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Does it pay to pay for health? How health expenditure translates into GDP growth in OECD countries

Summary

We estimate the impact of health expenditure on GDP in high-income countries (OECD sample) by adding more economic structure of theoretical transmission channels from health spending to productive capacity of the economy, as compared to reduced-form regressions widespread in the literature. Our approach is based on three separate panel regressions, simulating the effect of presenteeism and absenteeism (via labour productivity), long-term working disability (via employment rate) and mortality (via probability of death during working age). In all three cases, health expenditure has turned out to act in a GDP-improving, statistically significant way.

Keywords: health expenditure, indirect cost of illness, healthcare efficiency, panel estimation

1. Introduction and literature overview

There is a long strand of literature trying to investigate the casual relationship between health or health expenditure and economic variables, such as GDP. However, the dominant approach, i.e. investigating this linkage via reduced-form regressions, appears to be overly simplistic for the purpose of formulating policy implications, for a number of reasons.

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Firstly, health expenditure increases with GDP, since people with higher incomes and governments with higher revenues tend to spend more on health care in absolute terms. Secondly, consumers can spend a fixed proportion of their income on health purposes (i.e. they pay more for health when they are wealthy – see European Commission, p. 163, for an overview). This does not imply, however, that higher spending out of higher wealth improves the health stock – health services may just be more expensive or marginally hardly efficient when consumed in large amounts, but still demanded because of favourable income conditions. Thirdly, the results of reduced-form regressions may differ substantially depending whether the sample of countries under investigation is a group of high-income countries (like EU or OECD[3]) or is a mix of high- and low-income countries[4]. While high-income countries are seldom investigated at all[5], they do not seem to exhibit strong empirical dependence of GDP on health expenditure, or just suggest increases in spending because of higher income.

The abovementioned issues give rise to endogeneity problems[6] that may lead to demonstrating some spurious effects, dominated by short- to mid-term variance. Feedback effects between health and GDP lead to inconsistent and biased estimates, and – in the end – potential overestimation of the impact of health on the economy. Some authors point to problems related to measuring the efficiency of health expenditure on the macro level[7]. Our purpose, instead, is to concentrate on long-term effects, i.e. increase in the stock of population health and higher potential output by avoidance of so called indirect costs of illnesses[8]. This category can be seen as the economic cost of unproduced goods related to absence of sick employees from work (absenteeism), low-productivity presence at work (presenteeism), quitting the labour market due to long-term disability, or decease of a worker.

We propose to tackle the problem by factorizing the GDP (or, equivalently, decomposing the natural log of GDP) into a few categories that can be related to individual components of indirect costs of illness. We relate these categories to health expenditure,

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3 See e.g. Z. Or, *Exploring the Effects of Health Care on Mortality across OECD Countries*, OECD Labour Market and Social Policy Occasional Papers no. 46, 2001, http://dx.doi.org/10.1787/716472585704.

4 See e.g. J. Novignon, S. Olakojo, *The effects of public and private health care expenditure on health status in sub-Saharan Africa: new evidence from panel data analysis*, "Health Economics Review" 2012, vol. 2(22), pp. 1–8.

5 See M. Suhrcke, M. McKee, D. Stuckler, R.S. Arce, S. Tsolova, J. Mortensen, *The contribution of health to the economy in the European Union*, "Public Health" 2006, vol. 120, pp. 994–1001.

6 See e.g. D. Acemoglu, A. Finkelstein, M.J. Notowidigdo, *Income and Health Spending: Evidence form Oil Price Shocks*, "The Review of Economics and Statistics" 2013, vol. 95(4), pp. 1079–1095.

7 See P.H. De Cos, E. Moral-Benito, *Health Care Expenditure in the OECD Countries: efficiency and regulation*, "Banco de Espana Documentos Ocasionales" 2011, vol. 1107.

8 See e.g. *WHO Guide to Identifying the Economic Consequences of Disease and Injury*, WHO, 2009, http://www.who.int/choice/publications/d_economic_impact_guide.pdf (retrieved: 2015.03.27).

not to any possible health stock variables, since this approach is more relevant for policymakers[9].

Section 2 describes our empirical strategy regarding the decomposition of GDP and presents how regression equations are fitted for individual components, mapping the dependence of these variables on health expenditure and a number of equation-specific control variables (which should i.a. alleviate the issue of endogeneity). It also includes information on the utilised data sources. Sections 3 describes the estimation results. Section 4 concludes.

2. Empirical strategy: decomposition and panel regressions

For the purpose of our investigation, we propose the following identity decomposition of GDP (Y) as a basis for further econometric framework. This decomposition is a novel approach, that – to the best of our knowledge – has not been considered in the literature before:

$$Y_{it} = \frac{Y_{it}}{L_{it}} \cdot \frac{L_{it}}{L_{it} + I_{it}} \cdot \left(L_{it} + I_{it}\right) \tag{1}$$

with L – the size of working population (in working age), I – the size of non-working population (in working age), t – time index, i – country index. Hence, the above decomposition presents the GDP as the product of (i) Y/L, i.e. the productivity of working population, (ii) $L/(L+I)$, i.e. the share of working population in total population (in working age only), (iii) the size of working age population. Any health-related decrease in (i) can be attributed to a joint effect of presenteeism and, in dependence on prevailing labour market institutions, absenteeism (to an extent that sick leaves are counted as working hours or temporarily sick people are counted as employees). Component (ii) reflects i.a. involuntary long-term disability that forces potential labour force out of employment or even out of the labour market. Finally, component (iii) reflects the size of potential labour force, reduced by any premature death related to bad health prior to retirement.

In our research, we conduct separate econometric analyses for three variables that reflect those components, including the health expenditure and a set of control variables, dictated by economic theory and empirical research. A separate challenge is to operationalise the abovementioned concepts. For example, we decided to use the

[9] Policymakers can directly influence only health spending. Health stock variables may be affected by them only indirectly.

number of working people as *L* instead of the number of working hours, since available data on working hours for OECD countries is intended only for comparisons in time (not between countries). Also, to explain the impact of health policies on working age population, we do not use (*I*+*L*) directly (as the working age population size differs between countries in a natural way), but prefer to model the probability of death during the working age and then to recalculate it into *I*+*L*.

Our first equation attempts to capture the impact of total health expenditure per capita (*health_exp*) on labour productivity measured by real GDP per employed person[10] (*gdp_employed*). As control variables, we introduce the real value of capital stock per employed (*capital*, expected sign of coefficient: *"+"*[11]) to control for capital intensity, the share of the working-age with tertiary education (*edu, "+"*[12]) as a proxy for human capital and the average of the World Bank governance indicators (*govern, "+"*) to account for the quality of institutions potentially enhancing total factor productivity of economies[13]. In addition to this, we use average number of hours worked per employed person (*hours_worked, "+"*[14]) to control for the intensity of labour utilisation and add to the model the estimate of output gap (*output_gap, "+"*[15]) that should account for the changes in labour productivity at business cycle frequencies.

The second equation enables us to investigate the influence of total health expenditure (*health_exp*) on the employment rate (*emp_rate*) for people aged 25–59 years. To control for other determinants of labour supply and labour demand, the model also includes the measure of tax wedge for an average earner (*tax wedge, "–"*[16], the ratio of women labour participation rate to men labour participation rate (*women_part, "+"*[17]) as the indicator of relative female participation in the labour market and again

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10 Employed persons comprise paid employment and self-employment, in line with OECD definition based on ILO (https://stats.oecd.org/glossary/detail.asp?ID=764).

11 Cf. E.N. Wolff, *Capital Formation and Productivity Convergence over the Long Term*, "American Economic Review" 1991, vol. 81(3), pp. 565–579.

12 Cf. A. De la Fuente, *Human capital and productivity*, BBVA Bank, Economic Research Department Working Papers no. 11/03, pp. 1–22.

13 See e.g. D. Rodrik, A. Subramanian, F. Trebbi, *Institutions Rule: The Primacy of Institutions over Geography and Integration in Economic Development*, "Journal of Economic Growth" 2004, vol. 9(2), pp. 131–165.

14 See e.g. L. Golden, *The effects of working time on productivity and firm performance: a research synthesis paper*, International Labour Organization, ILO Working Papers, Conditions of work and employment series, no. 33, 2012, pp. 1–34.

15 See e.g. R.E. Hall, *Productivity and the business cycle*, Carnegie-Rochester Conference Series on Public Policy 1987, Elsevier, vol. 27(1), pp. 421–444.

16 See e.g. *Taxation and Employment*, OECD Tax Policy Studies 2011, no. 21, s. 1–165, http://dx.doi.org/10.1787/9789264120808-en (retrieved: 2015.04.08).

17 Cf. F. Jaumotte, *Female Labour Force Participation: Past Trends and Main Determinants in OECD Countries*, OECD Economics Department Working Papers no. 376, 2003, pp. 1–66.

the estimate of output gap (*output_gap, "+"*) that captures the changes in employment rates caused by the cyclical fluctuations in the aggregate demand.

In the third equation, the dependent variable is the mortality rate for adults (*mort_rate*), i.e. the probability of a 15-year-old dying before reaching age 60 if subject to current age-specific mortality rates between those ages. We prefer this variable to the number of people in working age and to the crude death rates for adults, as it is not affected by the demographic structure of population. The estimated impact of changes in total health expenditure (*health_exp*) on the probability in question is later recalculated into the effect on the size of working age population[18]. We also control for the number of "external" deaths (i.e. not health-related, e.g. road traffic deaths, *ex_deaths, "+"*), the consumption of alcohol (*alcohol, "+"*[19]) as a proxy for unhealthy attitudes in population and the measure of air pollution (*pollutants, "+"*[20]) to account for the environmental determinants of health. To isolate the effect of health expenditure from the effect of improvement in general wealth, we also estimate an additional variant of the third equation with GDP per capita (*gdp_capita, "+"*[21]).

Our three models may be summarised by the following panel equations:

$$ln\_gdp\_employed_{it} = b_0 + b_i + \alpha_1 ln\_health\_exp_{it} + \alpha_2 ln\_edu_{it} + \\ + \alpha_3 ln\_capital_{it} + \alpha_4 output\_gap_{it} + \alpha_5 govern_{it} + \alpha_6 ln\_hours_{it} + \varepsilon_{it} \quad (2)$$

$$ln\_emp\_rate_{it} = c_0 + c_i + \beta_1 ln\_health\_exp_{it} + \beta_2 tax\_wedge_{it} + \\ + \beta_3 women\_part_{it} + \beta_4 output\_gap_{it} + \epsilon_{it} \quad (3)$$

$$ln\_mort\_rate_{it} = d_0 + d_i + \gamma_1 ln\_health\_exp_{it} + \gamma_2 ln\_ex\_deaths_{it} + \\ + \gamma_3 alcohol_{it} + \gamma_4 pollutants_{it} + \gamma_5 ln\_gdp\_capita_{it} + \mu_{it} \quad (4)$$

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[18] Technical details of this derivation may be provided by the authors upon request.

[19] Cf. A. Di Castelnuovo, S. Costanzo, V. Bagnardi, M. Donati, L. Iacoviello, G. de Gaetano, *Alcohol Dosing and Total Mortality in Men and Women: An Updated Meta-analysis of 34 Prospective Studies*, "Archives of Internal Medicine" 2006, vol. 166(22), pp. 2437–2445.

[20] Cf. R. Beelen et al., *Effects of long-term exposure to air pollution on natural-cause mortality: an analysis of 22 European cohorts within the multicentre ESCAPE project*, "The Lancet" 2014, vol. 383, no. 9919, pp. 785–795.

[21] See e.g. J.A. Macinko, L. Shi, B. Starfield, *Wage inequality, the health system, and infant mortality in wealthy industrialized countries, 1970–1996*, "Social Science & Medicine" 2004, vol. 58(2), pp. 279–292.

in which *ln* stands for the natural logarithm of a variable[22]; b_0, c_0, d_0 are intercepts that are common for all countries in the respective equations; b_i, c_i, d_i represent country-specific effects that are time invariant and ε_{it}, ϵ_{it}, μ_{it} are error terms.

We estimate each of the three equations using a set of panel estimators. We start with the pooled estimator (*ols*) which disregards the presence of country-specific fixed effects (b_i, c_i, d_i) stemming from the time-invariant characteristics of a given country that affect the dependent variable. If these effects are present, the estimator is biased, hence we treat it as the first approximation only.

Next, we apply the fixed effects (*fe*) and random effects estimators (*re*), which assume homogeneous coefficients of the explanatory variables but do allow for country-specific effects. We use Wald test to check whether at least one country effect is significantly different from zero and Breusch and Pagan test to deduce whether variance of country effects is significantly different from zero. To decide between *fe* and *re* models we run the Hausman test.

Since our panels are unbalanced and many autocorrelation and cross-sectional dependence tests are not feasible, we use i.a. Driscoll and Kraay[23] nonparametric covariance matrix estimator (*dk*), which controls for these violations of standard assumptions and provides us with the (potentially) corrected standard errors. Thanks to this approach we are able to check whether the correction for potential autocorrelation and cross-sectional dependence in error terms leads to significant changes in the obtained results.

We estimate our panel equations using levels of the variables instead of using their differences or growth rates. This approach implies that we assume long run cointegrating relationships between the independent and the respective explanatory variables, as most variables are indicated as I (1) by the Maddala and Wu[24] and Pesaran[25] tests. If the explanatory variables are strictly exogenous, then the abovementioned models are adequate. If it is not the case, the estimates are asymptotically non-Gaussian, biased and are a function of non-scalar nuisance parameters. To control for this effect, we also apply Fully Modified OLS estimator (*fm_ols*) that corrects our estimates for the

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22 All the dependent and health expenditure variables are expressed in logarithms to obtain estimates of elasticities. Some other variables are introduced to the models in logarithms as (i) a reference to Cobb-Douglas production function (eq. (1): *edu*, *capital*), (ii) we intend to estimate elasticities (eq. (1): *hours*, eq. (3): *ex_deaths*, *gdp_capita*). On the other hand, the variables that take negative values (*output_gap*) or are expressed in ordinal scale (*govern*) were not logarithmised.

23 J.C. Driscoll, A.C. Kraay, *Consistent Covariance Matrix Estimation with Spatially Dependent Panel Data*, "Review of Economics and Statistics" 1998, vol. 80, pp. 549–560.

24 G.S. Maddala, S. Wu, *A comparative study of unit root tests with panel data and a new simple test*, "Oxford Bulletin of Economics and Statistics" 1999, vol. 61, pp. 631–652.

25 K. Im, H. Pesaran, Y. Shin, *Testing for unit roots in heterogeneous panels*, "Journal of Econometrics" 2003, vol. 115(1), pp. 53–74.

problems caused by the long run correlation between the cointegrating equation and stochastic regressors innovations.

There is one more estimation concern that is specific for the first equation. It is possible that health expenditure in this model is still endogenous. This stems from the fact that health spending may not only stimulate labour productivity, but may itself increase as a result of GDP growth and this growth in the long run is mostly driven by changes in labour productivity. In the case of such a simultaneity, the obtained estimate for health expenditure effect on labour productivity may be inconsistent and biased. To test for sensitivity to this issue, we additionally estimate the first equation with the two-stage least squares estimator (*2sls*) using the share of the elderly (people aged 65 years and over) in population and three-year lag of health expenditure as instrumental variables[26].

It is worth mentioning that in our estimation process some of the abovementioned approaches may be combined, e.g. we may use a two-stage ordinary least squares estimator with fixed effects (*fe_2sls*).

Most variables used in the analysis were extracted from the OECD database. Other data sources include the World Bank (*mort_rate* and *govern* variables) and Penn World Table (*capital* variable)[27]. The utilised panel dataset contains observations for 34 OECD countries in the years 1990–2012. This let us investigate economic effects of health expenditure in developed countries. As observations for some countries and time periods are missing, our panel dataset is unbalanced. Descriptions of the variables and their sources are included in Table 1.

3. Estimation results

Our estimation results are presented in Table 2 (labour productivity equation), Table 3 (employment rate equation) and Table 4 (mortality rate equation).

We begin with observation that for all estimated equations the results of Breusch and Pagan and Wald statistical tests indicate that random (*re*) and fixed (*fe*) effects

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[26] Share of the elderly in population should be a good instrumental variable in our analysis, since older people face more health problems and demand more health spending. The influence of ageing on labour productivity is not that clear. While older workers are more experienced, they may be less efficient due to age-related issues. Using a lag of the dependent variable as an instrument is a common approach in time series and panel econometrics.

[27] R.C. Feenstra, R. Inklaar, M.P. Timmer, *The Next Generation of the Penn World Table*, NBER Working Papers no. 19255, 2013, pp. 1–42, www.ggdc.net/pwt.

models fit data better than the simple pooled model (*ols*). Moreover, outcomes of the Hausman test suggests that *re* model assumptions are not satisfied, thus we base our discussion of the results on different variants of *fe* model.

In the first equation the obtained estimates imply that an increase of one percent in *per capita* health expenditure corresponds to approximately 0.22 percent increase in labour productivity on average in OECD countries, other thing being equal. This effect is statistically significant at 0.01 level and robust to application of different estimators. This is true specifically for instrumental variables estimation (*fe_2sls*) that might be regarded as more adequate[28] for the first equation with potentially endogenous health expenditure variable. However, the obtained coefficient of 0.21 for health spending with this approach is very similar to other fixed effects estimates.

Table 1. Variables: descriptions and sources

Variable	Description	Source
variable of interest – all equations		
health_exp	Total (general government and private) health expenditure at constant PPP prices per capita	OECD
labour productivity equation		
gdp_employed	GDP per employed at constant PPP prices	OECD
edu	Share of persons aged 25–64 years with tertiary education in persons aged 25–64 years	OECD
capital	Capital stock at constant PPP prices per employed, own calculation based on data for capital stock at constant 2005 national prices and capital stock at current PPPs	Penn World Table 8.0
output_gap	Actual GDP minus the potential GDP divided by the potential GDP	OECD
govern	Average of the World Bank governance indicators	The World Bank
hours_worked	Total number of hours worked over the year divided by total employment (intended for comparisons over time; not very suitable for comparisons between countries)	OECD
employment rate equation		
emp_rate	Share of employed persons aged 25–59 years in persons aged 25–59 years	OECD
tax_wedge	Average tax wedge for single person at 100% of average earnings, no child	OECD

[28] The result of Sargan test indicates that at least one of the utilised instruments in our two-stage ordinary least square estimation with fixed effects (*fe_2sls*) is exogenous. The instruments are also statistically significant with expected positive signs in the first stage regression (these results are available upon request).

Variable	Description	Source
women_part	Ratio of women labour participation rate to men labour participation rate for persons aged 25–59	OECD
output_gap	Actual GDP minus the potential GDP divided by the potential GDP	OECD
mortality rate equation		
mort_rate	Probability of a 15-year-old dying before reaching age 60, if subject to current age-specific mortality rates between those ages, average of data for men and women	The World Bank
ex_deaths	External deaths (e.g. accidents, assaults, suicides)	OECD
alcohol	Pure alcohol consumption per capita	OECD
pollutants	Average of standardized kg emissions per capita of (a) sulphur oxides, (b) nitrogen oxides, (c) carbon monoxide and (d) non-methane volatile organic compounds	OECD
gdp_capita	GDP per capita at constant PPP prices	OECD

Source: own elaboration based on data from OECD, World Bank and Penn World Table.

Table 2. Estimation results for the first equation explaining labour productivity

Dependent variable: ln_gdp_employed						
	ols	re	fe	fe_dk	fe_2sls	fe_fm_ols
ln_health_exp	0.1993***	0.2110***	0.2179***	0.2179***	0.2123***	0.2312***
	(0.0153)	(0.0213)	(0.0473)	(0.0095)	(0.0345)	(0.0290)
ln_edu	0.1072***	0.0100	0.0119	0.0119	0.0185	0.026179
	(0.0119)	(0.0179)	(0.0523)	(0.0115)	(0.0230)	(0.0311)
ln_capital	0.4009***	0.3921***	0.3994***	0.3994***	0.3576***	0.3949***
	(0.0222)	(0.0359)	(0.0906)	(0.0262)	(0.0431)	(0.0511)
output_gap	0.0122***	0.0075***	0.0072***	0.0072***	0.0071***	0.0073***
	(0.0017)	(0.0007)	(0.0011)	(0.0006)	(0.0008)	(0.0009)
govern	–0.0438***	0.0595***	0.0480	0.0480***	0.0218	0.039096
	(0.0120)	(0.0159)	(0.0393)	(0.0170)	(0.0197)	(0.0274)
ln_hours	–0.2955***	0.2004**	0.4020*	0.4020***	0.3184***	0.5264***
	(0.0448)	(0.0887)	(0.2336)	(0.1000)	(0.1141)	(0.1602)
Observations	472	472	472	472	454	434
Panels	34	34	34	34	33	33
R2-within	–	0.8379	0.8393	0.8393	0.8268	–
R2-between	–	0.9026	0.8868	0.8868	0.8802	–
R2-overall	0.9143	0.8889	0.8724	0.8724	0.8642	0.9893
Wald test (H0: all country specific fixed effects = 0, ols ≻ fe)						
p-value	–	–	0.0000	0.0000	0.0000	–
Breusch, Pagan test (H0: error term variances of country specific fixed effects = 0, ols ≻ re)						

p-value	–	0.0000	–	–	–	–
Hausman test (H0: country specific fixed effects not correlated with regressors, re ≻ fe)							
p-value	–	–	0.0000	–	–	–
Sargan test (H0: no correlation between error terms and instruments)							
p-value	–	–	–	–	0.0770	–

Notes: This table presents the estimated regression coefficients (standard errors in parentheses, * p<0.1, ** p<0.05, *** p<0.01) for the combination of applied estimators: ols – pooled ordinary least squares estimator with robust standard errors, re – random effects estimator with robust standard errors, fe – fixed effects estimator with robust standard errors, dk – estimator with Driscoll and Kray (1998) standard errors, 2sls – two-stage least squares estimator, fm_ols – fully modified ordinary least squares estimator.

Source: own elaboration based on data from OECD, World Bank and Penn World Table.

Most control variables in the first equation are statistically significant with expected signs of coefficients. More capital per employed person, more working hours and better governance (but only in one fixed effect estimation) are associated with higher expected labour productivity. Positive estimate for output gap implies that labour productivity in OECD countries is rather procyclical, which may be a result of labour hoarding during economic slowdowns. Surprisingly, higher share of population with tertiary education (*edu)* does not seem to influence labour productivity in fixed effects regressions. We suppose that, among developed countries, this variable may not properly capture the differences in quality of human capital.

The results for the second equation show that an increase of one percent in *per capita* health spending may lead to 0.03 percent higher employment rates in OECD countries[29]. This estimate is statistically significant at 0.01 significance level and stable across various estimators. In the second equation all the estimated coefficients for other explanatory variables are also statistically significant at 0.01. Higher tax wedge, higher women labour participation and better shape of the economy are, in line with expectations, accompanied by higher employment rates.

The obtained estimates for the third equation suggest that a rise of one percent in per capita health expenditure decreases the adult mortality rate, i.e. the probability that 15-year-old will die before reaching age 60, in OECD countries by approximately 0.36 percent. This result is statistically significant at 0.01 significance level for all the applied estimators. The differences in the obtained coefficients between utilised fixed effects estimators are again very small. This decrease can be transformed into an increment of working age population, for example in Poland by 0.0140%[30].

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[29] 0.03 *percent* change in employment rate should not be confused with a change of 0.03 *percentage points* in employment rate.

[30] To see this, express the survival probability between age 15 and 59 as a product of annual survival probabilities from 15 to 16, from 16 to 17 etc. These probabilities in the factual scenario can be implied from the demographic tables by Eurostat. Should the probability of dying before 60 decrease

Table 3. Estimation results for the second equation explaining employment rates

Dependent variable: ln_emp_rate					
	ols	re	fe	fe_dk	fe_fm_ols
ln_health_exp	0.0508***	0.0338***	0.0300***	0.0300**	0.0314***
	(0.0057)	(0.0063)	(0.0082)	–0.0116	–0.0104
tax_wedge	–0.0017***	–0.0022***	–0.0028***	–0.0028***	–0.0034***
	(0.0002)	(0.0004)	(0.0007)	(0.0005)	(0.0008)
women_part	0.0055***	0.0049***	0.0046***	0.0046***	0.0042***
	(0.0003)	(0.0004)	(0.0005)	(0.0005)	(0.0005)
output_gap	0.0045***	0.0048***	0.0047***	0.0047***	0.0050***
	(0.0008)	(0.0003)	(0.0005)	(0.0006)	(0.0004)
Observations	396	396	396	396	351
Panels	34	34	34	34	32
R2-within	–	0.6488	0.6511	0.6511	–
R2-between	–	0.8118	0.7747	0.7747	–
R2-overall	0.7067	0.6870	0.6323	0.6323	0.9709
Wald test (H0: all country specific fixed effects = 0, ols ≻ fe)					
p-value	–	–	0.0000	–	–
Breusch, Pagan test (H0: error term variances of country specific fixed effects = 0, ols ≻ re)					
p-value	–	0.0000	–	–	–
Hausman test (H0: country specific fixed effects not correlated with regressors, re ≻ fe)					
p-value	–	–	0.0000	–	–

Notes: This table presents the estimated regression coefficients (standard errors in parentheses, * p<0.1, ** p<0.05, *** p<0.01) for the combination of applied estimators: ols – pooled ordinary least squares estimator with robust standard errors, re – random effects estimator with robust standard errors, fe – fixed effects estimator with robust standard errors, dk – estimator with Driscoll and Kray (1998) standard errors, fm_ols – fully modified ordinary least squares estimator.

Source: own elaboration based on data from OECD.

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by 0,36%, then the survival probability is expected to rise by the same number. Hence, annual survival probabilities should rise for any age between 15 and 59 to yield the expected change in the product. We assume that all annual death probabilities change proportionately downwards. This mechanism yields a dynamic adjustment mechanism lasting until the youngest cohort at the moment of regime change retires. In the example for Poland, after 1 year, the result is 0,0012% increase in working age population. However, this effect should accumulate over time and a better proxy for long-term effect is the size of the cohort that was 15 years old at the moment of health expenditure growth at the moment when it retires, expressed as the difference between counterfactual and factual scenario. This implies a long-term difference of 0,0140%. We further treat this estimate as representative for the OECD countries.

Table 4. Estimation results for the third equation explaining mortality rates

Dependent variable: ln_mort_rate						
	ols	re	fe	fe_dk	fe_fm_ols	fe_fm_ols (II)
ln_health_exp	–0.2209***	–0.3482***	–0.3598***	–0.3598***	–0.3763***	–0.3403***
	(0.0160)	(0.0247)	(0.0842)	(0.0163)	(0.0219)	(0.0442)
ln_ex_deaths	0.4314***	0.2972***	0.2939***	0.2939***	0.2837***	0.2764***
	(0.0258)	(0.0285)	(0.0625)	(0.0245)	(0.0398)	(0.0417)
alcohol	0.0269***	0.0114***	0.0088	0.0088***	0.0099**	0.0114**
	(0.0020)	(0.0033)	(0.0087)	(0.0029)	(0.0049)	(0.0053)
pollutants	0.0459***	0.0218***	0.0171	0.0171**	0.0154	0.0156
	(0.0076)	(0.0077)	(0.0245)	(0.0071)	(0.0122)	(0.0124)
ln_gdp	–	–	–	–	–	–0.0626
	–	–	–	–	–	(0.0736)
Observations	594	594	594	594	550	546
Panels	33	33	33	33	32	31
R2-within	–	0.8418	0.8422	0.8422	–	–
R2-between	–	0.6338	0.6115	0.6115	–	–
R2-overall	0.7397	0.6595	0.6427	0.6427	0.9655	0.9657
Wald test (H0: all country specific fixed effects = 0, ols ≻ fe)						
p-value	–	–	0.0000	0.0000	–	
Breusch, Pagan test (H0: error term variances of country specific fixed effects = 0, ols ≻ re)						
p-value	–	0.0000	–	–	–	
Hausman test (H0: country specific fixed effects not correlated with regressors, re ≻ fe)						
p-value	–		0.0003	–	–	

Notes: This table presents the estimated regression coefficients (standard errors in parentheses, * p<0.1, ** p<0.05, *** p<0.01) for the combination of applied estimators: ols – pooled ordinary least squares estimator with robust standard errors, re – random effects estimator with robust standard errors, fe – fixed effects estimator with robust standard errors, dk – estimator with Driscoll and Kray (1998) standard errors, fm_ols – fully modified ordinary least squares estimator.

Source: own elaboration based on data from OECD and World Bank.

Our estimation results confirm the obvious negative link between the number of deaths due to external causes and mortality rate for adults. They also imply that higher alcohol consumption (and/or poor health attitudes that it may approximate) decrease the analysed probability of dying. Higher level of air pollution significantly increases the dependent variable only in one variant of fixed effect estimation (*fe_dk*). In addition to this, when one controls for the impact of health expenditure on the mortality rate for adults, the dependent variable is not significantly affected by the level of GDP per capita (*fe_fm_ols (II)*).

Having discussed the results for the three estimated equations, we are able to compare the magnitude of health expenditure impact on the economy for the three analysed channels. We find that an increase of one percent in health spending *per capita* has the strongest influence on labour productivity (0.22%, presenteeism and absenteeism channel). The influence of health expenditure is significantly smaller for employment (0.03%, working disability channel) and the weakest for the number of people in working age (0.01%, mortality channel).

Combining the three estimated effects, one may calculate that on average an increase of one percent in per capita health expenditure in OECD countries has historically been accompanied by 0.26 percent[31] growth in gross domestic product.

4. Conclusions and further research

This paper attempts to estimate the impact of health expenditure on GDP in high-income countries (OECD sample) by adding more economic structure of theoretical transmission channels from health spending to productive capacity of the economy. This should address the well-known issue of feedback effects between health and GDP, leading to inconsistent and biased estimates, and – in the end – potential overestimation of the impact of health on the economy. Our approach is based on three separate panel regressions, simulating the effect of presenteeism and absenteeism (via labour productivity), long-term disability (via employment rate) and mortality (via probability of death during working age). In all three cases, health expenditure has turned out to act in a GDP-improving, statistically significant way and the control variables take economically acceptable signs. We find that increase in health spending has the largest impact on GDP via enhancement of labour productivity and the smallest impact on GDP via reduction in the probability of death.

According to our results, we GDP is predicted to rise by approximately 0.26 percent in line with a sustainable increase of health expenditure by one percent. This result may be of importance while designing health policies in the context of population ageing.

Some reservations, however, have to be made. Our measurement is based on the health expenditure, not the health stock itself. The longitudinal approach – while efficient under short time series – averages out the efficiencies of "health production function" between different healthcare systems, while the differences might be substantial. It can also be argued that our disaggregation proposal does not fully solve the

[31] (1.0022*1.0003*1.0001–1) *100%=0.26%

issue of endogeneity, even though it seems to be limited, as far as formal and economic verification is possible.

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O wpływie wydatków zdrowotnych na PKB w państwach OECD

Streszczenie

Szacujemy wpływ wydatków zdrowotnych na PKB w próbie państw OECD, uzupełniając powszechne w literaturze przedmiotu modele w formie zredukowanej o pełniejsze odzwierciedlenie ekonomicznych kanałów wpływu wydatków zdrowotnych na potencjał gospodarki. Nasze podejście bazuje na trzech osobnych równaniach regresji panelowej, odzwierciedlających efekt „prezenteizmu" i „absenteizmu" (przez wydajność pracy), długotrwałej niezdolności do pracy (przez stopę zatrudnienia) oraz zgonów (przez prawdopodobieństwo zgonu w wieku produkcyjnym). We wszystkich trzech przypadkach wydatki zdrowotne oddziałują na PKB w statystycznie istotny, dodatni sposób.

Słowa kluczowe: wydatki na ochronę zdrowia, koszty pośrednie chorób, efektywność w ochronie zdrowia, estymacja panelowa

JEL: C23, C33, I13, I15

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