The Propagation of Public Health Spending Shocks

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Abstract

We study the dynamic response of output to a shock to government health spending. The shock (i) leads to an immediate and persistent rise in output, and (ii) has a sizable explanatory power for the long-run variation in output. These findings suggest that the output effects of health spending are propagated in a 'time-release' fashion.

Keywords: Health spending; Vector autoregressions; health outcomes

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1 Introduction

The United States has experienced substantial improvements in health outcomes over the last several decades. Average life expectancy at birth increased from 69.8 years in 1960 to 78.7 years in 2018. Over the same period, infant mortality decreased from 25.9 live births per thousand to 5.6, while adult mortality dropped from 181.9 adults to 109.1.[1] Not only has length of life increased but so too has health-related quality of life. For example, the percentage of noninstitutionalized persons 65 and over reporting fair or poor health decreased from 31.1% in 1972 to 22.2% in 2018.[2] The age-standardized disability-adjusted life year rate fell from 27,651 per 100,000 population in 1990 to 24,306 in 2018.[3] These length of life and health-related quality of life improvements have coincided with considerably increases in U.S. public health spending.[4]

Theoretical and empirical research provides evidence that increased health spending leads to improved health outcomes. Using an overlapping generations model, Bhattacharya and Qiao (2007) show that a young agent may increase her life expectancy if private investments in her own health are complemented with public health spending. A similar model by Varvarigos and Zakaria (2013) shows that health spending improves quality of life. Empirically, Mays and Smith (2011), and Cremieux et al. (1999) show that increased health spending lowers preventable deaths and infant mortality, and increases life expectancy, while Song et al. (2011) document improvements in the quality of care when health spending rises.

A related literature documents clear evidence that better health outcomes have positive, sizable, and significant effects on aggregate output or its growth rate (see e.g. Barro, 2013; Weil, 2007, 2014). Theoretical and empirical evidence in Barro (2013) shows that health

[1] These data come from the World Development Indicators database provided by The World Bank (https://databank.worldbank.org/source/world-development-indicators)

[2] National Center for Health Statistics (https://www.cdc.gov/nchs/fastats/older-american-health.htm) and Verbrugge (1984): https://www.jstor.org/stable/pdf/3349861.pdf

[3] Institute for Health Metrics and Evaluation (http://ghdx.healthdata.org/gbd-results-tool?params=gbd-api-2017-permalink/3c0ee862905ade1c81d9dba0447a18c6)

[4] Jakovljevic and Getzen (2016), Jakovljevic et al. (2021a), and Jakovljevic et al. (2022) find that health spending has generally been on the rise globally.

status, as measured by life expectancy or analogous indicators, is an important contributor to output. Barro (2013) goes as far as to conclude that "initial health seems to be a better predictor than initial education of subsequent economic growth" (Barro, 2013 pp. 329).

To the extent that health spending improves length of life, health-related quality of life, and other health outcomes, and that these improved health outcomes are beneficial for output, these allow the possibility that health spending may increase output.[5] The effect of the health spending shock, however, works through several channels over different time horizons. First, a short-run direct effect that arises from the fiscal stimulus and the subsequent general equilibrium output adjustments (Gemmell, 2011). That is, as a component of gross state product (GSP), an increase in health spending stimulates economic activity through a short-run increase in aggregate demand. Second, a short-run indirect effect when the health spending shock improves health of workers, in turn raising their productivity, and output (Barro, 2013). Third, the impact on output through expectations. That is, the health spending shock triggers expectations of future increases in length and quality of life, leading workers to increase private capital accumulation (e.g. saving for retirement), thereby generating a positive short-run wealth effect (Davig and Leeper, 2011). Fourth, a long-run effect on output when more health spending increases human capital accumulation (Weil, 2007). That is, improved health due to the spending shock enhances incentives for individuals to acquire education as the investments in education accrue over a longer working life, thereby decreasing the effective rate of depreciation on human capital. Human capital accumulation further increases as healthier students learn more in school and are less likely to miss school. Therefore, through this channel, human capital rises as a result of the increase in health expenditures, leading to further increases in productivity and output in the long run.

Together, these channels imply that a health spending shock leads to an instantaneous but shortlived increase in output, followed by a gradual but relatively longlasting response through longer life expectancy, improved quality of life, and higher private and human capital

[5] Evidence of a link between health spending and GDP growth in the U.S. and other countries has been documented by Jakovljevic et al. (2020), and Jakovljevic et al (2021b).

accumulation. Borrowing the terminology of Atems and Blankenau (2020, 2021), we refer to this delayed but persistent effect of a health spending shock on output as a 'time-release' effect.

Previous research has not considered this time-release aspect of a health spending shock. This paper employs a panel SVAR model to study the short-run and long-run output response to a shock to health expenditures using U.S. state-level data for the period 1963-2018. Our results indicate that in response to a shock to health expenditures, output rises immediately and persistently in a hump-shaped fashion, consistent with the short-run and time-release explanations. Furthermore, the shock has a small explanatory power for the variance of output in the short-run but a sizable explanatory power in the long-run. These results imply that increased health spending leads to improved health outcomes, and higher private and human capital accumulation, which in turn lead to higher productivity and output.

2 Methodology

We consider the reduced-form panel VAR model:

$$Y_{st} = A(L)Y_{s,t-1} + \theta_s + \varepsilon_{st}, \tag{1}$$

where $s = 1, ..., 51$ indexes U.S. states (including Washington D.C.), $t = 1, ..., T$ is time in years, $Y_{st} = [Y_{1t}\ Y_{2st}]'$, and $\varepsilon_{st} = [\varepsilon_{1t}\ \varepsilon_{2st}]'$. The vector $Y_{1t} = [g_t\ r_t\ o_t]'$ contains U.S. macroeconomic variables to account for common across state effects.[6] Specifically, g_t, r_t, and o_t respectively control for federal government spending, monetary policy, and oil shocks. U.S. state level variables are contained in the vector $Y_{2st} = [b_{st}\ h_{st}\ y_{-st}\ y_{st}]'$ where b_{st} is the budget surplus, h_{st}, y_{-st}, and y_{st} respectively represent the logarithms of health spending, the sum of output in all states except state s, and output of state s. The reduced-form residuals associated with $Y_{1t} = [g_t\ r_t\ o_t]'$ and $Y_{2st} = [b_{st}\ h_{st}\ y_{-st}\ y_{st}]'$ are $\varepsilon_{1t} = [\varepsilon_t^g\ \varepsilon_t^r\ \varepsilon_t^o]'$ and

[6] Y_{1t} does not contain an s subscript because variables in it are invariant across states.

$\varepsilon_{2st} = [\varepsilon^b_{st}\ \varepsilon^e_{st}\ \varepsilon^y_{-st}\ \varepsilon^y_{st}]'$. State fixed effects are denoted by θ_s, and $A(\cdot)$ is a polynomial in the lag operator L, with $L = 4$ as determined by the Akaike Information Criterion.

Equation (1) suffers from dynamic panel bias because it contains $X_{s,t-1}$ and θ_s. We apply the Helmert transformation to address this bias. Let $Z_{st} = [Y_{st}\ \varepsilon_{st}]'$ and let $\widetilde{Z}_{st} = \sqrt{\frac{T_s-t}{T_s-t+1}}\left[Z_{st} - \sum_{m=t+1}^{T_s}(\frac{Z_{sm}}{T_s-t})\right]$ denote Helmert-transformed variables. We then rewrite Equation (1) as:

$$\widetilde{Y}_{st} = A(L)\widetilde{Y}_{s,t-1} + \widetilde{\varepsilon}_{st}. \tag{2}$$

The above transformation corrects for the aforementioned bias and also provides orthogonality conditions that allow for GMM estimation of Equation (2).

Let $\widetilde{u}$ denote the structural shocks. Assuming the relationship between $\widetilde{u}$ and $\widetilde{\varepsilon}$ is $\widetilde{\varepsilon}_{it} = B_0^{-1}\widetilde{u}_{it}$, Equation (2) can be written in structural form as:

$$B_0\widetilde{Y}_{st} = B(L)\widetilde{Y}_{s,t-1} + \widetilde{u}_{st} \tag{3}$$

where B_0 a non-singular matrix with its main diagonal elements equal to one, and $B = B_oA$.

We identify structural shocks following Atems and Blankenau (2020). Specifically, our main identification restriction is that output responds to a health spending shock on impact, but that health spending responds to an output shock with a lag of one year or more. Further details and rationale for this and other identification restrictions imposed on the VAR model are discussed in Atems and Blankenau (2020). After identifying the structural shocks, we then present the response of output to a shock of 1% to public health expenditures.

We further summarize the output response in terms of a health spending multiplier.[7] We focus on two commonly used multipliers. The *impact multiplier*, denoted $M_{1,q}$, and calculated as:

$$M_{1,q} = \frac{\Delta y_{t+q}}{\Delta h_t}\frac{1}{h/y} \tag{4}$$

[7] That is, the additional dollar increase in output from an extra dollar increase in public health spending.

where Δy_{t+q} is the response of output to health spending shock in period $t+q$, Δh_t denotes the period t own response of health spending; and h/y is the average share of health spending in output over the sample. $M_{1,q}$ measures how an initial change in health spending impacts output q periods ahead. To capture the full dynamics of the spending shock and properly discount future output effects, we also estimate the present-value multiplier, $M_{2,q}$:

$$M_{2,q} = \frac{\sum_{j=0}^{q} (1+r)^{-j} \Delta y_{t+j}}{\sum_{j=0}^{q} (1+r)^{-j} \Delta h_{t+j}} \frac{1}{h/y} \tag{5}$$

where r is the average interest rate over the entire sample.[8] As $T \to \infty$, $M_{2,q}$ allows us to examine the long-run effect of the health spending shock as it measures the net present-value of the cumulative change in output from the moment of impact to q periods after the shock.

3 Data

Our data are annual spanning the period 1963-2018 for all 50 U.S. states and Washington DC. We control for federal government spending by including the Ramey (2011) defense news series. The percentage change in the West Texas Intermediate crude oil prices and the federal funds rate, both from the Federal Reserve Economic Database are used to measure oil and monetary policy shocks, respectively. Per capita state and local health expenditures, collected from the Census Bureau are deflated by the Consumer Price Index (CPI) and used as the measure of public health spending. State output is the per capita GSP, collected from the Bureau of Economic Analysis, and deflated by the CPI. Data on state budget comes from the Census and are expressed as a percentage of GSP.

[8] In our sample,$h/y = 0.0431$ and $r = 0.0513$.

4 Empirical results

Figure 1A displays the output response to a shock of 1% to health spending.[9] On impact, output rises by 0.01%, peaks at 0.15% after twelve years, and then begins a gradual decline thereafter but remains statistically significant throughout. This positive, persistent, and significant output response is consistent with the short-run and time-release hypotheses described above. That is, output rises immediately due to the increase in aggregate demand arising from the fiscal stimulus. This stimulus may generate subsequent general equilibrium output adjustments but its overall effects are expected to be shortlived. However, a secondary effect arises as the quality of care and health of workers improves, leading to fewer missed work days due to ill health, higher wages, productivity, and output. Through time, a tertiary effect emerges as the health spending shock lowers mortality, and increases life expectancy and quality of life, thereby increasing human (and private) capital accumulation. This effect dominates until output reaches its peak, but then the effect gradually diminishes leading to the gradual decline in output observed in Figure 1A.

(FIGURE 1 ABOUT HERE)

The impact multiplier implied by Equation (4) is shown in Figure 1B. An additional dollar of public health spending delivers 31 cents of additional output in the year of implementation. The multiplier peaks at $3.44 after twelve years, then begins to decline. Davig and Leeper (2011) discuss several issues with this multiplier. We remedy these issues by estimating the present-value multiplier (Figure 1C). In year 40, the multiplier is 4.51 indicating that an additional dollar of government health spending elicits an additional increase in output of $4.51 in the long-run. The multiplier is statistically different from zero at every horizon.

Table 1 displays the contribution of a health spending shock to the variance of output. The shock has low explanatory power for the variance of output in the short-run. However, the importance of the shock grows with time, explaining more than 30% of the long-run

[9] Output responses to shocks to the other variables not shown because they are not surprising. See Atems and Blankenau (2020) for those responses and discussion.

variance of output. This increase in the explanatory power of the shock through time, together with the persistence in the output response in Figure 1 are consistent with the hypothesis that the output effects of health spending are propagated in a time-release fashion.

(TABLE 1 ABOUT HERE)

5 Concluding remarks

Does health spending increase output? If so, over what time horizon and through what mechanisms? What is the magnitude of the effect at various horizons, and what proportion of the variation of output is explained by fluctuations in health spending? We estimate a panel SVAR model using U.S. state-level data from 1963-2018 to address these questions. In response to a health spending shock, output rises immediately and persistently in a hump-shaped manner. Furthermore, the shock has a small explanatory power for the short-run variation of output but a sizable power in the long-run. These results support the hypothesis that the output effects of health spending are propagated in a time-release fashion.

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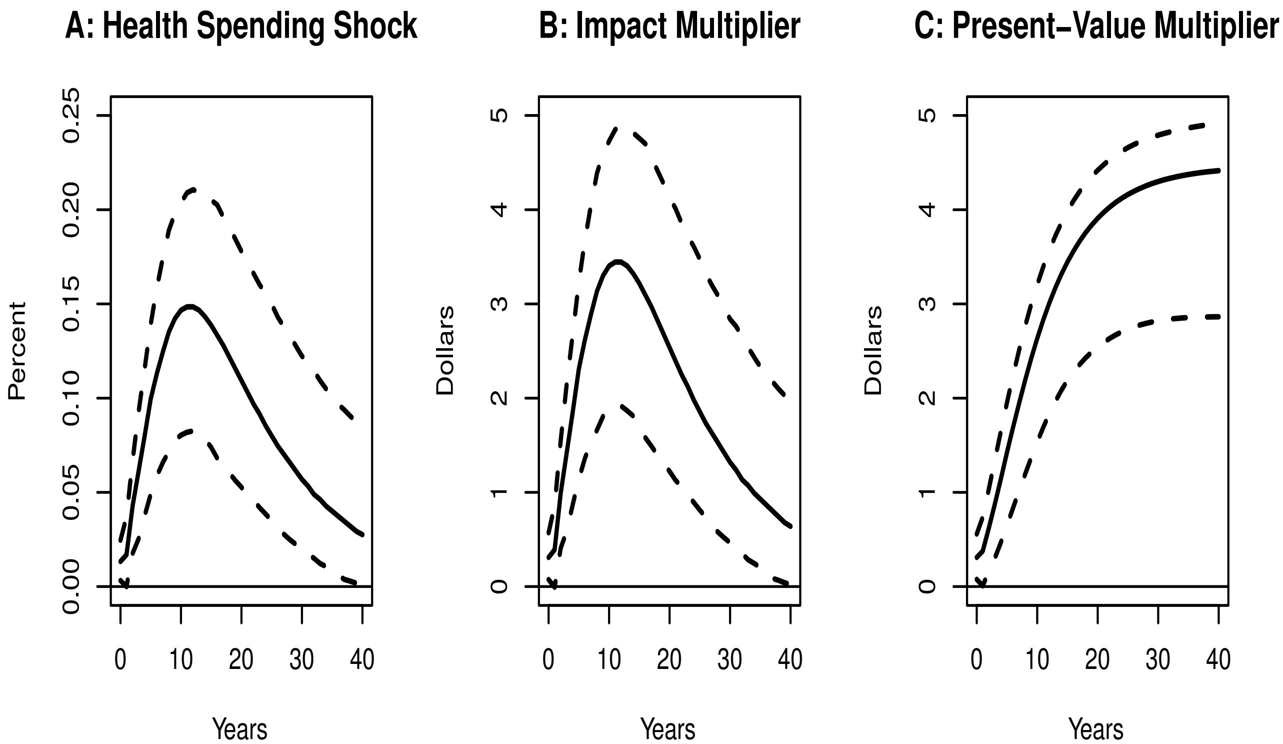
Figure 1: Output Response and Multipliers Effects of a Health Spending Shock



Notes: Dashed lines are 95% confidence bands computed by Monte Carlo simulation with 1000 replications.

Table 1: Percent Contribution of Public Health Spending to Variability of Output

Horizon	1	5	10	15	20	25	30	35	40
Percent	0.25	3.05	13.90	25.20	31.99	35.25	36.72	37.37	37.66

Notes: The k-step-ahead forecast error variances are based on the VAR model described in text.