----	-0.012***	----	-0.019*	----	-0.008*	----	-0.021

*** Significant at .001 level

** Significant at .01 level

* Significant at .05 level

Table A5: SFA Efficiency Estimates from Regressions with LnGenPract as an Independent Variable

	LEFB		LEF60		LEMB		LEM60	
Country	No Sugar	Sugar	No Sugar	Sugar	No Sugar	Sugar	No Sugar	Sugar
AUS	0.98638	0.98494	0.95294	0.94799	0.98491	0.98129	0.96397	0.95554
AUST	0.96846	0.96594	0.90308	0.89735	0.95869	0.95428	0.91220	0.90341
BELG	0.98337	0.97985	0.94599	0.93556	0.97939	0.97394	0.94477	0.93169
CAND	0.98950	0.98794	0.97761	0.97505	0.98675	0.98411	0.98447	0.98116
DEN	0.98577	0.98793	0.95900	0.96558	0.98653	0.98856	0.96220	0.96874
FIN	0.99350	0.99210	0.97464	0.97132	0.98375	0.98385	0.96218	0.96239
FRAN	0.99734	0.99485	0.99102	0.98433	0.98660	0.98451	0.98236	0.97595
GERM	0.98885	0.98926	0.96421	0.96721	0.98673	0.98709	0.96643	0.96799
ICE	0.99423	0.99484	0.97409	0.97716	0.99896	0.99897	0.99713	0.99728
IRE	0.99331	0.99409	0.97580	0.97984	0.99172	0.99253	0.96954	0.97519
ITAL	0.99811	0.99521	0.99023	0.98295	0.99585	0.99247	0.98857	0.98140
NETH	0.99041	0.99001	0.96423	0.96400	0.98778	0.98704	0.94672	0.94978
NEW	0.98556	0.98561	0.95707	0.95798	0.98255	0.98190	0.95828	0.95832
NORW	0.99106	0.99014	0.96520	0.96355	0.99013	0.98899	0.97325	0.96972
PORT	0.98413	0.97794	0.94896	0.93396	0.97171	0.96363	0.94868	0.93155
SWED	0.99705	0.99592	0.98039	0.97936	0.99827	0.99731	0.98959	0.98883
SWITZ	0.99890	0.99863	0.99610	0.99590	0.99284	0.99254	0.99080	0.99481
UK	0.98658	0.98520	0.94840	0.94610	0.98590	0.98358	0.94580	0.94308
US	0.98310	0.98658	0.96235	0.96894	0.98085	0.98467	0.97233	0.97763

Table A6: SFA Efficiency Estimates from Regressions with LnPhys as an Independent Variable

	LEFB		LEF60		LEMB		LEM60	
Country	No Sugar	Sugar	No Sugar	Sugar	No Sugar	Sugar	No Sugar	Sugar
AUS	0.98266	0.98637	0.95505	0.96332	0.98748	0.98789	0.95374	0.95857
AUST	0.96657	0.97020	0.90673	0.91677	0.96690	0.96756	0.91854	0.92407
BELG	0.97808	0.97893	0.93561	0.93681	0.98267	0.98137	0.93740	0.93703
CAND	0.98312	0.98606	0.97154	0.97699	0.98588	0.98672	0.97333	0.97654
DEN	0.98375	0.98762	0.95496	0.96546	0.98906	0.99122	0.96361	0.97136
FIN	0.99556	0.99691	0.98678	0.99054	0.99322	0.99537	0.98056	0.98658
FRAN	0.99850	0.99861	0.99602	0.99650	0.99410	0.99384	0.99573	0.99604
GERM	0.98811	0.99067	0.96422	0.97286	0.99039	0.99173	0.96973	0.97596
ICE	0.97571	0.98108	0.92928	0.94146	0.99832	0.99862	0.97560	0.97906
IRE	0.98855	0.99142	0.96318	0.97197	0.99106	0.99232	0.95904	0.96674
ITAL	0.99569	0.99491	0.98359	0.98233	0.99766	0.99662	0.98760	0.98621
NETH	0.98487	0.98838	0.95008	0.95971	0.99303	0.99354	0.94928	0.95482
NEW	0.97787	0.98216	0.94538	0.95603	0.98148	0.98301	0.94003	0.94735
NORW	0.97215	0.97651	0.90649	0.91905	0.98664	0.98656	0.92665	0.92967
PORT	0.98488	0.98309	0.95615	0.95380	0.97772	0.97528	0.95762	0.95535
SWED	0.97882	0.98150	0.92519	0.93322	0.99665	0.99582	0.95876	0.95997
SWITZ	0.98445	0.98925	0.94833	0.95932	0.99848	0.99815	0.99167	0.99372
UK	0.97994	0.98271	0.94057	0.94977	0.98407	0.98461	0.92759	0.93269
US	0.98285	0.98784	0.96198	0.97264	0.98438	0.98824	0.97393	0.98083