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Tomoki FUJII
Singapore Management University, tfujii@smu.edu.sg

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*School of Economics, Singapore Management University,

90 Stamford Road, Singapore 178903

Phone: +65-6828-0279

Fax: +65-6828-0833

e-mail: tfujii@smu.edu.sg

Tomoki FUJII*

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Abstract

We study the differential impacts of public and private sources of health spending on health outcomes using a triple difference approach. We find that private health spending has on average a higher health-promoting effect than public health spending. This result is robust with respect to the choice of outcome measure and covariates in the regression and driven primarily by the countries with ineffective governments. Once we restrict our sample to countries with effective governments, private health spending is no better than public health spending for improving the health outcome.

JEL classification codes: I10, I15, I18

Keywords: Child mortality rate, Life expectancy at birth, Health spending, Government effectiveness, Triple difference

1 Introduction

Over the last few decades, the overall health status of people around the world have significantly improved. On average, people live longer than ever before, regardless of their income level. In high income countries (HIC), the life expectancy at birth (LEAB) has increased from about 70 years in 1970 to around 80 in 2010 (Figure 1(a)). During the same period, low income countries (LIC) and middle income countries (MIC) have achieved an even larger increase in LEAB. Similarly. the under-five mortality rate (U5MR) has dropped substantially. This improvement is particularly apparent in LIC and MIC (Figure 1(b)).

There are a few (plausible) reasons for this remarkable improvement. First, the advancement of medicine has enabled the prevention and treatment of diseases that were previously not possible. Second, higher standards of living have also contributed to the improvement in health as people can get more and better food and clean and safe drinking water. For example, Pritchett and Summers (1996) found that richer people tend to be healthier and live longer on average. Finally, richer people and people in richer countries also tend to enjoy better public health and sanitation and receive better education, which in turn help people to avoid contracting preventable diseases and live a healthier life overall.

However, there are considerable variations in health across individuals and countries even at a similar level of income. For example, according to the World Development Indicators (WDI) compiled by the World Bank, the highest and lowest LEAB in 2010 among upper middle income countries were 79.2 (Costa Rica) and 53.1 (Botswana) years, respectively, even though the Gross Domestic Product (GDP) per capita of Botswana in purchasing power parity exceeds that of Costa Rica. Thus, it is clear that higher income alone cannot guarantee healthier life.

One obvious question that arises here is what other factors affect health outcomes. There are indeed a number of factors that potentially affect health. Some factors are difficult to change by policy at least in the short run. For example, the diet varies substantially across countries even at a similar level of income and it affects the health of a nation. The disease environment is also different from place to place even for countries at a similar level of income. On the other hand, policy-makers may be able to control their country's health financing, at least to a certain degree. Thus, we investigate whether and how different sources of health spending affect health outcomes.

This is an important research question. According to the World Health Organization (2010), 20-40 percent of health resources are being wasted at a conservative estimate. This is clearly an important problem for poor countries, because they cannot afford to waste any resources. It is also an important problem for rich countries because the health expenditure share in GDP tends to be higher for richer countries as shown in Section 3. Hence, efficient provision of health-care services is critical for both rich and poor countries.

One important source of health financing is public health expenditure. It is an important source because it can potentially improve the health of millions of people, who

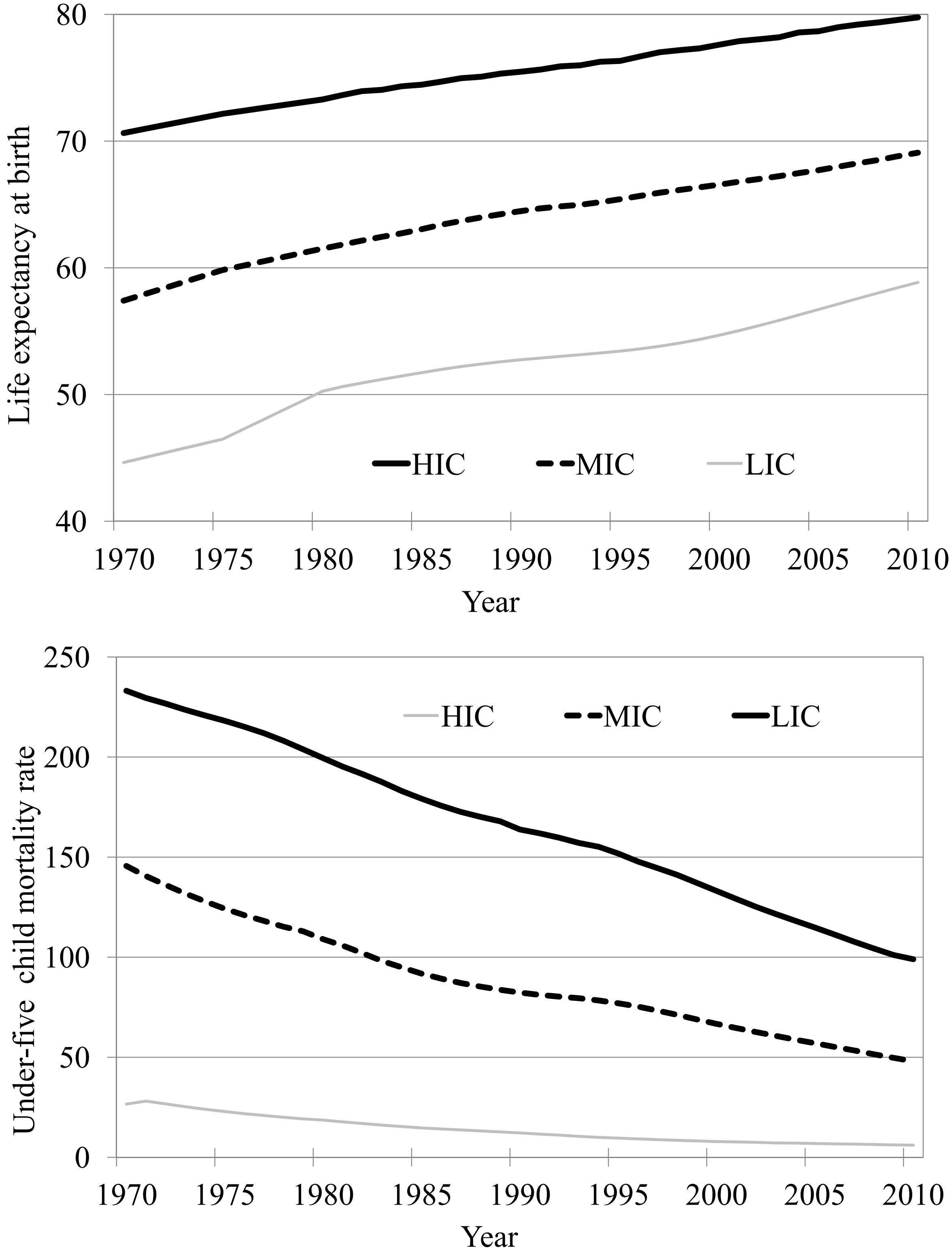


Figure 1: The changes in (a) life expectancy at birth in years (top) and (b) under-five child mortality rate in the number of deaths per thousand live births (bottom) over time (Source: World Development Indicators).

are prevented from receiving health care by the obligation to pay directly at the moment of need (World Health Organization, 2010). Public involvement is also desirable when the consumption of health-care services entail positive externalities, as is the case for the immunization for vector-borne diseases, or when the government can mitigate the information asymmetry in the health sector, for example, between doctors and patients.

However, government intervention can lead to inefficient health-care provision when it interferes with the incentive structure. Another potential issue with the government intervention is that it is often inequitable as the non-poor are typically the main beneficiaries of free or subsidized health care, which tends to be available only in urban hospitals. This issue is particularly salient in developing countries. Even if services are available in every area, wealthier people may benefit more from health care provided by the government because they can afford the travel and time costs (Musgrove, 1996). Government spending may also be inefficient in the presence of corruption, because the government health-care payments may be diverted for other purposes.

Another important source of health financing is private health expenditure, which includes out-of-pocket expenditure and private health insurance among others. Out-of-pocket expenditure has a desirable property from the efficiency perspective under some assumptions. That is, consumers (patients) have an incentive to pay health-care expenses out of pocket only when the private marginal cost of health care is no greater than the private marginal benefit. Thus, non-negligible out-of-pocket payment helps to prevent excess use of medical services (Ellis and McGuire, 1993).

Private health insurance allows individuals to share the risk of unexpected medical costs and allow them to receive expensive but rarely needed life-saving health-care services when they are necessary. While publically provided health insurance also fulfills the same purpose and over-utilization and cost escalation can be a concern even for private insurance (e.g., Psacharopoulos and Nguyen (1997)), private insurance companies have a direct financial incentive to keep the payments for unnecessary medical treatments in check. Therefore, in the absence of information asymmetry, externality, and other market failures, private sources of health expenditure are likely to be more efficiently used than public sources.

In reality, however, various forms of market failures exist and they are far from negligible. The information asymmetry between doctors and patients is well known. Partly for this reason, markets for health-care services are normally regulated. Similarly, adverse selection and moral hazard in the private health insurance market can also be a serious problem.

The discussion above indicates that the impact of health spending on health outcomes is likely to vary with the source of health spending. Because public and private sources have different strengths and weaknesses, which source has a more positive health effect is an empirical question. Therefore, we investigate this question using a cross-country panel data set that covers almost all the countries and areas in the world. As we elaborate in Section 2, there are many studies that look at the difference between private and public ownership of hospitals. However, to our knowledge, this is the first study to systematically link private and public sources of health financing directly to health outcomes around the world over a long time horizon.

One of the possible reasons why previous study on this topic is nonexistent is because the identification of the effect of different sources of health expenditure is difficult because health expenditure is endogenous. That is, people may live longer because they have more and better health care. However, at the same time, they may need to allocate a higher share of their incomes to health care because they live longer.

We tackle the endogeneity issue by triple difference, or difference in differences in differences, where the differences are taken along the dimensions over time, share of health spending in GDP, and private share in health spending. This approach allows us to isolate the effect of different mix of private and public sources for health spending from the total amount of health spending as a share of GDP. As we elaborate subsequently, our triple difference approach plausibly allows us to identify the effect of private source of health expenditure relative to public expenditure.

Our main finding is that health spending on average tends to have a higher health-promoting effect when it comes from a private source than when it comes from a public source. However, this difference is primarily driven by the presence of countries in which the government is ineffective. When we analyze the subsample of countries with effective governments, we do not find any evidence that private sources of health spending have a higher health-promoting effect. Given that the public share in health spending has been increasing over the last two decades as shown in Section 3, it is important to consider carefully whether this general trend is desirable.

This paper is organized as follows. In the next section, we review relevant studies. In Section 3, we describe the data and some measurement issues. To convey the basic idea behind the triple difference approach, we start with a naïve version in Section 4, where all the three dimensions along which differences are taken are dichotomized. Then, we consider various regression versions of triple difference in Section 5, which allow us to explicitly take into account different levels of health spending share in GDP and private share in health spending. We offer some discussion and policy implications in Section 6.

2 Review of related literature

One of the first studies on the relationship between health inputs and health outcomes is Auster et al. (1969). Estimating cross-state regression models in the United States, they find that medical care is related to better health (age-adjusted mortality), though environmental variables are found to be far more important. Using data for six OECD countries, Wolfe (1986) finds that health-care expenditures bear a positive relationship to health status once the life-style variables such as smoking and drinking are controlled for.

A number of subsequent studies also find a positive relationship between health inputs and health outcomes. Hitiris and Posnett (1992) find that lower mortality rates are associated with higher total health spending per capita after controlling for, among others, GDP per capita. Using a panel data for ten Canadian provinces over 15 years, Crémieux et al. (1999) find that lower health spending is associated with a statistically significant increase in infant mortality and a decrease in life expectancy. Anand and Bärninghausen (2004) find a significant and positive relationship between the density of human resources for health (i.e., doctors and nurses) and health outcomes. Similarly, Martin et al. (2008)

find that the marginal cost of a life year saved is quite low and challenge the view that health care has little marginal impact on health.

However, these results are far from overwhelming. Using a cross-country data for 117 countries, Kim and Moody (1992) find that health resource measures do not have significant explanatory power of the variations in infant mortality rates, once socioeconomic resources that have impact on health—such as income, food consumption, education, and access to safe water—are controlled for. Their findings are consistent with Filmer and Pritchett (1999), who find that the impact of public spending on child mortality and infant mortality are small, even though their finding was challenged by Hanmer et al. (2003). McGuire (2006) finds that developing countries with more health spending do not have systematically lower U5MR, whereas countries with better infant health-care services do. Nixon and Ulmann (2006) also find that the contribution of health-care expenditure to health was small in the 15 EU countries over the period 1980-1995.

The discussion above indicates that the relationship between health inputs and outputs is far from obvious. It is indeed not very surprising to have these apparently conflicting results. On one hand, a higher health spending may lead to a better health outcome if health-care services directly improve the health status of individuals. On the other hand, the healthiest people are generally those people who do not need to spend much on health care. Therefore, it is *a priori* not clear whether the health spending is positively or negatively related to health outcomes.

While we also study the relationship between health input and output, our study is different from the above-mentioned studies in three aspects. First, we clearly distinguish between private and public sources of health spending. In this sense, our study is related to Self and Grabowski (2003), who find that disability-adjusted life expectancy tends to increase with public health spending but not with private health spending in middle and less developed countries in their cross-country regressions. However, they do not appropriately account for the unobserved heterogeneity across countries. A similar issue exists in Anand and Ravallion (1993), who run a regression of shortfall of life expectancy on public, but not private, health spending per capita, among others. Kennelly et al.

(2003) include the share of public health spending in the total health spending in their regression analysis but omit the total health expenditure in the regression. Therefore, an increased private health expenditure would not affect the health outcome at all in Anand and Ravallion (1993) and only through the decreased share of public spending on health in Kennelly et al. (2003), both of which appear implausible. In contrast to these studies, we control for the total health expenditure as a share of GDP, among others, to estimate the differential impacts of private and public health spending on health outcomes.

Second, we use a panel data set for our regression analysis, which allows us to control for the time-invariant unobserved heterogeneity across countries. While there have been a few studies that use a panel data, we cover a longer period of time and a larger number of countries such that this study does not suffer from the concern for over-fitting unlike some other studies.

Finally, we take into account the quality of the government in our analysis. Because the effects of health expenditure from public sources are likely to depend on how the government manages its spending, the quality of government is likely to matter. Despite this apparent importance, little attention was paid to the government quality in the cross-country analysis of health expenditures and health outcomes. Therefore, we explicitly incorporate the government quality into our analysis. Indeed, our empirical analysis shows that the quality of government matters significantly.

This study further relates to three strands of literature. First, it relates to a large body of literature on the relationship between the hospital ownership and its performance. In this literature, private and pubic hospitals are compared by some performance measures often using the data envelopment analysis (DEA). For example, Chang et al. (2004) find that private hospitals have a higher operating efficiency than public hospitals in Taiwan using DEA. Similarly, Tiemann and Schreyögg (2012) find that the conversions from public to private for-profit status were a associated with an increased in efficiency in Germany. In Bangladesh, private hospitals were perceived to be better on responsiveness, communication, and discipline based on a survey dataset (Andaleeb, 2000). On the other hand, in the US, public hospitals are found more efficient than private hospitals (Hollingsworth et al., 1999; Hollingsworth, 2003, 2008). Even in the same country, the relative efficiency of private and public hospitals is mixed (see Tiemann et al. (2012) for the case of Germany). By bringing the unit of analysis to a country, we complement this literature.

Second, this study is relevant to a large body of literature on the determinants of health spending (e.g., Fuchs (1990); Gerdtham (1992); Gerdtham et al. (1992); Di Matteo and Di Matteo (1998); and Newhouse (1987, 1992)). A common observation in this literature is that health-care expenditure rises faster than aggregate income per capita and that income per capita is the most important determinant of health spending.[1] Thus, compared with poorer nations, wealthier nations tends to spend more than proportionately on health care, a point that is sometimes taken as evidence for the assertion that health care is a luxury good. While we do not try to prove or disprove this assertion, we contribute to this literature by underscoring the importance of the distinction between private and public sources and between out-of-pocket and other private sources.

Third, this study also contributes to the body of literature on the role of private sector in the provision of health-care services. Berman and Rose (1996) study the role of private sector in meeting the needs for maternal and child health in 11 developing countries and find that public sector tends to play a more significant role in the provision of health-care services with public-goods property (e.g., immunization of infectious diseases) than health-care services that can be considered private goods (e.g., treatment of diarrhea and acute respiratory infections). On the other hand, Bojalil et al. (1998) report that the quality of private general practitioners are worse than public ones, which may be because of the poor quality control of physicians. A similar finding is made in Bolivia, Ecuador, Guatemala, Nicaragua, Panama, and Peru (Waters et al., 2008).

Therefore, even though the importance of private sector engagement in health care is well recognized (See, for example, Bustreo et al. (2003)) and private health-care providers already coexist with public ones in many poor countries (Meessen et al., 2011), it is not clear on balance how private and public sources of health financing perform from

[1] A notable exception is Sen (2005). He finds that the income elasticity of health expenditure is well less than unity once year- and country-specific factors and other demand and supply factors and are controlled for.

the perspective of improving health outcomes. This research answers this question by explicitly distinguishing between private and public sources of health spending.

3 Data

The primary data source for this study is the World Development Indicators (WDI) compiled by the World Bank.[2] The WDI database covers a number of country-level variables including health outcome variables, health spending from various sources, and other covariate such as GDP per capita. Although the time-series dimension of the WDI starts from 1960, the health spending data in the WDI database are available only from 1995. Therefore, this study will focus on the two decades starting from 1995. We shall call the 1995-2004 and 2005-2014 periods the first and second decades, respectively.

We use the life expectancy at birth (LEAB) taken from the WDI database as the main measure of overall health status, where the LEAB represents the number of years a newborn infant would live if the prevailing patterns of mortality at the time of its birth were to stay the same throughout its life. We chose to use the LEAB as the main health outcome variable for three reasons. First, the LEAB is available every year or almost every year in many countries and regions in recent years. Because it is calculated from the mortality of all age groups, it reflects the health of people for all age groups rather than certain specific groups, which other common health measures such as the mortality rate for children under five (U5MR) do not possess. This point is important because the WDI database contains only aggregated data for health spending rather than spending targeted at specific age groups. For this reason, we take LEAB as the main health outcome of interest.

We also take some covariates from the WDI database. The main variables of interest in this database are the following variables: the health expenditure share in GDP (HESH) and private health expenditure share (PRHS), which is calculated as one minus the share of public sources in the total health expenditure. HESH is slightly positively correlated

[2] `http://data.worldbank.org/data-catalog/world-development-indicators` accessed on July 15, 2017. We use the version updated on July 1, 2017.

Table 1: Key summary statistics

Variable	1994-1999	2000-2004	2005-2009	2010-2014
Life expectancy at birth	66.20	67.23	68.82	70.46
(LEAB, years)*	(9.88)	(10.05)	(9.45)	(8.72)
Health expenditure share in GDP	5.78	6.03	6.32	6.66
(HESH, %)*	(2.36)	(2.29)	(2.40)	(2.57)
Private health share in total health	44.13	43.95	43.00	41.54
expenditure (PRHS, %)*	(19.81)	(19.73)	(19.55)	(18.52)
Logarithmic GDP per capita	8.78	8.89	9.04	9.13
(PPP, const 2011 US dollar)	(1.22)	(1.24)	(1.24)	(1.20)
Share of population with access	81.61	83.50	85.64	87.71
to improved water source (%)	(19.09)	(17.64)	(16.23)	(15.03)
Under five mortality rate	61.21	52.45	43.15	35.59
(U5MR, per 1,000 live birth)*	(62.13)	(53.43)	(44.07)	(36.30)
Number of observations	179	182	179	179

Note: the sample standard deviation is reported in parentheses below the mean. The number of observations apply to those variables followed by an asterisk (*). The number of observations for other variables is slightly smaller due to missing values.

with GDP per capita whereas PRHS is negatively correlated with GDP per capita as shown in Figure 2.

Table 1 reports some summary statistics for the key variables mentioned above. It shows that LEAB and U5MR improved over time as already discussed earlier. It also shows that the income level and access to water went up around the world. At the same time, HESH has increased over time, reflecting the fact that people live longer and that older people tend to need more health-care services. On the other hand, PRHS dropped over time, which indicates the trend for a higher public involvement in health-care services. As the large standard deviation of PRHS and Figure 2(b) indicate, there is a large variation in PRHS across countries. Therefore, it is both interesting and important to understand how the private share matters for health outcomes.

Along with these health expenditure indicators, we also consider other covariates that are found to be important determinants of health status in previous studies. The choice of covariate are also partly driven by the availability of relevant data annually. Arguably the most essential covariate is the income, for which we use the GDP per capita adjusted for purchasing power parity and expressed in constant international dollars. Further, as a

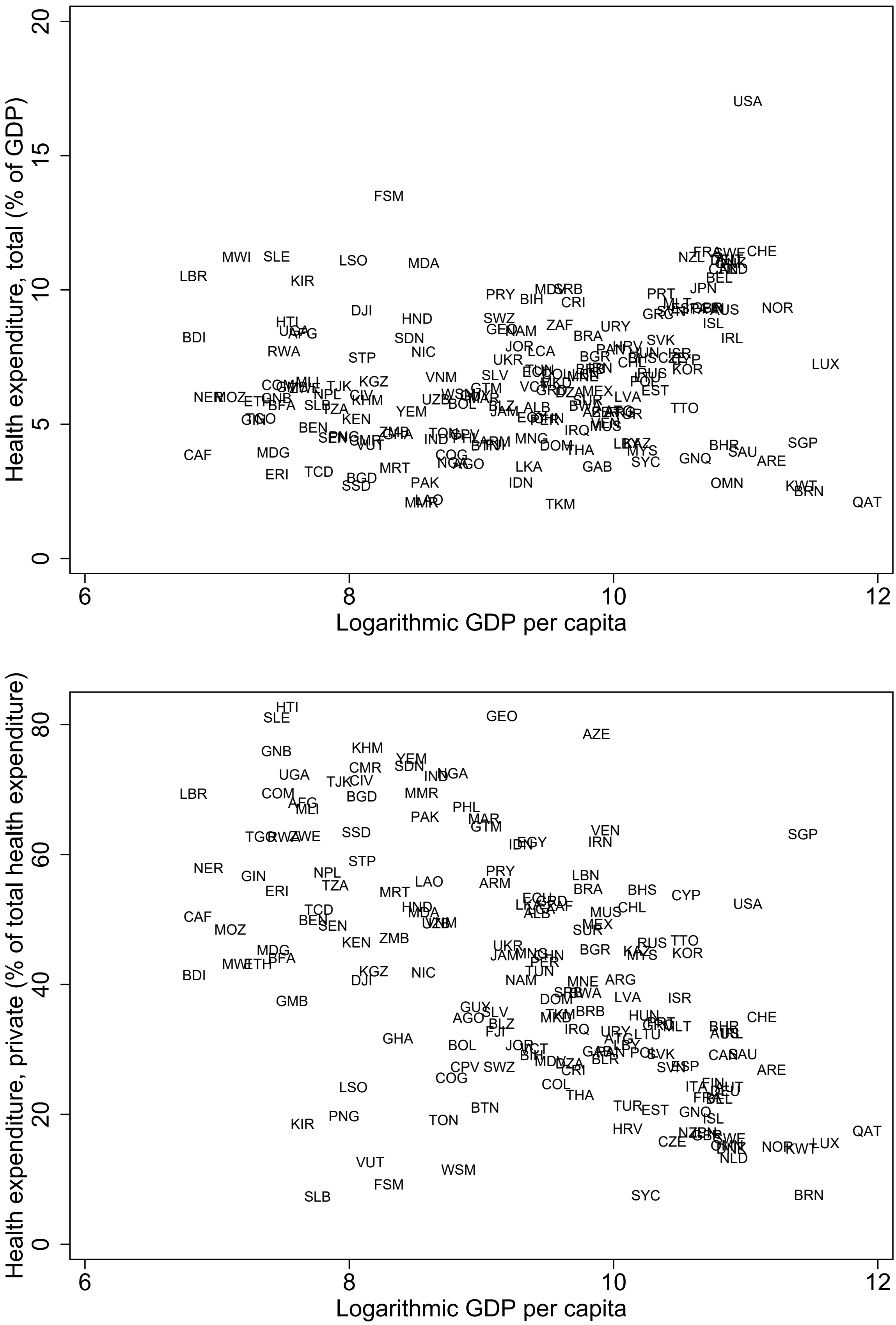


Figure 2: The scatter plot between (a) health expenditure share in GDP (top) and (b) private health share (bottom) against the logarithmic GDP per capita in the year 2010.

proxy for the public health conditions, we use the proportions of population with access to improved water source.

It is likely that the relative impact of public and private sources of heath spending depends on the quality of government. Therefore, as a proxy for the quality of government, we use the Government Effectiveness (GE) compiled in the World Governance Indicators compiled by the World Bank.[3] GE captures perceptions of the quality of public services, the quality of civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies (Kaufmann et al., 2010). GE is available every two years between 1996 and 2002 and every year after 2002.

4 Naïve Triple Difference

We start with a naïve version of triple difference analysis to convey the basic idea behind the triple difference approach. In this analysis, we dichotomize all the dimensions along which difference is taken. To this end, we first collapse the data over the time dimension to the first and second decades (i.e., the decade before and after 2005, respectively) by taking the average over each decade for each country or area.[4] We classify each country into either a low HESH country or a high HESH country based on whether the country's HESH before 2005 is below or above the median HESH in this period.[5] We also classify each country into either a high PRHS country or a low PRHS country in a similar manner. Therefore, we categorize each observation into one of the eight categories defined by before/after 2005, low/high HESH, and low/high PRHS. We then take the difference along each of these dimension to obtain triple difference.

In Table 2, we report the average LEAB for each of these eight categories and take the differences. Panel (A) focuses on the countries in which the private share in health spending is low. The left column ("Low health share") in this panel shows the average

[3] `http://info.worldbank.org/governance/wgi` accessed on July 15, 2017. We use the version updated on September 23, 2016.

[4] Hereafter, we simply call country unless the distinction is relevant.

[5] The median country is categorized in the high category.

Table 2: Average life expectancy at birth (LEAB) by the level of health expenditure share in GDP (HESH) and the level of private health expenditure share in the total health expenditure (PRHS) for years before and after 2005 (all countries).

	Low HESH	High HESH	Difference
(A) Low PRHS			
1995-2004	66.46	74.35	7.89***
	(1.36)	(0.77)	(1.56)
2005-2014	69.26	76.86	7.59***
	(1.25)	(0.73)	(1.45)
Change	2.80***	2.50***	-0.30
	(0.33)	(0.18)	(0.38)
# Countries	40	49	89
(B) High PRHS			
1995-2004	62.26	62.49	0.24
	(1.26)	(1.80)	(2.20)
2005-2014	65.82	66.12	0.30
	(1.11)	(1.60)	(1.94)
Change	3.57***	3.63***	0.06
	(0.37)	(0.46)	(0.59)
# Countries	49	41	90
(C) Difference between (A) and (B)			
1995-2004	-4.21**	-11.86***	-7.65***
	(1.86)	(1.95)	(2.70)
2005-2014	-3.44**	-10.73***	-7.29***
	(1.67)	(1.76)	(2.42)
Change	0.77	1.13**	0.36
	(0.50)	(0.50)	(0.70)

Note: The standard errors calculated from a regression of LEAB for each country and each decade on the indicator variables for each combination of pre/post-2005 period, low/high HESH and low/high PRHS without a constant and clustered for each country are reported in the parentheses below the point estimates. $*$, $**$, and $***$ in the cells for differences (i.e., "Change" rows and "Difference" column in Panels (A) and (B) as well as all cells in Panel (C)) denote that the point estimate is statistically different from zero at 10, 5, and 1 percent levels, respectively.

LEAB for the countries with low health share in GDP. Therefore, the average LEAB for countries with low HESH and low PRHS increased from 66.46 years in the first decade (1995-2004) to 69.26 years in the second decade (2005-2014) by 2.80 years as reported in the third row ("Change"), which is statistically significant by a two-sided t-test. The next column ("High health share") shows that the average LEAB for countries with high HESH and low PRHS increased from 74.35 years to 76.86 years by 2.50 years, which is again statistically significant. The improvement in LEAB over time is observed across different categories of countries.

The last column ("Difference") takes the difference between low and high HESH countries. There is a significant difference in LEAB between low and high PRHS countries but as the bottom right corner of panel (A) shows, the double difference (or difference-in-differences) estimate of the impact of high health expenditure share relative to low health expenditure share is insignificant.

One has to be cautious when making a causal inference here. Even though the point estimate is negative, the initial condition for low and high HESH countries appear to be very different. The high HESH countries tend to be wealthier as shown in Figure 2(a) and thus the LEAB in these countries tends to be high in the first place. Therefore, it is not surprising that the incremental increase in LEAB may be lower for high HESH country if, for example, the increase in the standards of living is slower for these countries due to convergence in economic growth. Therefore, the negative double difference estimate may not be driven by the causal effect of high health expenditure but the negative correlation of the initial standards of living with subsequent economic growth and increment in LEAB.

Panel (B) is similar to panel (A) except that it focuses on the countries in which the private share in the total health expenditure is high. The double difference estimate in this case is slightly positive (0.06 years) but the point estimate is very close to zero. Given that the initial LEAB is similar between the low and high HESH countries, we would not need to worry about the convergence discussed above. Therefore, if we are willing to make a causal inference, the double difference estimate indicates that the impact of high health spending is essentially zero.

Panel (C) takes the difference between panels (A) and (B). For example, among low HESH countries, there is -3.44(=65.82-69.26) years of difference in the average LEAB between the countries with high and low PRHS in the second decade (2005-2014). The last row ("Difference") can be interpreted as a double-difference estimate of the impact of moving from low to high private health expenditure share given the level of health share in GDP. This impact is not significant in countries where health spending is low but it is positive and significant where health spending is high.

The bottom right corner of panel (C) reports the triple difference. This number is positive, suggesting that the private health spending on average has a higher health-promoting effect than the same amount of public health spending. However, we cannot draw a strong conclusion because the triple difference estimate is not statistically significant.

Table 2 uses all countries and thus do not take into account the quality of government. To take into account government quality, we classify countries whose GE indicator is on average negative [positive] over the first decade as low- [high-] GE countries and redo the naïve triple difference. We report the same table as Table 2 with a subsample of low- and high-GE countries in Tables 3 and 4, respectively.

Each cell in Panel (A) of Table 3 has the same sign as the corresponding cell in Table 2. However, the countries with ineffective governments are generally poorer countries and the LEAB is generally lower. The double difference estimator of the impact of high health expenditure share is negative (-0.84 years) and marginally significant for low-GE low-PRHS countries.

As Panel (B) shows, among low-GE high-PRHS countries, the average LEAB for high HESH countries is marginally lower than that for low HESH countries for both decades as "Difference" column indicates. The double difference estimator of the impact of high health expenditure share is positive (0.52 years) but insignificant. As a result, the triple difference estimator is positive as the bottom right corner of Panel (C) shows. While the point estimate (1.36 years) is insignificant, this is moderately large.

Let us now compare Tables 3 and 4. The signs of the first difference with respect to time (as shown in "Change" rows in Panels (A) and (B)) and the first difference with

Table 3: Average life expectancy at birth (LEAB) by the level of health expenditure share in GDP (HESH) and the level of private health expenditure share in the total health expenditure (PRHS) for years before and after 2005 (low-GE countries only).

	Low HESH	High HESH	Difference
(A) Low PRHS			
1995-2004	62.52	69.70	7.18***
	(1.72)	(1.18)	(2.08)
2005-2014	65.38	71.72	6.34***
	(1.62)	(1.20)	(2.02)
Change	2.86***	2.02***	-0.84*
	(0.44)	(0.15)	(0.47)
# Countries	23	10	33
(B) High PRHS			
1995-2004	60.70	59.44	-1.27
	(1.27)	(2.03)	(2.39)
2005-2014	64.43	63.68	-0.74
	(1.09)	(1.79)	(2.10)
Change	3.72***	4.24***	0.52
	(0.41)	(0.55)	(0.69)
# Countries	43	31	74
(C) Difference between (A) and (B)			
1995-2004	-1.82	-10.27***	-8.45***
	(2.14)	(2.34)	(3.17)
2005-2014	-0.96	-8.04***	-7.09**
	(1.96)	(2.15)	(2.91)
Change	0.86	2.23***	1.36
	(0.60)	(0.57)	(0.83)

Note: The standard errors calculated from a regression of LEAB for each country and each decade on the indicator variables for each combination of pre/post-2005 period, low/high HESH and low/high PRHS without a constant and clustered for each country are reported in the parentheses below the point estimates. $*$, $**$, and $***$ in the cells for differences (i.e., "Change" rows and "Difference" column in Panels (A) and (B) as well as all cells in Panel (C)) denote that the point estimate is statistically different from zero at 10, 5, and 1 percent levels, respectively.

Table 4: Average life expectancy at birth (LEAB) by the level of health expenditure share in GDP (HESH) and the level of private health expenditure share in the total health expenditure (PRHS) for years before and after 2005 (high-GE countries only).

	Low HESH	High HESH	Difference
(A) Low PRHS			
1995-2004	71.25	75.72	4.47***
	(1.41)	(0.85)	(1.65)
2005-2014	74.00	78.50	4.50***
	(0.92)	(0.73)	(1.18)
Change	2.75***	2.79***	0.04
	(0.55)	(0.19)	(0.58)
# Countries	16	37	53
(B) High PRHS			
1995-2004	73.38	71.96	-1.42
	(1.24)	(1.87)	(2.24)
2005-2014	75.83	73.69	-2.14
	(1.68)	(2.27)	(2.82)
Change	2.45***	1.73***	-0.72
	(0.53)	(0.50)	(0.73)
# Countries	6	10	16
(C) Difference between (A) and (B)			
1995-2004	2.13	-3.76*	-5.88**
	(1.88)	(2.06)	(2.78)
2005-2014	1.83	-4.81**	-6.65**
	(1.91)	(2.38)	(3.06)
Change	-0.29	-1.06*	-0.76
	(0.77)	(0.54)	(0.94)

Note: The standard errors calculated from a regression of LEAB for each country and each decade on the indicator variables for each combination of pre/post-2005 period, low/high HESH and low/high PRHS without a constant and clustered for each country are reported in the parentheses below the point estimates. $*$, $**$, and $***$ in the cells for differences (i.e., "Change" rows and "Difference" column in Panels (A) and (B) as well as all cells in Panel (C)) denote that the point estimate is statistically different from zero at 10, 5, and 1 percent levels, respectively.

respect to the health share (as shown in the first two rows of "Difference" column in these panels) are the same. However, the sign of the double difference estimator in each of these panels are flipped.

Next, compare the double difference estimators at the bottom of Panel (C) in Tables 3 and 4. They can be interpreted as the impact of high private health share if we allow causal interpretation. They are positive in Table 3 but negative in Tables 4 even though the point estimate is insignificant for low-HESH countries. This comparison suggests that the effect of private source of health spending relative to public source on the health outcome is dependent on the government quality.

As the comparison of the bottom right corner of Panel (C) between Tables 3 and 4 indicates, the sign of the triple difference estimator is also the opposite. If we take the quadruple difference, or the difference in the triple difference estimates between the two tables, the point estimate is negative (-2.13 years) and marginally significant at a 10 percent level. If we allow causal interpretation, the effect of high private health spending share for low-GE countries is lower than that for high-GE countries by 2.13 years of LEAB.

The points above indicate that there may be a differential causal effect of health spending on health outcome between private and public sources. However, we have to be cautious not to over-interpret the results because we do not control for the characteristics that may be correlated with the health outcome. Therefore, we also consider below regression versions of triple difference estimation. In the regression analysis, we will take the health spending share in GDP and private health expenditure share in the total health expenditure instead of dichotomizing them. This is important because it allows us to exploit the variations within each category (i.e., low/high HESH and low/high PRHS) such that we may be able to identify the differential effect between private and public sources of health spending more sharply.

5 Regression-based Triple Difference Estimation

Baseline results

In our baseline regression analysis, we use a lustrum, or a five-year interval, as a main time unit. There are a few reasons for this choice. First, it may take some time before the effect of health spending shows up in mortality. Second, by reducing the number of time periods, we can readily report the regression results in a table without making strong assumptions about the time trend. Finally, because some variables may be missing for some countries in some years, aggregation over time helps to retain most countries in the analysis. As a result of this choice, the two decades of data are divided into the following four lustra: 1995–1999, 2000–2004, 2005–2009, and 2010–14, which we respectively denote by $l = 0, \cdots, 3$.

To introduce the regression-based triple difference estimator, we need additional notations. Subscript c is used to denote a country. Vector of time-varying covariates and country-level fixed-effects term are denoted by $\mathbf{X}_{cl}$ and F_c, respectively. For most of our analysis, $\mathbf{X}_{cl}$ includes the logarithmic GDP per capita and the proportion of people with access to improved water source. Denoting the time (lustrum) fixed effects by $I_l^t \equiv \mathbf{1}(t = l)$, the regression-based triple difference estimator can be written as follows:

$$\begin{aligned} \text{LEAB}_{cl} &= \alpha^0 + \alpha^1 \text{HESH}_{cl} + \alpha^2 \text{PRHS}_{cl} + \alpha^3 \text{HESH}_{cl} \cdot \text{PRHS}_{cl} \\ &\quad + \sum_{t=1}^{t=3} I_l^t \cdot \left[\beta_t^0 + \beta_t^1 \text{HESH}_{cl} + \beta_t^2 \text{HESH}_{cl} + \beta_t^3 \text{HESH}_{cl} \cdot \text{PRHS}_{cl}\right] \\ &\quad + \gamma \mathbf{X}_{cl} + F_c + \epsilon_{cl}, \end{aligned} \tag{1}$$

where HESH and PRHS are continuous variables on a unit interval, ϵ_{cl} the error term, and β_t^3 the main coefficient of interest.

In Table 5, we report the regression results using a balanced panel data for 165 countries. To highlight the nature of our analysis, we start with Columns (1) and (2), which respectively report the double difference estimates of the impact of the health expenditure share on life expectancy at birth with and without covariates. The estimation equation

Table 5: Baseline double and triple difference regressions.

Dep. var.: Life expectancy at birth	(1)	(2)	(3)	(4)
Lustrum 1 (I^1, Yr 2000-2004)	1.633***	0.845**	1.554**	1.110*
	(0.332)	(0.344)	(0.672)	(0.619)
Lustrum 2 (I^2, Yr 2005-2009)	3.782***	2.159***	4.127***	3.227***
	(0.519)	(0.599)	(0.954)	(0.914)
Lustrum 3 (I^3, Yr 2010-2014)	5.920***	3.512***	6.175***	4.989***
	(0.696)	(0.866)	(1.296)	(1.208)
Health expenditure share	0.297	0.251	0.234	0.118
in GDP (HESH, %)	(0.196)	(0.173)	(0.266)	(0.242)
$I^1 \times$ HESH	0.217	0.226	0.0881	0.0271
	(0.165)	(0.146)	(0.222)	(0.200)
$I^2 \times$ HESH	0.134	0.190	-0.136	-0.138
	(0.144)	(0.133)	(0.187)	(0.165)
$I^3 \times$ HESH	0.0701	0.177	-0.279	-0.240
	(0.157)	(0.150)	(0.209)	(0.185)
Private health expenditure			-0.0192	-0.0101
share (PRHS, %)			(0.0288)	(0.0262)
$I^1 \times$ PRHS			-0.0198	-0.0155
			(0.0235)	(0.0203)
$I^2 \times$ PRHS			-0.0346	-0.0346**
			(0.0217)	(0.0172)
$I^3 \times$ PRHS			-0.0409	-0.0485*
			(0.0308)	(0.0257)
HESH $\times$ PRHS			0.000690	0.00244
			(0.00531)	(0.00480)
$I^1 \times$ HESH $\times$ PRHS			0.00266	0.00410
			(0.00390)	(0.00348)
$I^2 \times$ HESH $\times$ PRHS			0.00682*	0.00752**
			(0.00348)	(0.00304)
$I^3 \times$ HESH $\times$ PRHS			0.0101**	0.0106***
			(0.00454)	(0.00396)
Logarithmic GDP per capita		1.208**		1.108**
		(0.535)		(0.515)
Share of population with access		0.146***		0.132***
to improved water source (%)		(0.0431)		(0.0439)
Observations	660	660	660	660
R^2	0.631	0.674	0.655	0.685
Number of countries	165	165	165	165

Note: Country fixed effects are included in each model. Standard errors clustered for each country are reported in parentheses. $*$, $**$, and $***$ denote statistical significance at 10, 5, and 1 percent levels, respectively.

for Column (2) in this case is the same as eq. (1) except that all the terms involving PRHS are dropped. Column (1) further drops the term involving $\mathbf{X}_{cl}$.

As the first three rows of the table shows, there is a secular increase in LEAB over time. As the comparison between Columns (1) and (2) indicate, this increase can be partly ascribed to the increase in the logarithmic GDP per capita and share of population with improved water source. While all the coefficients on the terms involving HESH are all positive, they are statistically insignificant. According to Column (2), an increase of HESH by one percentage point is associated with about 0.2 years gain in LEAB. Noting that HESH for a majority of countries ranges between 5 and 10 percent (See Figure 2(a)), one percentage point increase in HESH is a sizable increase. Thus, a higher health expenditure is associated with only a modest gain in health outcome at best.

Columns (3) and (4) provide the estimation results for eq. (1). As the coefficients β_t^3 on $I_l^t \times \text{HESH} \times \text{PRHS}$ for $t \in \{1, 2, 3\}$ indicate, the marginal effect of health expenditure is positive and significant for $t = 2, 3$. This suggest that the health promoting effect of health spending tends to be higher when a higher share comes from the private source. This finding is consistent with our naïve triple difference estimator presented in Table 2 and we take Column (4) as our baseline result against which other results are compared.

Next, we consider the regression analogue of Tables 3 and 4 by restricting our sample to the set of households in which the government effectiveness in each of the four lustra is, respectively, always negative and positive. These results are reported, respectively, in Columns (1) and (2) of Table 6. Consistent with Table 3, Column (1) shows that the health promoting effect of health spending tends to be higher in countries with ineffective governments when a higher share comes from a private source when $t = 2, 3$. However, the point estimates are much smaller and insignificant in Column (2), indicating that the private source is no better than public source in promoting health in countries with efficient governments. In Column (3), we report the results of a regression based on the two samples for Columns (1) and (2) combined. The results are similar to Column (4) of Table 5 indicating that the omission of a small number of countries for which GE is not observed or its sign changed over the four lustra did not alter the results much.

Table 6: Triple difference regression by the government efficiency.

Dep. var.: Life expectancy at birth	(1)	(2)	(3)
Lustrum 1 (I^1, Yr 2000-2004)	1.707	0.718	1.068
	(1.207)	(1.088)	(0.670)
Lustrum 2 (I^2, Yr 2005-2009)	5.784***	2.402*	3.758***
	(1.650)	(1.357)	(0.958)
Lustrum 3 (I^3, Yr 2010-2014)	9.225***	3.657**	5.879***
	(2.172)	(1.788)	(1.276)
Health expenditure share	0.771*	-0.0556	0.191
in GDP (HESH, %)	(0.390)	(0.260)	(0.271)
$I^1 \times$ HESH	0.374	0.0286	0.0922
	(0.389)	(0.235)	(0.229)
$I^2 \times$ HESH	-0.139	0.0181	-0.151
	(0.305)	(0.202)	(0.183)
$I^3 \times$ HESH	-0.446	-0.00511	-0.295
	(0.375)	(0.232)	(0.203)
Private health expenditure	0.0342	-0.0404	-0.00742
share (PRHS, %)	(0.0287)	(0.0585)	(0.0268)
$I^1 \times$ PRHS	0.0189	-0.0320	-0.0113
	(0.0282)	(0.0602)	(0.0219)
$I^2 \times$ PRHS	-0.0324	-0.0428	-0.0401**
	(0.0240)	(0.0569)	(0.0177)
$I^3 \times$ PRHS	-0.0761**	-0.0429	-0.0603**
	(0.0375)	(0.0686)	(0.0264)
HESH $\times$ PRHS	-0.00833	0.00880	0.00177
	(0.00569)	(0.00852)	(0.00483)
$I^1 \times$ HESH $\times$ PRHS	-0.00137	0.00478	0.00335
	(0.00523)	(0.00673)	(0.00353)
$I^2 \times$ HESH $\times$ PRHS	0.00834*	0.00364	0.00814***
	(0.00453)	(0.00626)	(0.00307)
$I^3 \times$ HESH $\times$ PRHS	0.0155**	0.00407	0.0121***
	(0.00616)	(0.00705)	(0.00399)
Logarithmic GDP per capita	1.279*	1.511*	1.327**
	(0.694)	(0.858)	(0.556)
Share of population with access	0.123**	0.109	0.136***
to improved water source (%)	(0.0486)	(0.118)	(0.0456)
Observations	344	256	600
R^2	0.700	0.735	0.690
Number of countries	86	64	150

Note: Country fixed effects are included in each model. Standard errors clustered for each country are reported in parentheses. $*$, $**$, and $***$ denote statistical significance at 10, 5, and 1 percent levels, respectively. Column (1) [column (2)] uses only the countries in which the government efficiency is on average negative [positive] in each of the four lustra. Column (3) uses all the countries included either in column (1) or column (2).

Robustness Checks

In Tables 5 and 6, we treated each country equally and only considered LEAB as the health outcome variable of interest. While we believe that these are reasonable choices because our unit of analysis throughout the paper is a country rather than an individual and because LEAB reflects the health of all individuals in the country, some robustness checks are warranted.

In Column (1) of Table 7, we report the same regression as the baseline results reported in Column (4) of Table 5 except that observations are weighted by the average population over the four lustra. The results are similar and β_2^3 and β_3^3 remain significant. In Columns (2) and (3) of Table 7, we report the regressions of LEAB for males and females separately. As can be seen form Table 7, the point estimates remain similar.

One concern about the triple difference estimates presented so far is the potential endogeneity issue. That is, when people live longer, they would generally allocate a higher share of expenditure to health. Further, depending on what is covered in private and public sources of health spending, this increase in health spending may potentially affect the private share in health spending if, for example, older people are more likely to depend on public sources. Given that the health financing system is diverse across countries, we do not have a strong reason to believe that this potential endogeneity issue would substantially bias our triple difference estimator in a particular direction. However, it is also difficult to exclude this possibility.

A standard approach to address the endogeneity issue is to use instrumental variables. Unfortunately, we do not have compelling instruments to suit our purpose. Therefore, we instead use the logarithm of under-five child mortality (LU5MR) as an alternative dependent variable. An advantage of using LU5MR is that the endogeneity concern is much weaker; it is unlikely that a higher share of health spending comes from private sources just because their children are less likely to die.

In Column (4) of Table 7, we report the result of a regression in which the dependent variable is replaced by LU5MR in the baseline regression. Because the healthier population would have lower mortality, we would expect that the signs are the opposite of the

Table 7: Alternative specifications for robustness checks.

Dependent variable	(1) LEAB (Weighted)	(2) LEAB Male	(3) LEAB Female	(4) LU5MR
Lustrum 1 (I^1, Yr 2000-2004)	0.687	0.644	1.600**	-0.165**
	(1.079)	(0.608)	(0.687)	(0.0767)
Lustrum 2 (I^2, Yr 2005-2009)	4.336***	2.551***	3.936***	-0.257**
	(1.344)	(0.941)	(0.963)	(0.130)
Lustrum 3 (I^3, Yr 2010-2014)	5.550***	4.253***	5.755***	-0.448***
	(1.570)	(1.255)	(1.236)	(0.169)
Health expenditure share	0.116	0.0163	0.224	0.00496
in GDP (HESH, %)	(0.293)	(0.240)	(0.257)	(0.0259)
$I^1 \times$ HESH	0.182	0.00730	0.0466	0.00737
	(0.281)	(0.197)	(0.214)	(0.0202)
$I^2 \times$ HESH	-0.0829	-0.119	-0.158	0.00484
	(0.244)	(0.163)	(0.178)	(0.0158)
$I^3 \times$ HESH	-0.0832	-0.198	-0.285	0.00936
	(0.237)	(0.183)	(0.199)	(0.0182)
Private health expenditure	-0.000232	-0.0201	0.000339	-0.000922
share (PRHS, %)	(0.0320)	(0.0260)	(0.0284)	(0.00316)
$I^1 \times$ PRHS	0.00745	-0.0178	-0.0133	-0.000302
	(0.0280)	(0.0206)	(0.0217)	(0.00254)
$I^2 \times$ PRHS	-0.0279	-0.0353**	-0.0339*	-0.000570
	(0.0281)	(0.0175)	(0.0187)	(0.00221)
$I^3 \times$ PRHS	-0.0306	-0.0510*	-0.0462*	-0.000232
	(0.0311)	(0.0261)	(0.0270)	(0.00310)
HESH $\times$ PRHS	0.00724	0.00395	0.000877	-9.04e-05
	(0.00621)	(0.00480)	(0.00501)	(0.000499)
$I^1 \times$ HESH $\times$ PRHS	0.00523	0.00447	0.00374	-0.000167
	(0.00475)	(0.00363)	(0.00351)	(0.000398)
$I^2 \times$ HESH $\times$ PRHS	0.00891*	0.00747**	0.00758**	-0.000270
	(0.00460)	(0.00315)	(0.00310)	(0.000324)
$I^3 \times$ HESH $\times$ PRHS	0.00907*	0.0105**	0.0108***	-0.000330
	(0.00479)	(0.00413)	(0.00399)	(0.000426)
Logarithmic GDP per capita	-1.035	1.233**	0.972*	-0.247***
	(0.679)	(0.521)	(0.523)	(0.0640)
Share of population with access	0.186***	0.129***	0.135***	-0.00603**
to improved water source (%)	(0.0521)	(0.0406)	(0.0479)	(0.00261)
Observations	660	660	660	660
R^2	0.845	0.701	0.658	0.832
Number of countries	165	165	165	165

Note: LEAB and LU5MR stand for life expectancy at birth and logarithm of under-five mortality rate, respectively. Country fixed effects are included in each model. Standard errors clustered for each country are reported in parentheses. $*$, $**$, and $***$ denote statistical significance at 10, 5, and 1 percent levels, respectively.

baseline regression. Column (4) shows that this is indeed the case for the triple difference estimators β^3 (i.e., coefficients on I × HESH × PRHS) and almost all other covariates. While the triple different estimator is not statistically significant, the results based on LEAB and LU5MR are broadly consistent. Therefore, the bias due to the endogeneity of HESH and PRHS are unlikely to be the main driver of our results.[6]

As a further robustness check, we performed baseline regressions with potentially important additional covariates to see whether our results are driven by omitted variables. Namely, we included (1) the number of physicians per 1,000 people, (2) share of population with access to improved sanitation facilities, (3) share of urban population, and (4) secondary school enrollment rates as the additional covariate and these regression results are reported in Table 9 in the Appendix. The results are similar both qualitatively and quantitatively.

Finally, we also included the quadratic terms for PRHS to see if we can infer about the optimal private health share. However, the coefficient on the quadratic term is generally insignificant and its sign changes over different lustra, which may be due to the high collinearity between the linear and quadratic terms. This is true even when we split the sample into low- and high-GE countries.

Linear time trend

So far, our results are based on the data aggregated over each lustrum. This formulation has an advantage that we can present the results in a table without making too restrictive assumptions. However, we can potentially obtain sharper results if we are willing to make a linear time trend assumption. To see the validity of this assumption, we first conduct a F-test of the linear trend with the following null hypothesis based on eq. (1):

[6] Ideally, private share of health spending should be based on the health spending for children under five when LU5MR is used as the dependent variable. However, such data are not readily available to our knowledge. The closest we can find is the private share in human capital spending taken from the National Transfer Accounts (`http://www.ntaccounts.org/` accessed on August 8, 2017), which is based on per capita health spending for children age 0-17 and per capita education spending for children age 3-26. With this data set, we can only construct a panel data for two years for 18 countries. When we run a regression of the linear time trend model in eq. (3) discussed below, we obtain results that are qualitatively similar to Column (4) of Table 7.

$$H_0 : \beta_1^j = \beta_2^j/2 = \beta_3^j/3 \quad \text{for} \quad \forall j \in \{0, 1, 2, 3\} \tag{2}$$

In each of the regressions presented above for which we can carry out this test (i.e., Columns (3) and (4) in Table 5 and all columns in Table 6), we failed to reject the null hypothesis even at a 10 percent level. We have also run a regression similar to Column (4) of Table 5 using annual data and using year instead of lustrum as the time unit of analysis. As a result, the running variable t in the summation goes from 1 (year 1996) to 19 (year 2014). The point estimate and 95 percent confidence interval of β_t^0 to β_t^3 for $t \in \{1, \cdots, 19\}$ are, respectively, presented in Figures 3 (a) to (d).

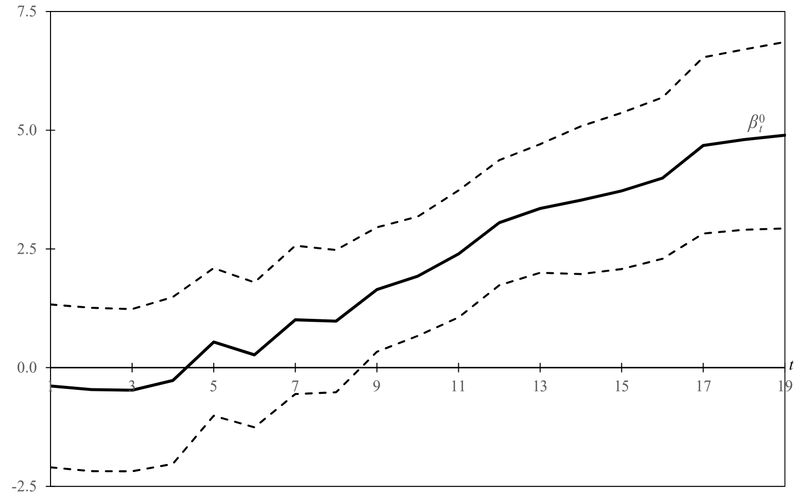
Figure 3 (a) shows that there is a clear positive secular time trend. Figures 3 (b) and (c) show that the point estimates of the impact of HESH and PRHS are mostly negative but insignificant. Figure 3 (d) shows that the triple difference estimator is positive and significant at $t = 9$ (year 2004) onwards. Therefore, Figure 3 is consistent with the results presented so far and indicates that the use of the following model with a linear time trend is reasonable:

$$\begin{aligned} \text{LEAB}_{ct} &= \alpha^0 + \alpha^1 \text{HESH}_{ct} + \alpha^2 \text{PRHS}_{ct} + \alpha^3 \text{HESH}_{ct} \cdot \text{PRHS}_{ct} \\ &\quad + \left[\beta^0 + \beta^1 \text{HESH}_{ct} + \beta^2 \text{HESH}_{ct} + \beta^3 \text{HESH}_{ct} \cdot \text{PRHS}_{ct}\right] t \\ &\quad + \gamma X_{ct} + F_c + \epsilon_{ct}, \end{aligned} \tag{3}$$

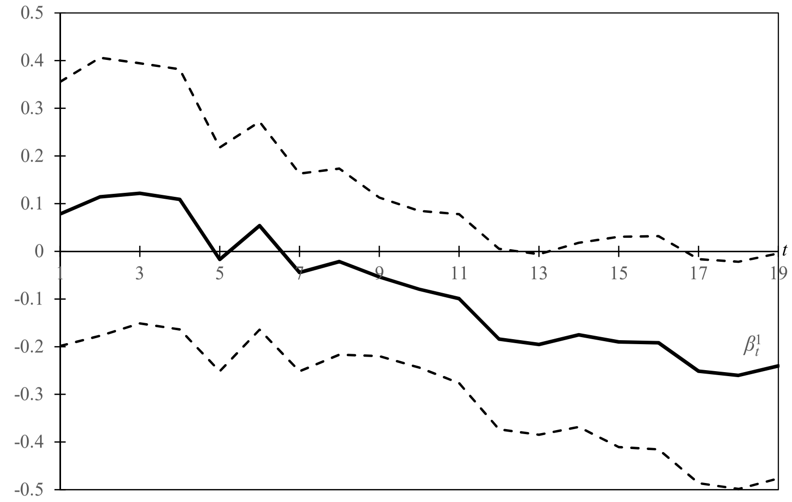
Table 8 presents the regressions based on eq. (3). The main coefficient of interest is the coefficient β^3 on HESH $\times$ PRHS $\times$ t, which is an analogue of the triple difference estimator. Column (1) uses all the available observations for which GE is also observed. Columns (2) and (3) use only the countries in which GE in the first year of observations is negative and positive, respectively.[7] Column (4) can be regarded as quadruple difference specification in which GE and its interaction terms are additionally included.

The linear trend models are qualitatively consistent with previously shown results. In

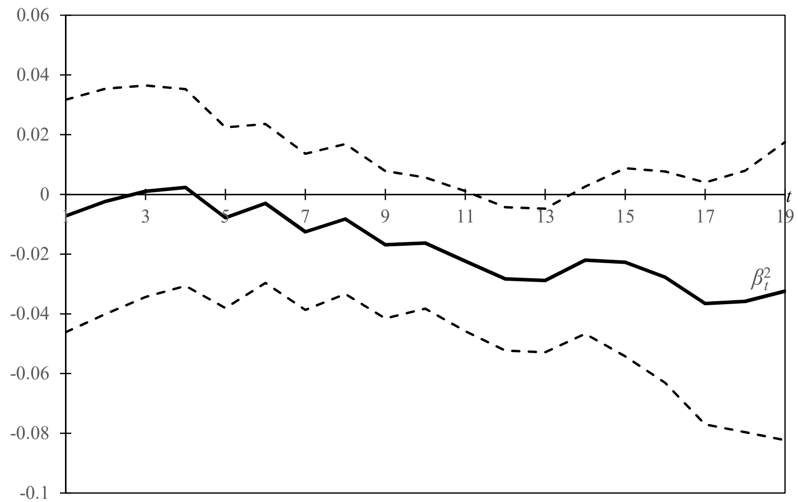
[7]Note that GE is available only from the year 1996.



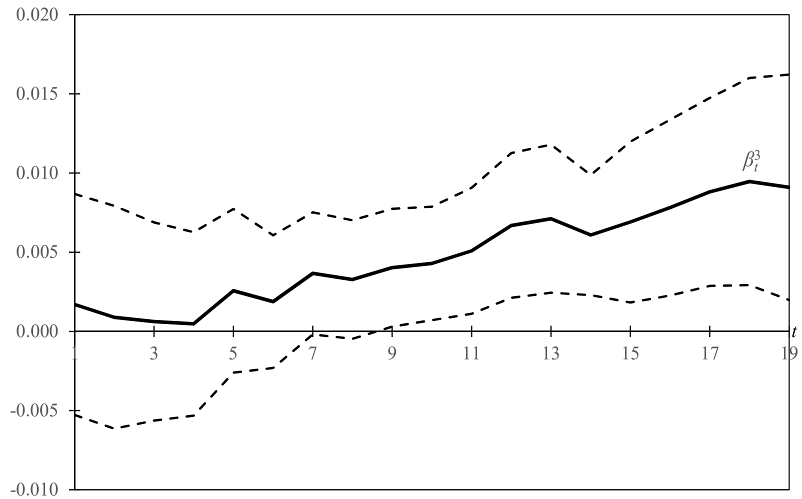
(a) Coefficient β^0 on I^t



(b) Coefficient β^1 on $I^t \times$ HESH



(c) Coefficient β^2 on $I^t \times$ PRHS



(d) Coefficient β^3 on $I^t \times$ HESH $\times$ PRHS

Figure 3: Point estimates (bold line) and 95% confidence intervals (dashed line) for β^0, β^1, β^2, and β^3. The confidence intervals are based on the annual version of eq. (1) with the standard errors clustered for each country.

Table 8: Linear trend models.

Dep. var.: Life expectancy at birth	(1)	(2)	(3)	(4)
Health expenditure share	0.157	0.553***	-0.225*	0.233**
in GDP (HESH, %)	(0.0987)	(0.156)	(0.130)	(0.109)
HESH × t	-0.0194***	-0.0527***	0.0134**	-0.0235***
	(0.00530)	(0.00949)	(0.00639)	(0.00624)
Private health expenditure	0.00525	0.0398**	-0.0449**	0.0164
share (PRHS, %)	(0.0115)	(0.0156)	(0.0216)	(0.0138)
PRHS × t	-0.00167**	-0.00471***	0.00228*	-0.00233***
	(0.000727)	(0.00105)	(0.00117)	(0.000832)
HESH × PRHS	-0.000295	-0.00777***	0.00927***	-0.000690
	(0.00182)	(0.00266)	(0.00307)	(0.00213)
HESH × PRHS × t	0.000443***	0.00108***	-0.000493***	0.000459***
	(0.000109)	(0.000167)	(0.000160)	(0.000124)
Logarithmic GDP per capita	0.640***	0.251	1.539***	0.459**
	(0.198)	(0.255)	(0.331)	(0.203)
Share of population with access	0.127***	0.117***	0.0965***	0.111***
to improved water source (%)	(0.00997)	(0.0124)	(0.0233)	(0.0102)
Government effectiveness (GE)				1.657**
				(0.683)
GE × t				-0.151***
				(0.0427)
GE × HESH				-0.275***
				(0.0952)
GE × HESH × t				0.0258***
				(0.00552)
GE × PRHS				-0.0203
				(0.0133)
GE × PRHS × t				0.00202**
				(0.000859)
GE × HESH × PRHS				0.00703***
				(0.00188)
GE × HESH × PRHS × t				-0.000531***
				(0.000111)
Observations	2,719	1,631	1,088	2,719
R^2	0.984	0.976	0.975	0.984
Number of countries	178	108	70	178

Note: All countries are used in Columns (1) and (4). Column (2) [Column (3)] uses a subsample of countries in which GE is negative [positive] in the year 1996. Country fixed effects are included in each model. Standard errors clustered for each country are reported in parentheses. $*$, $**$, and $***$ denote statistical significance at 10, 5, and 1 percent levels, respectively.

particular, the coefficientβ^3 on HESH$\times$PRHS$\times t$ is positive and significant in Columns (1) and (2) as with the previous results. On the other hand, we find that β^3 is negative and significant in Column (3). This result is also consistent with what we found in Table 4. However, the sign changes and statistical significance disappears once we restrict our sample to the set of middle income countries as reported in Table 10 in the Appendix. Nevertheless, Column (3) provides no evidence contradicting with our earlier finding that private sources are no better than public sources in promoting health in countries with effective governments.

Finally, the coefficient on GE $\times$ HESH $\times$ PRHS $\times$ t, which is essentially a quadruple difference estimator, is negative and significant, indicating that the private sources tends to have an even higher health promoting effect than public sources in countries where the government is not effective.

Because GE is strongly corrected with the income level, our results that are based on low- and high-GE countries may be partly driven by the heterogeneous impacts of private and public health spending across different income levels. To address this concern, we also redo the same analysis as Table 8 only with middle income countries. As shown in Table 10 in the Appendix, the qualitative nature of the results remain mostly unchanged. That is, the triple difference estimator (the coefficient β^3 on HESH$\times$PRHS$\times t$ is positive and significant when a sample of all countries or only low-GE countries is used. However, this is not the case for the high-GE country. Further, the quadruple difference estimator (the coefficient on GE $\times$ HESH $\times$ PRHS $\times$ t) is negative, even though it is not significant.

6 Discussion

Using a panel data set with two decades of observations for a large number of countries, we have investigated the differential impacts of private and public sources of health expenditure on health outcomes. To our knowledge, this is the first study that clearly distinguishes private and public sources of health spending to analyze health outcomes systematically using the triple difference estimation approach. Our main finding is that private health spending on average has a stronger health-promoting effect than public health spending. Therefore, our results indicate that taking advantage of private sources of health expenditure is important. This implication is important not only in developing countries where resources are generally scarce but also in rich countries where health spending share is likely to increase as their societies age. Our result is robust with respect to the choice of health outcome indicator and inclusion of various covariates and unlikely to be driven by the potential endogeneity of the private health share.

We also find that the differential health impacts of private and public health spending depend on the quality of the government. In fact, our main results are driven by the presence of countries with ineffective governments. Once we restrict our sample to a set of countries with effective governments, we find no evidence that private sources have a higher health-promoting effect than public sources. Therefore, our results indicate that a larger involvement of private sector in health is desirable particularly where ineffective government has to be taken as given. However, in countries where there is an effective government, we caution against over-reliance on private health sources because some of our results (e.g., column (3) of Table 8) suggests that public sources of health spending have a higher health-promoting effect than private sources, even though this results is suggestive at best.

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Appendix: Additional Tables

Table 9 is the same as Column (4) of Table 5 except that an additional covariate is included in each column. Table 10 uses the same specifications as Table 8 but is based on a subsample of middle income countries.

Table 9: Triple difference regressions with additional regressors.

Dep. var.: Life expectancy at birth	(1)	(2)	(3)	(4)
Lustrum 1 (I^1, Yr 2000-2004)	0.784	1.077*	1.034*	0.702
	(0.667)	(0.625)	(0.621)	(0.760)
Lustrum 2 (I^2, Yr 2005-2009)	3.492***	3.217***	3.117***	2.268**
	(0.953)	(0.913)	(0.895)	(1.053)
Lustrum 3 (I^3, Yr 2010-2014)	4.851***	5.046***	4.747***	3.401**
	(1.261)	(1.215)	(1.186)	(1.307)
Health expenditure share	0.224	0.118	0.130	-0.131
in GDP (HESH, %)	(0.224)	(0.255)	(0.237)	(0.279)
$I^1 \times$ HESH	0.196	0.0284	0.0373	-0.119
	(0.180)	(0.212)	(0.196)	(0.231)
$I^2 \times$ HESH	-0.0387	-0.141	-0.133	-0.199
	(0.141)	(0.180)	(0.163)	(0.196)
$I^3 \times$ HESH	-0.0934	-0.249	-0.228	-0.230
	(0.165)	(0.204)	(0.181)	(0.223)
Private health expenditure	0.0136	-0.00973	-0.00496	-0.0433
share (PRHS, %)	(0.0275)	(0.0267)	(0.0257)	(0.0323)
$I^1 \times$ PRHS	0.0123	-0.0147	-0.0114	-0.0379
	(0.0220)	(0.0212)	(0.0199)	(0.0255)
$I^2 \times$ PRHS	-0.0145	-0.0343*	-0.0328*	-0.0501**
	(0.0192)	(0.0192)	(0.0170)	(0.0237)
$I^3 \times$ PRHS	-0.0180	-0.0495*	-0.0469*	-0.0573*
	(0.0283)	(0.0285)	(0.0255)	(0.0314)
HESH $\times$ PRHS	-0.000895	0.00239	0.00197	0.00816
	(0.00437)	(0.00487)	(0.00474)	(0.00595)
$I^1 \times$ HESH $\times$ PRHS	-0.000427	0.00406	0.00380	0.00682
	(0.00300)	(0.00361)	(0.00338)	(0.00456)
$I^2 \times$ HESH $\times$ PRHS	0.00440*	0.00757**	0.00751**	0.00891**
	(0.00250)	(0.00335)	(0.00302)	(0.00421)
$I^3 \times$ HESH $\times$ PRHS	0.00644*	0.0108**	0.0105***	0.0109**
	(0.00372)	(0.00444)	(0.00394)	(0.00491)
Logarithmic GDP per capita	0.983*	1.105**	1.159**	1.070*
	(0.513)	(0.496)	(0.538)	(0.630)
Share of population with access	0.119***	0.131***	0.123***	0.128**
to improved water source (%)	(0.0404)	(0.0485)	(0.0464)	(0.0562)
Number of physicians	-0.141			
to per 1,000 people	(0.196)			
Share of population with access		0.00189		
to improved sanitation facilities (%)		(0.0332)		
Share of urban population (%)			0.0719	
			(0.0526)	
Secondary school enrollment rate (%)				0.0174
				(0.0124)
Observations	601	654	660	584
R^2	0.710	0.684	0.688	0.687
Number of countries	165	164	165	161

Note: Country fixed effects are included in each model. Standard errors clustered for each country are reported in parentheses. $*$, $**$, and $***$ denote statistical significance at 10, 5, and 1 percent levels, respectively.

Table 10: Linear trend models, middle income countries only.

Dep. var.: Life expectancy at birth	(1)	(2)	(3)	(4)
Health expenditure share	0.473***	0.576***	0.344	0.425***
in GDP (HESH, %)	(0.122)	(0.107)	(0.389)	(0.142)
HESH × t	-0.0358***	-0.0413***	-0.0304	-0.0296***
	(0.00740)	(0.00637)	(0.0253)	(0.00969)
Private health expenditure	0.0392**	0.0459***	0.0211	0.0364*
share (PRHS, %)	(0.0155)	(0.0128)	(0.0566)	(0.0188)
PRHS × t	-0.00414***	-0.00453***	-0.00434	-0.00355***
	(0.00105)	(0.000872)	(0.00404)	(0.00135)
HESH × PRHS	-0.00667***	-0.0103***	0.00118	-0.00562**
	(0.00240)	(0.00207)	(0.00817)	(0.00281)
HESH × PRHS × t	0.000652***	0.000825***	0.000496	0.000504**
	(0.000162)	(0.000135)	(0.000635)	(0.000209)
Logarithmic GDP per capita	0.302	-0.216	1.408*	0.217
	(0.270)	(0.240)	(0.829)	(0.289)
Share of population with access	-0.0402***	-0.0439***	-0.102**	-0.0438***
to improved water source (%)	(0.0143)	(0.0123)	(0.0480)	(0.0146)
Government effectiveness (GE)				0.711
				(1.512)
GE × t				-0.0672
				(0.109)
GE × HESH				-0.304
				(0.244)
GE × HESH × t				0.0220
				(0.0175)
GE × PRHS				-0.0254
				(0.0335)
GE × PRHS × t				0.00206
				(0.00249)
GE × HESH × PRHS				0.00774
				(0.00518)
GE × HESH × PRHS × t				-0.000577
				(0.000385)
Observations	1,343	900	443	1,343
R^2	0.981	0.989	0.956	0.981
Number of countries	121	82	23	121

Note: All countries are used in Columns (1) and (4). Column (2) [Column (3)] uses a subsample of countries in which GE is negative [positive] in the year 1996. Country fixed effects are included in each model. Standard errors clustered for each country are reported in parentheses. $*$, $**$, and $***$ denote statistical significance at 10, 5, and 1 percent levels, respectively.