The Influence of Alcohol Consumption on Income and Health: Empirical Evidence from a Panel of OECD Countries

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Employing the panel data from 2001, 2003, and 2005 from 27 OECD countries, regression results suggest that income and a set of three indicators of health (that is, lung cancer mortality, mortality due to 14 kinds of cancers, and healthy life expectancy) are found to be related, thus implying that income and health may be one package in policy formulation. In this sense, expenditure on health care can be self-financing, at least partially. Increased government spending on health care results in improved health, which subsequently results in higher income and more government revenue. Evidently, the differences in alcohol consumption are causal to both income and health differentials. Given that the total income elasticity of moderate alcohol consumption is low, any alcohol taxes designed to discourage excessive drinking will result to welfare losses on drinkers who may not be imposing external costs by their drinking; higher prices are unfair on moderate drinkers (UK parliament, 2010). Education and campaigns implemented with the aim of influencing behavior such as anti-binge drinking programs will not only improve income (partially self- funding) but also health, as primarily intended.

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* Professor. Woosuk University. (Tel) 063-290-1712. (Fax) 82-63-290-1004. (E-mail) jhlee2000@woosuk.ac.kr. Addressing the points raised by paper examiners improved the paper.

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I. Introduction

Even though many countries including Korea have experienced progress in health care spending over the last few years,[1] medical care has been increasingly recognized as but one of the factors contributing towards good health. As a result, academic interest in the non-medical determinants of health has grown; people want good health and health care are means to that end. Studies that use a production of health function regard health as the outcome of a production process involving health inputs such as income, education, and lifestyle factors, as well as medical care.

The present literature suggests that once the basic levels of medical sophistication, personnel, and facilities become available, additional inputs of medical care do not have much effect on health; that is, while medical care probably has a substantial contribution in modern societies, its marginal contribution in generating improvements in health is small. Furthermore, the marginal products of other variables (*e.g.* income, education, and lifestyle factors) are significantly different from zero in general (Fuchs 1974; Wagstaff 1989). Often it is the marginals, not the totals, which are most relevant in policy formulation.

Fuchs asserted that medicine plays a relatively minor historical role (1974), concluding that rising living standards, the spread of literacy and education, and a substantial decline in birth rate all played a part in the sharp reduction in the infant mortality rate between 1900 and 1930. In the 1930s, sulphonamide, the first of the anti-microbial drugs, was introduced. Fuchs argues that both medical advances and rising living standards contributed to the reduction in infant deaths from 1935 to 1950, in which the decline in infant death rates accelerated. Fuchs also notes that "how medical care is used may be more important than how much is used," and that "what is required is some sense of balance so that the contribution of medical care is not oversold."

This observation reveals that higher income is generally associated with improved health; that is, people with higher incomes tend to consume higher quality goods and better housing, have a better diet, and use better medical care, all of which may affect their health favorably. In turn, this proposition suggests a causality which operates from income

[1] For example, Kang (2012) reports statistical data that the ratio of health expenditure to public social expenditure for Korea is 46.5% in 2007, whereas the average ratio for OECD countries is 31.5% during the same period.

to health. For instance, according to the National Longitudinal Mortality Survey, people belonging to the top 5 percent of incomes whose family income was greater than $50,000 in 1980 had a life expectancy at all ages that was about 25 percent longer than those in the bottom 5 percent, whose family income was less than $5,000, thus implying that health and income are positively associated (Deaton 2003a).

Deaton's results (2003b) also suggest that for all three races (Blacks, Coloreds and Whites, ages 18 to 88) a negative and significant relationship exists between the respondent's own income (from all sources) and self-reported health status, measured using the five-point scale (1=Excellent, 5=Very Poor). For all three races, a doubling of income is associated with an improvement in health status of roughly two-tenths of one point (the estimated t-values are -2.508, -4.361, and -3,361, respectively). Age and education are controlled.

Assuming that healthy workers have lower rates of absenteeism, employers will be willing to pay a higher wage to healthy persons. Therefore, better health will increase income. For instance, based on a panel data set of 85 countries over seven five-year periods from 1965 to 2000, Barro and Lee (2003) present the results of three-stage least squares regressions that two measures of health have significant influences upon the growth rate of real per capita Gross Domestic Product (GDP); the log of the total fertility rate is negative (t-statistic=3.560), whereas the log of life expectancy is positive (t-statistic=3.768).

More recently, employing data for the panel of five South Asian countries over the period from 1974 to 2007, Narayan *et al.* (2010) also find that health has a statistically significant and positive impact on per capita income. After controlling for investment, exports, and imports, the long-run elasticity of health appears to be 0.22, which implies that a 1 percent increase in health expenditure, measured as a percentage of GDP, leads to at most a 0.22 percent increase in per capita income.

Hence, the relationship between these two variables suggests the direction of causation from health to income, as well as the direction of causation from income to health. Not only does economic status influence health status, but evidently, health status also affects economic status (Case 2000; Marmot 2002).

The above propositions suggest a full simultaneous equations model,[2] which implies that the choice of policy instruments should not be based

[2] Ettner (1996) also argues that income and health are determined simultaneously.

upon the stability analysis of a single final target variable.

On the other hand, different patterns of behavior such as alcohol consumption may explain differentials in health. While such differences in alcohol consumption make an important contribution to socio-economic differences in health, there may be higher morbidity and mortality in lower socio-economic groups. Moderate alcohol consumption yields beneficial physical and psychological effects, which may have positive health effects (Hamilton and Hamilton 1997). Given the relationship between income and health, moderate alcohol consumption actually raises income. For example, although alcoholism alone leads to an 18 percent reduction in wages after controlling for education, MacPherson (1998) has estimated that wages peak for individuals consuming an average of 2.40 drinks per day (see also National Health Strategy of Australia 1992).

Given the importance of health, alcohol consumption may therefore be considered as a package in policy formulation and health outcome.

Twenty-seven OECD countries were selected for the study because of the availability of in-depth data[3] for 2001, 2003, and 2005. Even though these twenty-seven OECD countries do not provide sufficient observations to allow a full econometric evaluation of the causal relationship between income and health, and of the possibility that differences in alcohol consumption are causal to the differentials in income and health, the OECD data have the advantage of having accessible health status indicators (that is, lung cancer mortality, mortality due to 14 kinds of cancers, and healthy life expectancy) by country. Note that each of these three indicators of health status is likely to be an important determinant of the values of income.

To our knowledge, however, none have shown empirical evidence on the relationship between income and health, as well as the total proportionate rate of changes in income and health with respect to alcohol consumption. Diagnostic evaluations are conducted to double-check all the models so that the more tests that are carried out, the less the chance of accepting a poor model (Beggs 1988). Among those performed are: non-nested tests, tests for endogeneity, RESET tests for functional form misspecification, and tests for heteroskedasticity.

The next section develops the analytical framework that highlights two causal relationships between income and health, and the effect of alcohol consumption on both income and health. Section 3 outlines the data. Section 4 presents and discusses the empirical results. Finally, the sum-

[3] Belgium, Mexico, and Turkey are excluded.

mary of the principal findings and the policy implications are presented in Section 5.

II. Analytical Framework

The primary purpose of this section is to analyze the interdependence between income and health. Therefore, this section specifies the proposition that differences in alcohol consumption are causal to the differentials in income and health. Distinguishing three indicators of health (that is, lung cancer mortality, mortality due to 14 kinds of cancers, and healthy life expectancy) the double-natural logarithmic structural equations are defined, respectively, by (Fuchs 1974; Hamilton and Hamilton 1997)[4]:

$$\ln Y = \alpha_0 + \alpha_1 \ln H_j + \alpha_2 \ln R1 + \alpha_3 D^* \ln R1 + \alpha_4 \ln ED + \alpha_5 \ln LPI + \alpha_6 \ln PT + \alpha_7 \ln SERVICE + \alpha_8 \ln R2 + Error \tag{1}$$

$$\ln H1 = \beta_0 + \beta_1 \ln Y + \beta_2 \ln R1 + \beta_3 D^* \ln R1 + \beta_4 \ln ED + \beta_5 \ln EXP + \beta_6 \ln SERVICE + \beta_7 \ln R2 + \beta_8 \ln BED + Error \tag{2}$$

$$\ln H2 = \gamma_0 + \gamma_1 \ln Y + \gamma_2 \ln R1 + \gamma_3 D^* \ln R1 + \gamma_4 \ln ED + \gamma_5 \ln EXP + \gamma_6 \ln SERVICE + \gamma_7 \ln R2 + \gamma_8 \ln BED + Error \tag{3}$$

$$\ln H3 = \delta_0 + \delta_1 \ln Y + \delta_2 \ln R1 + \delta_3 D^* \ln R1 + \delta_4 \ln ED + \delta_5 \ln EXP + \delta_6 \ln SERVICE + \delta_7 \ln R2 + \delta_8 \ln BED + Error \tag{4}$$

where Y denotes GDP per capita converted with Purchasing Power Parity (hereafter, per capita real income). $H_j=(H1, H2, H3)'$ refers to the row vector of the explanatory variables in the structural equation (1): $j=1$, 2, 3. $H1$, $H2$, and $H3$ represent lung cancer mortality per a population of 100,000, mortality by 14 kinds of cancers per 100,000 population, and a healthy life expectancy, respectively.

$R1$ represents alcohol consumption per capita. D denotes a dummy variable (outlying countries=1, corresponding to Czech Republic except in 2005, France, Hungary, and Slovakia with more alcohol consumption than average; otherwise=0). $D^*\ln R1$ denotes an interaction variable when D interacted with $\ln R1$.

[4] We have performed a non-nested test in Table 4 and have found the double-natural logarithmic transformation suitable (Moschini 1992).

ED represents the proportion of persons with tertiary level educational attainment in a population aged 25 to 64 years. *LPI* represents the labor productivity index. *PT* represents part-time employment as a proportion of total employment. *SERVICE* represents employment in the service industry as a proportion of total employment. *R*2 stands for the proportion of smokers aged 15 years and above. *BED* stands for the acute care hospital beds per 100,000 population. Finally, *EXP* stands for per capita real health expenditure.

Table 1 describes the variables used in the structural equations. The estimated Pearson correlation coefficients among the three indicators of health are very high; the estimated Pearson correlation coefficients between *H*1 and *H*2, *H*1 and *H*3, and *H*2 and *H*3 are 0.608, -0.648, and -0.709, respectively. Therefore, these indicators are included in separate regressions.

On the other hand, the estimated Pearson correlation coefficient between *R*1 and *R*2 appears to be very low[5] at 0.263, therefore implying that the fit is not affected by multicollinearity. Hence, two variables can be included in the double-natural logarithmic structural equations (1), (2), (3), and (4). Furthermore, all the equations include an interaction term, so that multicollinearity will be reduced.

Structural equations (1) to (4) also comply with the hypothesis that causal relationships between per capita real income and each of three indicators of health exist. All the equations are assumed to be identified (see for example Appendix Table 1). The reduced-form equations for the double natural logarithmic structural equations (1) to (4) are specified as:

$$V=\pi_{v0}+\pi_{v1}\ln R1+\pi_{v2}D^{*}\ln R1+\pi_{v3}\ln ED+\pi_{v4}\ln LPI+\pi_{v5}\ln PT \\ +\pi_{v6}\ln EXP+\pi_{v7}\ln SERVICE+\pi_{v8}\ln R2+\pi_{v9}\ln BED+Error \quad (5)$$

where $V=(Y, H_j)'$ refers to the row vector of the dependent variables, while the π's are the functions of the structural parameters indicated in the structural equations (1) to (4).

The structural equations (1) to (5) stand for well-behaved production functions exhibited everywhere that diminish returns to inputs, and show, for example, that there are two channels through which alcohol consumption affects health. Alcohol consumption affects health directly and

[5] This suggests that drinkers and smokers are not associated with each other, on average (Bobo and Husten 2000).

TABLE 1
VARIABLE DEFINITIONS AND SOURCES

Variable	Definition (Source)	Mean (SD)	Max (Min)	Normality Test (z-value)[13]
Y[1]	Per capita GDP, US$PPPs (Education at a Glance, OECD)	27.928 (9.763)	69.984 (10.360)	Accept H_0(0.952)
$H1$[2]	Mortality rate by lung cancer per 100,000 population (OECD Health Data)	45.423 (17.386)	105.100 (21.400)	Accept H_0(1.302)
$H2$[3]	Mortality rate due to 14 kinds of cancers per 100,000 population (OECD Health Data)	173.467 (24.646)	258.900 (137.800)	Accept H_0(1.436)
$H3$[4]	Healthy life expectancy (OECD Health Data)	70.589 (3.017)	76.000 (59.900)	Accept H_0(1.210)
$R1$[5]	Annual alcohol consumption per capita in liters among adults aged 15 years and above (OECD Health Data)	10.014 (2.384)	15.500 (5.700)	Accept H_0(0.592)
ED[6]	The percentage of the population with tertiary level educational attainment to population aged 25 to 64 (OECD iLibrary)	25.189 (9.127)	46.10 (9.100)	Accept H_0(0.913)
LPI[7]	Labor productivity index (StatExtracts, OECD)	106.548 (6.772)	126.800 (93.100)	Accept H_0(1.366)
PT[8]	Part-time employment as a proportion of total employment (Employment Outlook, OECD)	15.317 (7.878)	35.700 (1.900)	Accept H_0(0.830)
EXP[9]	Per capita total health expenditure, US$ PPPs (OECD Health Data)	1871.210 (822.222)	4851.000 (465.000)	Accept H_0(0.576)
$SERVICE$[10]	Employment in the service industry as a proportion of total employment (Labor Force Statistics, OECD)	67.651 (7.340)	77.800 (50.400)	Accept H_0(1.036)
$R2$[11]	The percentage of daily smokers to population aged 15 years and above (OECD Health Data)	25.457 (4.984)	38.600 (15.900)	Accept H_0(0.628)
BED[12]	Acute care beds per 1000 population (OECD Health Data)	4.362 (1.544)	9.600 (2.200)	Accept H_0(1.542)

Notes: 1), 9). In equivalent US dollars, converted using Purchasing Power Parities (PPPs).
2), 7). Excludes Belgium and Greece. Therefore, n (total number of observations) = 75 (25 countries); unit: %.
2), 3). All mortality rates are age-standardized to the OECD standard population (Health at a Glance: OECD, 1980).
4). unit: year
2), 3), 6), 8), 10), 11). unit: %.
13) Kolmogorov-Smirnov Test. The alternatives are: H_0 = the fits of normal distribution to the sample data is adequate, and H_1 = the fits of a normal distribution to the sample data is not adequate. By "Accept H_0" we strictly mean "cannot reject H_0." The α risk controlled at 0.01 on a two-tailed test.

indirectly, through per capita real income,

$$d\ln H1/d\ln R1 = \ln H1_{\ln R1} + \ln H1_{\ln Y}{}^{*}(d\ln Y/d\ln R1) \tag{6}$$

III. Data

Variations in reporting practices and the accuracy of information, which may be serious at the individual level, tend to be averaged out when using countries as a unit of observation. Moreover, each of the three health indicators is likely to vary less relative to variations in income across countries than across individuals.

Nevertheless, the approach can be justified by the assumption that the country's preferences for health and lifestyle factors such as alcohol consumption versus their consumption goods represent an aggregation of individual preferences. For example, in examining the production model of health measured by mortality rates in logarithmic form across 51 states of the United States as the unit of observation (sample size of white population in the labor force), Auster *et al.* (1969) note that the relationships among aggregates depend on individual characteristics and resources.

Details of the variables definition and source are given in Table 1. The order of the data is taken from the data package of the "2001-2005 OECD Health Data," conducted by the Organization for Economic Cooperation and Development (OECD). Each of the two health variables $H1$ and $H2$ in the above model implies a negative effect, so that a higher value in the variable will be associated with relatively worse health. On the other hand, $H3$ reveals a positive effect; as such, a higher value will be associated with a relatively better health.

The mean (average) alcohol consumption per capita is 10.014 liters. However, excluding outlying countries with more alcohol consumption than average, the average annual alcohol consumption is 9.716 liters (0.027 liters daily).

A healthy life expectancy indicates the number of years that a person can be expected to live in good health. Therefore, the emphasis is not exclusively on the length of life as in the case of life expectancy, but also on the quality of life.

Labor productivity (2000=100) is defined as GDP per hour worked. Underlying series of GDP refers to the GDP in the national currency, at constant prices, OECD base year 2000 for each country; and to the GDP, in US dollars, at constant prices, constant Purchasing Power Parities

TABLE 2
THE PEARSON CORRELATION COEFFICIENT AMONG SELECTED VARIABLES[1)]

ED/H3	*ED/PT*	*ED/ SERVICE*	*PT/Y*	*PT/ SERVICE*	*SERVICE/ EXP*	*Y/EXP*
0.499 (0.000)	0.528 (0.000)	0.705 (0.000)	0.450 (0.000)	0.646 (0.000)	0.726 (0.000)	0.929 (0.000)

Note: 1) p-values are shown in parenthesis below the estimated coefficients.

(PPPs), OECD base year 2000 for country groups/zones. Labor input is defined as the total hours worked by all persons engaged.

The data are derived as the average hours worked (from the OECD Employment Outlook, OECD Annual National Accounts, OECD Labor Force Statistics, and National Sources) multiplied by the corresponding and consistent measure of employment for each particular country.

The measures of labor productivity are presented as indices and as rates of change. Main data sources used are the OECD Annual and Quarterly National Accounts, OECD Employment Outlook, and the OECD Labor Force Statistics and National Sources.

Least squares regression assumes that the dependent variable and, less critically, the independent variables are normally distributed, an assumption that is reasonably satisfied by our data. Standard tests for normality fail to reject the hypothesis of normal distribution for both dependent and independent variables. For example, the commonly used Kolmogorov-Smirnov test for normality produces insignificant z statistics for both variables (Black 2001).

In Table 2, the estimated Pearson correlation coefficient among selected variables appears to be very high. For instance, the estimated Pearson correlation coefficients between *ED* and *H*3, and between *ED* and *PT*, and between *ED* and *SERVICE* are 0.499, 0.528, and 0.705, respectively. Therefore, to avoid the possibility of multicollinearity, *ED* will be excluded in equations (1) to (5). Based on the Pearson correlation coefficients, *PT* will be excluded from equations (2) to (4), and *EXP* will be excluded from equations (2) to (5).

Although we estimated two stage least squares (TSLS) and fixed effect (FE) models for per capita real income and three health indicators, we analyzed Pooled Ordinary Least Squares (OLS) estimations over the TSLS and FE estimations given that the standard errors of the estimates (SEE) in the former are smaller than those in the latter. Therefore, we concentrate on an analysis of the econometric results from the OLS es-

TABLE 3
STANDARD ERROR OF THE ESTIMATES

	Dependent Variables					
	ln$Y$			ln$H1$	ln$H2$	ln$H3$
	(1)	(2)	(3)			
OLS	0.165	0.163	0.152	0.323	0.102	0.031
TSLS	0.172	0.173	0.173	0.344	0.102	0.032
FE	0.173	0.167	0.160	0.321	0.107	0.031

timates for all regressions. Table 3 provides the standard error of estimates.[6]

IV. Results OF Estimation

The primary objective of this section is to analyze the interdependence between income and health. Subsequently, we explore the possibility that differences in alcohol consumption are causal to the differentials in income and health.

A. Diagnostic Check of the Hypothesis

Diagnostic testing is concerned with establishing whether an estimated model provides an adequate description of an economic phenomenon. Beggs (1988) argues that diagnostic testing of econometric models is a positive activity which stimulates recourse to improved economic and statistical modeling, in the sense that it can help indicate where problems may lie in existing models; the more tests that are carried out, the less the chance of accepting a poor model. In this subsection, we conduct a diagnostic test of the inter-relationships among income and a set of three indicators of health.

[6] All structural equations are estimated using OLS, TSLS, and FE methods, since all the structural equations are identified by the rank condition (see for instance Appendix Table 1. Twenty seven OECD countries in 2001, 2003, and 2005 do not generate a sufficient number of observations. Therefore, we use the standard errors of estimates (SEE) in choosing between models (*e.g.* Maddala, 1977). The use of SEE is also based upon the overall model performance, as suggested by Associate Professor John Mangan of Lancaster University, UK. With small panel data sets with eighty one we choose FE estimates rather than random effect estimates. FE estimates are given in Appendix Table 2.

Table 4

Non-Nested Test of Double Logarithmic Versus Linear Models of Income and Three Health Indicators: Pooled OLS Estimates[1)]

Structural	Regression	Box	Cox[2)]	Theil[3)]	
Equations	Equations	Logarithmic model (H_1)	Linear model (H_0)	Logarithmic model (H_1)	Linear model (H_0)
Y	(1)	RSS = 0.003 Reject H_0	RSS = 2.692	Adj.R^2 = 0.775 Reject H_0	Adj.R^2 = 0.702
	(2)	RSS = 0,003 Reject H_0	RSS = 2.632	Adj.R^2 = 0.782 Reject H_0	Adj.R^2 = 0.709
	(3)	RSS = 0.002 Reject H_0	RSS = 2.555	Adj.R^2 = 0.810 Reject H_0	Adj.R^2 = 0.717
$H1$		RSS = 0.004 Reject H_0	RSS = 11.026	Adj.R^2 = 0.181 Reject H_0	Adj.R^2 = 0.107
$H2$		RSS = 0.0003 Reject H_0	RSS = 0.948	Adj.R^2 = 0.408 Reject H_0	Adj.R^2 = 0.377
$H3$		RSS = 0.0001 Reject H_0	RSS = 0.082	Adj.R^2 = 0.518 Reject H_0	Adj.R^2 = 0.391

Notes: 1) By "Accept H_0," we strictly mean "cannot reject H_0."
2) The Box-Cox procedure, as described by Maddala (1977); RSS stands for the residual sum of squares.
3) The Theil maximum adjusted multiple determination criterion, as described by Maddala (1992).

In the first stage of testing, the linear and double natural logarithmic versions of the function are contrasted to each other using non-nested tests to determine which model provides a better representation of behavior. Consequently, only the diagnostic tests of the double natural logarithmic functions which have survived stage one are reported in the following subsection.

We have dealt with functional form issues through the Box-Cox transformation framework and the Theil maximum adjusted multiple determination (Adj.R^2) criterion in Table 4, and have found the double-natural logarithmic transformation suitable.[7]

To test the null hypothesis of independence, each dependent variable

[7] The estimated value of Adj.R^2 for each income and health function is smaller than that of double-natural logarithmic functions. Thus, we chose the double-natural logarithmic model (Gupta *et al.* 2001).

TABLE 5

TESTS OF INDEPENDENCE BETWEEN REAL INCOME PER CAPITA AND THREE HEALTH INDICATORS[1)]

Cross-Classified Variables	Pearson Chi-Square[2)]	Decision
Real income per capita (*Y*)/Lung Cancer Mortality (*H*1)	(289) = 306	Accept H_0
Real income per capita (*Y*)/14 Kinds of Cancer Mortality (*H*2)	(240) = 255	Reject H_0
Real income per capita (*Y*)/Healthy Life Expectancy (*H*3)	(115) = 120	Reject H_0

Notes: 1) For the test procedure, see Lewis *et al.* (1990). "Accept H_0" means "cannot reject H_0."
2) The degrees of freedom in the parentheses are based on the maximum number of valid cases.

is classified as the top, middle, and bottom thirds of the countries in terms of the sample proportions, as introduced by Lewis *et al.* (1990). The null hypothesis of independence between each pair of variables is rejected if the calculated chi-square (χ^2) is larger than the critical value. Rejection of the null hypothesis indicates that the variables are dependent on each other. The 90% critical values for $\chi^2(289)$, $\chi^2(240)$, and $\chi^2(115)$ are 307.553, 249.000, and 115.006, respectively.

The null hypothesis of independence between the real income per capita and each of the 14 kinds of cancer mortality and healthy life expectancy is rejected, whereas the null hypothesis of independence between real income per capita and lung cancer mortality is not rejected (Table 5).[8] For example, the null hypothesis of independence between income and healthy life expectancy is rejected, implying that the proportion of the countries from each of the three categories of healthy life expectancy is not the same as that of real income per capita.

Therefore, the close association between real income per capita and each of the 14 kinds of cancer mortality and healthy life expectancy primarily resulted from a system of causations. In this regard, this study conducts tests for endogeneity, one of its major objectives.

In the estimated regressions for real income per capita and three

[8] The "acceptance" of the null hypothesis may simply reflect that 27 countries in 2001, 2003, and 2005 are an insufficient number of observations for a full evaluation for the test of independence between real income per capita and lung cancer mortality.

TABLE 6
DIAGNOSTIC EVALUATION OF STATISTICS ON INCOME AND THREE HEALTH INDICATORS: OLS ESTIMATES

Equation		Endogeneity Tests[1]	Test of Functional Form Misspecification[2]				Hetero-skedasticity[3]
			RESET2	R^2	DW	Joint F-Statistic	
ln*Y*	(1)	t=138.279***	t=0.634	0.797	1.062	37.512***	$\chi^2(7)=10.425$
	(2)	t=69.426***	t=0.728	0.802	1.008	38.819***	$\chi^2(7)=11.400$
	(3)	t=103.948***	t=0.328	0.828	1.078	45.937***	$\chi^2(7)=11.175$
ln*H*1		t=17.306***	t=0.940	0.243	1.780	3.955**	$\chi^2(6)=11.550$
ln*H*2		t=8.737***	t=2.644**	0.453	0.631	10.202***	$\chi^2(6)=14.250$
ln*H*3		t=12.328***	t=1.528	0.555	1.251	15.356***	$\chi^2(6)=15.000$

Notes: 1) ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively, on a two-tailed test.
2) For the test procedure, see Beggs (1988).
3) For the test procedure, see Breusch and Pagan (1979). The degrees of freedom are shown in the parentheses. The 99% critical values of $\chi^2(7)$ and $\chi^2(6)$ are 18.475 and 16.812, respectively.

health indicators (*i.e.*, lung cancer mortality, 14 kinds of cancer mortality, and healthy life expectancy), endogeneity tests were conducted by augmenting the pooled OLS regression with each of the residual value of the suspected regressor of endogeneity from the reduced-form estimations.

Endogeneity exists between real income per capita and each of the three health indicators (Table 6). For example, the endogeneity tests for real income per capita reject the null hypothesis that each of the three health indicators is not endogenous to the dependent variable because the absolute values of the t-statistics are larger than the critical value.

Therefore, real income per capita and each of the three health indicators are interrelated (*cet. par.*).

We use Ramsey's RESET2 test as a general test for misspecification. This test assumes that the effect of omitted variables can be substituted by some function of the original regressors.

The null hypothesis of functional form misspecification is rejected in all the estimated regressions for real income per capita and two health indicators except ln*H*2 (Table 6). The observed Durbin-Watson (DW) statistic suggests that correct specifications are not implied, except for the ln*H*1 equation. However, the observed R^2 is high, and the estimated joint

F-statistic is higher than the 95% critical value. In sum, the null hypothesis of functional form misspecification is rejected in all the estimated regressions for real income per capita and the three health indicators, indicating that the assumption of the expected zero value of the residuals is not violated in any of the six regressions.

Heteroskedasticity is not detected because the calculated $\chi^2(7)$ and $\chi^2(6)$ are lower than the 99% critical values (Table 6).

B. Estimates of Structural Equations

The lung cancer mortality rate (*H*1) is negatively related to real income per capita (*Y*) (Table 7). The mortality rate based on the 14 kinds of cancer (*H*2) is also negatively related to real income per capita, but healthy life expectancy (*H*3) is positively related to it. Therefore, improving health levels increases income levels (*cet. par.*).

The estimated coefficients of alcohol consumption per capita in liters among adults aged 15 or over (*R*1) are positive and significant at the 1% level (Table 7). For example, a 10 percent increase in the proportion of persons aged 15 years or over who consume alcohol increases real income per capita by 3.44 to 3.95 percent.

Analysis of the coefficient stability (D*ln$R$1) indicates that the average annual alcohol consumption per capita higher than 9.716 liters of the outlying countries (*i.e.*, Czech Republic, France, Hungary, and Slovakia) may be excessive. A 10 percent increase in the proportion of persons aged 15 years or over who moderately consume alcohol consumption increases real income per capita by 2.32 to 3.07 percent. These results are consistent with MacPherson (1998), implying that excessive alcohol consumption negatively affects real income per capita. Therefore, if no outlying countries have alcohol consumption higher than average, the average alcohol consumption of 9.716 L (0.027 L daily) may be defined as moderate alcohol consumption.[9]

The coefficients of the labor productivity (*LPI*) and part-time employment as a proportion of total employment (*PT*) is not significantly related

[9] The National Health and Medical Research Council (NH&MRC) of Australia also recommends moderate alcohol consumption as the average daily consumption of alcohol greater than zero but less than 0.05 litres or 35 gram for males and 0.025 litres or 17.5 grams for females on a regular basis (National Health Strategy of Australia, Research Paper No.1, 1992). On the other hand, Hamilton and Hamilton (1997) define moderate drinkers as those who drank at least once a week or everyday and drank 8 or less drinks (about 0.083 litres of pure alcohol) on a single day in the previous week).

TABLE 7
POOLED OLS ESTIMATES OF INCOME EQUATION[1)]

Explanatory Variables	Dependent Variable: lnY		
	(1)	(2)	(3)
ln*H*1	-0.162 (0.063)**	-	-
ln*H*2	-	-0.580 (0.196)***	-
ln*H*3	-	-	2.802 (0.628)***
ln*R*1	0.347 (0.089)***	0.395 (0.087)***	0.344 (0.082)***
*D**ln*R*1	-0.105 (0.034)***	-0.088 (0.034)**	-0.112 (0.031)***
ln*LPI*	0.328 (0.380)	0.759 (0.354)**	0.313 (0.338)
ln*PT*	-0.045 (0.053)	-0.036 (0.052)	-0.107 (0.052)**
ln*SERVICE*	2.068 (0.239)***	2.517 (0.237)***	2.277 (0.231)***
ln*R*2	0.072 (0.115)	0.084 (0.114)	0.030 (0.102)
Constant	-9.492 (2.281)***	-8.920 (2.289)***	-20.258 (2.787)***
Chow *t*	3.111***	2.588**	3.594***
Adj.R^2	0.775	0.782	0.810

Notes: The values in parentheses are the estimated absolute standard errors of the regression coefficient. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively, on a two-tailed test. The fixed effect estimates are reported in Appendix Table 2.

to real income per capita.[10] Thus, the *LPI* cannot be a good empirical proxy for income (*e.g.*, OECD StatExtracts, 2007). Having the highest Adj.R^2, the coefficient of part-time employment is negatively and signifi-

[10] On the contrary to these results, the linear regression results in Appendix Table 3 suggest that both LPI and PT are significantly related to per capita real income. For example, the estimated coefficient of PT maintains a negative sign and is statistically significant at the 1%-5% levels on a two-tailed test.

cantly related to healthy life expectancy (Table 7), as expected. This result is consistent with previous findings that the lower the level of part-time employment as a proportion of PT, the better the economic performance (Terry 1981; Nelen *et al.* 2011).

The estimated coefficient of employment in the service industry as a proportion of total employment (*SERVICE*) is positive and significant at the 1% level on a two-tailed test. These results support the argument of Francois and Reinert (1996) that the growth of the service sector is an important aspect of economic development and a significant factor for income growth.

By contrast, the pooled OLS estimates suggest that the proportion of smokers aged 15 years or over (*R*2) is not significantly related to real income per capita.

Real income per capita is significantly related to the three health indicators at the 1% level, negatively related to the lung cancer mortality rate and mortality rate based on the 14 kinds of cancer per 100,000 population, and positively related to healthy life expectancy (Table 8). Therefore, countries with relatively higher levels of real income per capita have better health on average.

Alcohol consumption per capita in liters among adults aged 15 years or over marginally affects *H*2 and *H*3. Analysis of coefficient stability suggests that a 10 percent increase in alcohol consumption per capita among such adults increases the mortality rate based on the 14 kinds of cancer per 100,000 population by 0.51 percent in outlying countries with alcohol consumption higher than average (*cet. par.*). Therefore, excessive alcohol consumption negatively affects good health.

Countries with a higher proportion of employment in the service industry tend to have higher lung cancer mortality rates (Table 8). The number of workers exposed to environmental tobacco smoke is obtained from carcinogen exposure, with the higher-exposure group including the service industry and the lower-exposure group including the manufacturing industry (*e.g.*, Rushton *et al.* 2007).

The coefficient of the ratio of daily smokers to the population aged 15 years or over is positively and significantly related to the lung cancer mortality rate per 100,000 population at the 5% level. Therefore, smoking has a harmful effect on lung cancer. These results are consistent with the argument of Richardson (2001) that tobacco smoking causes most lung cancers. Acute-care hospital beds per 1000 population (BED) does not affect health.

Two-way causal directions are revealed by the findings (Tables 7 and

TABLE 8
POOLED OLS ESTIMATES OF THREE HEALTH EQUATIONS[1)]

Explanatory Variables	Dependent Variables		
	ln*H*1	ln*H*2	ln*H*3
ln*Y*	-0.737 (0.217)***	-0.197 (0.069)***	0.091 (0.020)***
ln*R*1	0.227 (0.182)	0.106 (0.058)*	-0.029 (0.017)*
*D**ln*R*1	-0.025 (0.053)	0.051 (0.017)***	-0.006 (0.005)
ln*SERVICE*	1.588 (0.659)**	0.272 (0.209)	-0.023 (0.062)
ln*R*2	0.414 (0.202)**	0.076 (0.064)	0.002 (0.019)
ln*BED*	0.024 (0.129)	0.012 (0.041)	0.004 (0.012)
Constant	-2.397 (2.414)	4.126 (0.765)***	4.111 (0.228)***
Chow *t*	0.462	3.024***	1.011
Adj.R^2	0.181	0.408	0.518

Note: See Notes in Table 7.

8): (1) Better health increases real income per capita, and higher real income per capita improves health. (2) A 10 percent reduction in the lung cancer mortality rate per 100,000 population increases real income per capita by 1.62 percent, whereas a 10 percent increase in real income per capita reduces such rate by 7.37 percent. These results are consistent with Deaton (2003b), who found that higher income is generally associated with better health.

V. Principal Findings and Policy Implications

The income and three health indicators (*i.e.*, lung cancer mortality, mortality caused by 14 kinds of cancer, and healthy life expectancy) of the 27 OECD countries in 2001, 2003, and 2005 are interrelated. Real income per capita and health have a mutually causal relationship. Therefore, the choice of policy instruments should not be based on stability

TABLE 9

DIRECT, INDIRECT, AND TOTAL PROPORTIONATE RATE OF CHANGES IN INCOME AND THREE HEALTH INDICATORS WITH RESPECT TO ALCOHOL CONSUMPTION (CET. PAR.)

	Dependent Variables			
	ln$Y$	ln$H1$	ln$H2$	ln$H3$
Direct Effect[1)]	0.232	0.202	0.157	-0.035
Indirect Effect[2)]	0.045	-0.383	-0.097	0.050
Total Effect[3)]	0.277	-0.181	0.060	0.015

Notes: 1) Coefficients of pooled OLS estimates in Table 7 and Table 8
2) Difference between the direct and total effects
3) Coefficients of reduced-form estimates in Appendix Table 5. These estimates indicate that alcohol consumption is not significantly related to the total proportionate rate of changes in the three health indicators.
1, 3) Obtained from coefficient stability analysis in Table 7, Table 8, and Appendix Table 5; ln$R1+D^*$ln$R1$. For example, the positive total income elasticity of demand for moderate alcohol consumption is 0.388-0.111=0.277 (Appendix Table 5).

analysis for single final target variables because income and health may form one package in policy formulation. In this sense, expenditure on health care can be (at least partially) self-financing. Increased government spending on health care improves general health, thereby increasing income and government revenue.

Health can also be viewed as goods. The empirical observations indicate that the benefits from government expenditures on the three health indicators are progressing.

The pooled OLS estimates suggest that differences in alcohol consumption have a causal relationship with either income or health status differentials. Given that moderate alcohol consumption is defined as consumption of 9.716 L (0.027 L daily) based on the pooled OLS estimates and coefficient stability, the reduced-form estimates suggest that moderate alcohol consumption also has additional benefits.

Moderate alcohol consumption has positive physical and psychological effects (Table 9), which signify positive health effects. Given the two-way causality between income and health, moderate alcohol consumption increases income. For example, a 10 percent increase in the proportion of persons aged 15 years or over with moderate alcohol consumption per capita increases real income per capita by 2.77 percent (by 2.32 percent directly and by 0.45 percent indirectly because of a reduction in the lung cancer mortality rate and mortality rate based on the 14 kinds of cancer per 100,000 population) as well as healthy life expectancy. Annual consumption of 9.716 L (0.027 L daily) of alcohol or lower may be regarded as moderate alcohol consumption.

Given that the positive total income elasticity of demand for moderate alcohol consumption is low (0.277), any alcohol taxes designed to discourage excessive drinking impose welfare losses on drinkers who may not be imposing external costs by their drinking. In other words, higher prices are unfair for moderate drinkers (UK Parliament 2010). Education and campaigns against drinking behavior (*e.g.*, anti-binge drinking) improve not only income (partially self-funding) but also health (as primarily intended).[11]

The reduced-form estimates suggest that alcohol consumption is not significantly related to the total proportionate rate of changes in the three health indicators (Appendix Table 5).[12]

However, alcohol consumption per capita in liters among adults aged 15 years or over only marginally affects the mortality rate based on the 14 kinds of cancer per 100,000 population as well as healthy life expectancy (Table 8).

Excessive alcohol consumption also has harmful effects on health (*i.e.*, mortality rate based on 14 kinds of cancer) and thus on income (Table 8).[13]

Our findings are subject to some constraints that limits the above conclusions. For example, the date limitations preclude an ideal measure of acute-care hospital beds. The definition of acute care beds may vary from one country to another. Education was also excluded from the structural equations. Fuchs (1974) argues that the marginal products of education are generally significantly different from zero. Thus, the mul-

[11] Using the annual time-series data of South Korea from 1981 to 2009, Kang and Lee (2011) find that real tax rate has had a neutral effect on the demand for soju, the traditional Korean alcoholic beverage, since 2000. Estimates of real tax rate elasticities of real price range from 0.07 to 0.28. The evidence implies that education and campaigns may be more effective than taxes.

[12] The reduced-form estimates of the linear equation in Appendix Table 6 suggest that the estimated coefficient of the interaction variable (D^*R1) is positively and significantly related to $H2$, implying that excessive alcohol consumption influences the mortality rate based on the 14 kinds of cancer per 100,000 population. The *cet. par*. total mean elasticity of such mortality rate with respect to alcohol consumption is 0.11 according to $(\partial H2/\partial R)^*R_{\text{mean}}/H2_{\text{mean}}$, where $R=D^*R1$.

[13] The reduced-form estimates of the linear equation in Appendix Table 6 also show that the interaction variable is positively and significantly related to Y.

tiple interrelationships among income, health, and education should be analyzed (*cet. par.*).

Twenty-seven countries (2001, 2003, and 2005) are not a sufficient number of observations for a full econometric evaluation of the causal relationships between income and health and of the possibility that differences in alcohol consumption are causally linked to health differentials.

When assessing alcohol dependence criteria or evaluating guidelines for moderate drinking, assessing and adjusting for heterogeneity in the relation between drinking patterns and alcohol problems are important (Russell *et al.* 2004). Swaffield (2001) argues that just as micro-level data herald the start of estimate improvements of aggregate data, the availability of individual-level panel data offers further improvement.

These conclusions are expected to stimulate further research and discussion to resolve these issues.

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Appendix

Appendix Table 1. Rank Criterion Matrix of Structural Equations for Real Income Per Capita (*Y*) and Three Health Indicators (*H*1, *H*2, and *H*3)

$$A * \ln Y = \overset{\ln BED}{\begin{bmatrix} \beta 6 \\ \gamma 6 \\ \delta 6 \end{bmatrix}}$$

$$A * \ln H_j = \overset{\ln LPI \quad \ln PT}{\begin{bmatrix} \alpha 4 & \alpha 5 \\ 0 & 0 \\ 0 & 0 \end{bmatrix}}$$

Notes: 1) $A*_X$ denotes a rank criterion matrix for the structural equation X; $X=Y$, H_j, $j=1, 2, 3$.
2) Zero denotes a variable not found in the structural equation.
3) All the equations have rows and columns with non-zero determinants. The pair of structural equations for *H*1, *H*2, and *H*3 has no simultaneous relationships. See Baumal (1977).

Appendix Table 2. Fixed Effect Estimates of Income and Three Health Indicators[1)]

Explanatory Variables	Dependent Variable					
	ln*Y*			ln*H*1	ln*H*2	ln*H*3
	(1)	(2)	(3)			
ln*Y*	-	-	-	-0.708 (0.204)***	-0.263 (0.068)***	0.103 (0.019)***
ln*H*1	-0.163 (0.066)***	-	-	-	-	-
ln*H*2	-	-0.661 (0.199)***	-	-	-	-
ln*H*3	-	-	2.880 (0.666)***	-	-	-
ln*R*1	0.329 (0.098)***	0.390 (0.094)***	0.340 (0.090)***	0.211 (0.184)	0.148 (0.061)**	-0.040 (0.017)**
*D**ln*R*1	-0.359 (0.249)	-0.343 (0.242)	-0.493 (0.232)**	-0.102 (0.414)	0.167 (0.137)	0.019 (0.039)
ln*LPI*	0.104 (0.389)	0.597 (0.356)*	0.080 (0.347)	-	-	-
ln*PT*	0.045 (0.047)	0.035 (0.046)	-0.015 (0.047)	-	-	-
ln*SERVICE*	2.450 (0.243)***	2.382 (0.236)***	2.114 (0.237)***	1.551 (0.660)**	0.370 (0.219)*	-0.050 (0.063)
ln*R*2	0.016 (0.119)	0.049 (0.116)	-0.030 (0.106)	0.425 (0.199)**	0.052 (0.066)	0.005 (0.019)
ln*BED*	-	-	-	0.013 (0.125)	0.037 (0.042)	0.0001 (0.012)
R^2(Adj.R^2)	0.775 (0.752)	0.789 (0.768)	0.808 (0.788)	0.241 (0.181)	0.397 (0.349)	0.550 (0.514)
Joint F-Stat (1,68)	33.510***	36.384***	40.853***	3.974***	8.227***	15.268***
DW	1.019	0.938	1.011	1.798	0.683	1.225
SEE	0.173	0.167	0.160	0.321	0.107	0.031
Chow *t*	1.438	1.418	2.124**	0.246	1.212	0.483

Notes: See Notes in Table 7. The fixed model can be formulated as

$y_{it} - \bar{y}_i = (X_{it} - \bar{X}_i)\beta + (\alpha_i - \bar{\alpha}_i) + (u_{it} - \bar{u}_i) = \ddot{y}_{it} = \ddot{X}_{it} + \ddot{u}_{it}$, where $\bar{X}_i = \frac{1}{T}\sum_{t=1}^{T} X_{it}$ and $\bar{u}_i = \frac{1}{T}\sum_{t=1}^{T} u_{it}$.

Given that α_i is constant $\bar{\alpha}_i = \alpha_i$, the FE estimator is obtained from the OLS regression of $\ddot{y}$ on $\ddot{X}$ (Wooldridge 2000).

Appendix Table 3. Pooled OLS Estimates of Linear Equation for Income[1)]

Explanatory Variables	Dependent Variable (*Y*)		
	(1)	(2)	(3)
*H*1	-0.070 (0.043)	-	-
*H*2	-	-0.072 (0.035)**	-
*H*3	-	-	0.724 (0.287)**
*R*1	1.373 (0.296)***	1.486 (0.290)***	1.372 (0.287)***
*D***R*1	-0.806 (0.198)***	-0.731 (0.202)***	-0.802 (0.193)***
LPI	0.188 (0.110)*	0.279 (0.102)***	0.207 (0.102)**
PT	-0.287 (0.118)**	-0.260 (0.116)**	-0.354 (0.120)***
SERVICE	1.126 (0.111)***	1.089 (0.112)***	1.038 (0.115)***
*R*2	0.167 (0.157)	0.181 (0.155)	0.146 (0.150)
Constant	-77.024 (16.852)***	-76.926 (16.233)***	-125.888 (21.414)***
R^2(Adj.R^2)	0.730 (0.702)	0.736 (0.709)	0.744 (0.717)
Joint F-Stat (1,67)	25.903***	26.701***	27.798***
DW	1.261	1.228	1.242
SEE	5.268	5.210	5.133
Chow *t*	4.062***	3.623***	4.158***

Note: See Notes in Table 7.

Appendix Table 4. Pooled OLS Estimates of Linear Equation for Three Health Indicators[1)]

Explanatory Variables	Dependent Variable (*Y*)		
	*H*1	*H*2	*H*3
Y	-0.770 (0.352)**	-0.702 (0.417)*	0.095 (0.050)*
*R*1	0.915 (0.998)	1.562 (1.183)	-0.114 (0.143)
*D***R*1	0.071 (0.552)	2.327 (0.654)***	-0.135 (0.079)*
SERVICE	0.438 (0.449)	-0.061 (0.532)	0.128 (0.064)*
*R*2	0.729 (0.409)*	0.566 (0.485)	-0.013 (0.059)
BED	0.379 (1.393)	0.347 (1.650)	0.123 (0.200)
Constant	7.855 (30.297)	161.856 (35.884)***	60.436 (4.341)***
R^2(Adj.R^2)	0.174 (0.107)	0.423 (0.377)	0.437 (0.391)
Joint F-Stat (1,74)	2.598*	9.054***	9.566***
DW	1.991	0.705	1.274
SEE	16.429	19.460	2.353
Chow *t*	0.128	3.560***	1.712*

Note: See Notes in Table 7.

Appendix Table 5. Reduced-Form Estimates of Income and Three Health Indicators[1)]

Explanatory Variables	Dependent Variables			
	ln*Y*	ln*H*1	ln*H*2	ln*H*3
ln*R*1	0.388 (0.093)***	-0.192 (0.174)	0.027 (0.055)	0.014 (0.016)
*D**ln*R*1	-0.111 (0.036)***	0.011 (0.066)	0.033 (0.021)	0.001 (0.006)
ln*LPI*	0.658 (0.373)*	-2.064 (0.696)***	0.167 (0.219)	0.124 (0.063)*
ln*PT*	-0.019 (0.054)	-0.166 (0.102)	-0.032 (0.032)	0.032 (0.009)***
ln*SERVICE*	2.651 (0.257)***	0.030 (0.480)	−0.157 (0.151)	0.126 (0.044)***
ln*R*2	-0.045 (0.123)	0.517 (0.231)**	0.172 (0.072)**	-0.022 (0.021)
ln*BED*	0.061 (0.070)	-0.046 (0.131)	-0.024 (0.041)	0.014 (0.012)
Constant	-11.691 (2.248)***	12.520 (4.203)***	4.519 (1.321)***	3.084 (0.382)***
R^2(Adj.R^2)	0.779 (0.756)	0.217 (0.135)	0.293 (0.220)	0.504 (0.452)
Joint F-Stat (1,67)	33.726***	2.647*	3.976**	9.728***
DW	1.110	1.581	0.726	1.120
SEE	0.172	0.322	0.101	0.029
Chow *t*	3.115***	0.167	1.557	0.158

Notes: See Notes in Table 7.

Appendix Table 6. Reduced-Form Estimates of Linear Equation for Income and Three Health Indicators[1)]

Explanatory Variables	Dependent Variables			
	Y	*H*1	*H*2	*H*3
*R*1	1.538 (0.291)***	-1.152 (0.846)	0.361 (1.008)	0.130 (0.121)
*D***R*1	−0.900 (0.197)***	0.455 (0.572)	1.537 (0.682)**	-0.062 (0.082)
LPI	0.243 (0.101)**	-0.922 (0.294)***	0.387 (0.351)	0.060 (0.042)
PT	−0.285 (0.116)**	-0.359 (0.336)	0.048 (0.401)	0.121 (0.048)**
SERVICE	1.218 (0.115)***	-0.253 (0.333)	-0.836 (0.397)**	0.162 (0.048)***
*R*2	-0.007 (0.160)	0.914 (0.464)*	1.191 (0.553)**	-0.083 (0.066)
BED	0.986 (0.447)**	-0.595 (1.300)	-1.572 (1.549)	0.258 (0.186)
Constant	-93.772 (15.558)***	156.285 (45.237)***	157.962 (53.913)***	51.207 (6.470)***
R^2($Adj.R^2$)	0.738 (0.711)	0.214 (0.132)	0.285 (0.210)	0.438 (0.379)
Joint F-Stat (1,67)	27.023***	2.603*	3.806*	7.459***
DW	1.245	1.783	0.765	1.152
SEE	5.187	15.082	17.974	2.157
Chow *t*	4.573***	0.796	2.255**	0.756

Notes: See Notes in Table 7.

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