Adjusting National Accounting for Health

Is the Business Cycle Countercyclical?

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October 2017

Motivation

National accounts offer an incomplete picture of total output

- Home production
- Value of leisure
- Health/mortality

Propose a new methodology: Health/Mortality Adjusted GDP

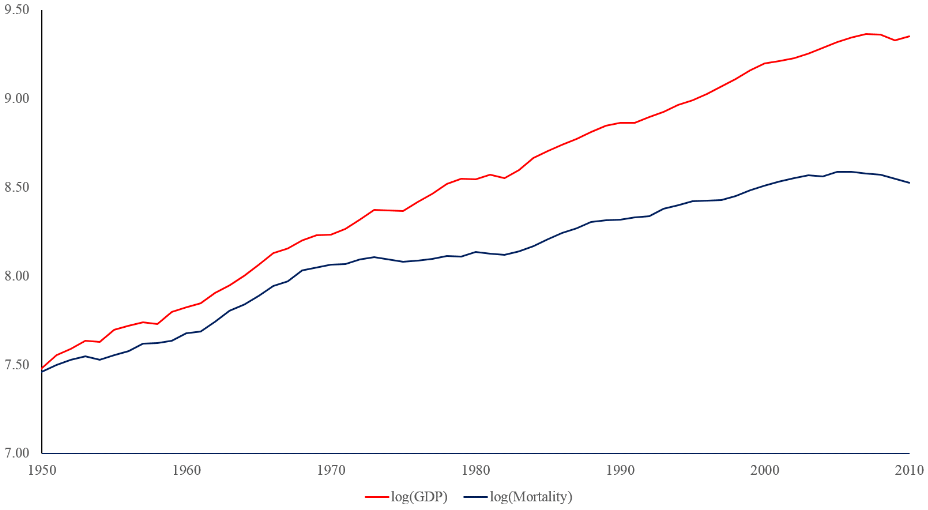
- Incorporate monetized changes in health
- Implications for cycle and recessions

Motivation

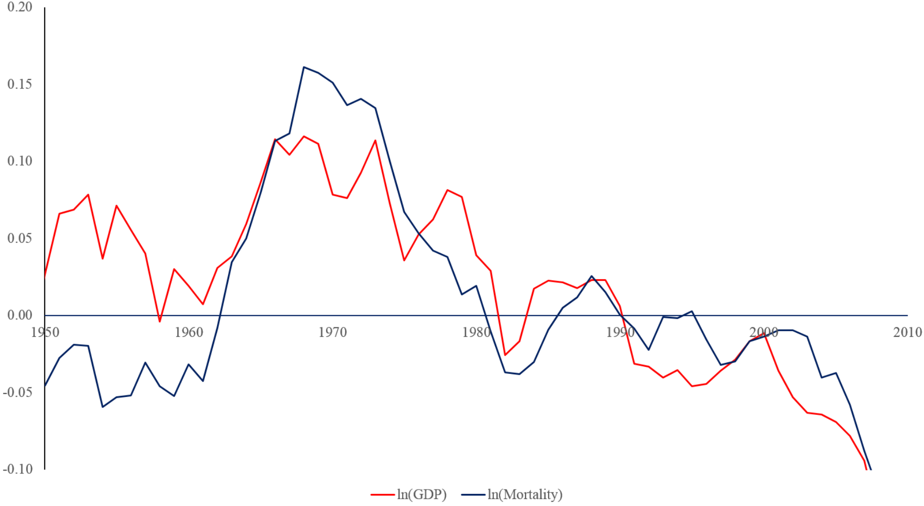
To illustrate the quantitative magnitudes, consider that in 2016

- 2.5 million deaths in the United States
- Suppose we value a life at $9 million (EPA, USDOT)
- Implies a mortality cost of $22.5 trillion
- To put this in perspective, GDP was $19 trillion

Motivation
GDP and Mortality



It is well known that mortality is cyclical (Ruhm, 2000)



This paper

- Propose a methodology to measure of health adjusted GDP
  - Incorporates monetized changes in health
  - Mortality Adjusted GDP
- Construct mortality adjusted GDP
  - Use existing Value of Statistical Life estimates
  - US and 21 other countries
- Reexamine recessions and the business cycle after adjusting for mortality

Preview of Results

Relative to GDP, mortality is

- Quantitatively meaningful
- Cyclical

Consequently

- Booms are not as valuable due to increased mortality
- Busts are not as costly due to decreased mortality

Preview of Results

We find that adjusting for mortality...

- Reduces the volatility of measured output by 15-30%
- Reduces the measured severity of recessions by 2pp
- Accounting for mortality essentially reverses one in four recessions

Roadmap

- Economic Framework for Depreciation
- Constructing Health/Mortality Adjusted GDP
- Implications
  - Adjusting recessions for health
  - Reexamining the business cycle
  - International results

Economic Framework

Measuring economic activity involves recognizing the value of capital is different at the end of the time frame

- Investment
- Depreciation

The “Ideal" method for measuring depreciation is to infer an age-value prole from purchase price data from a frictionless resale marked for used assets.

- We don’t have a resale market for humans.
- We use existing value of statistical life (VSL) estimates

Begin with a cohort of assets of age a

Let $v(a)$ denote the present value, conditional on survival to age a, of an assets service flows

$$v(a) = \frac{\int_a^\infty \left[\int_a^x e^{-r(z-a)} b(a) dz\right] m(x) dx}{S(a)}$$

where

- $S(\cdot)$: is the survival function with corresponding density $m(\cdot)$
- $b(a)$: service flow of age a asset
- r : discount rate
- $\left[\int_a^x e^{-r(z-a)} b(a) dz\right]$: present value of asset that lasts exactly x years

Depreciation reflects the decline in a cohort's value

$$\begin{aligned} Depreciation &= \frac{d}{da}\left[S(a)v(a)\right] \\ &= m(a)v(a) - S(a)v'(a) \end{aligned}$$

where

- $m(a)v(a)$: cohort members retired from service
- $S(a)v'(a)$: change in value among surviving cohort members

Consider depreciation in the context of human capital

$$Depreciation = m(a)v(a) - S(a)v'(a)$$

where

- $v(a)$: value of a statistical life
- $m(a)v(a)$: depreciation due to mortality
- $S(a)v'(a)$: depreciation due to aging/morbidity

Define mortality adjusted GDP (N_t) as

$$N_t = Y_t - M_t - A_t$$

where

- Y_t : GDP
- M_t : Value of mortality $(m(a)v(a))$
- A_t : Value of aging/morbidity $(S(a)v'(a))$

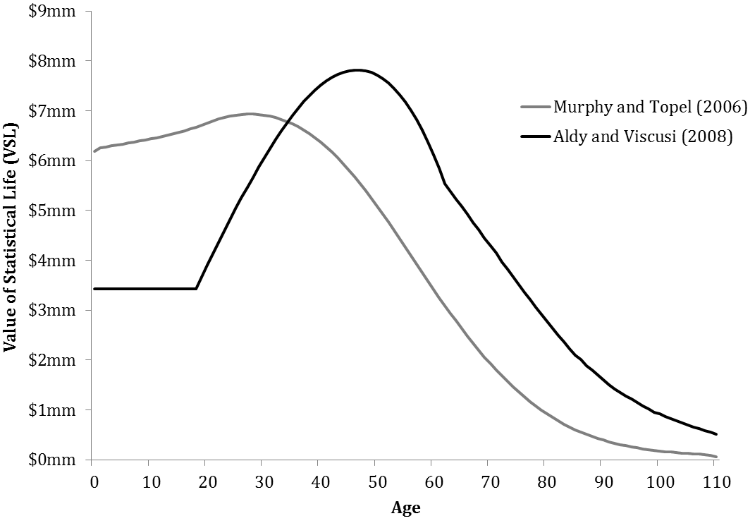
Calculate mortality as

$$M_t = \left(\sum_{age,g} \frac{death_{age,g,t}}{pop_{age,g,t}} VSL_{age,g,t} s_{age,g,2000} \right) \left(\sum_{age,g} pop_{age,g,t} \right)$$

Use two methodologies for calculating the Value of a Statistical Life (VSL)

- Aldy and Viscussi (2008): hedonic wage regressions
- Murphy and Topel (2006): calibrated life-cycle model

Constructing Mortality Adjusted GDP
Value of Statistical Life



Calculate aging as

$$A_t = \left(\sum_{age,g} \frac{death_{age,g,t}}{pop_{age,g,t}} \Delta VSL_{age,g,t} s_{age,g,2000} \right) \left(\sum_{age,g} pop_{age,g,t} \right)$$

where

$$\Delta VSL_{age,g,t} = VSL_{age,g,t+1} - VSL_{age,g,t}$$

Only observe VSL for one year (2000), not over time

- Scale VSL across time by trend GDP per capita

$$VSL_{age,g,t} = VSL_{age,g,2000} \times \left(\frac{\frac{Y_t^T}{pop_t}}{\frac{Y_{2000}^T}{pop_{2000}}} \right)$$

- Assume elasticity of VSL to trend income is one (Miller, 2000)

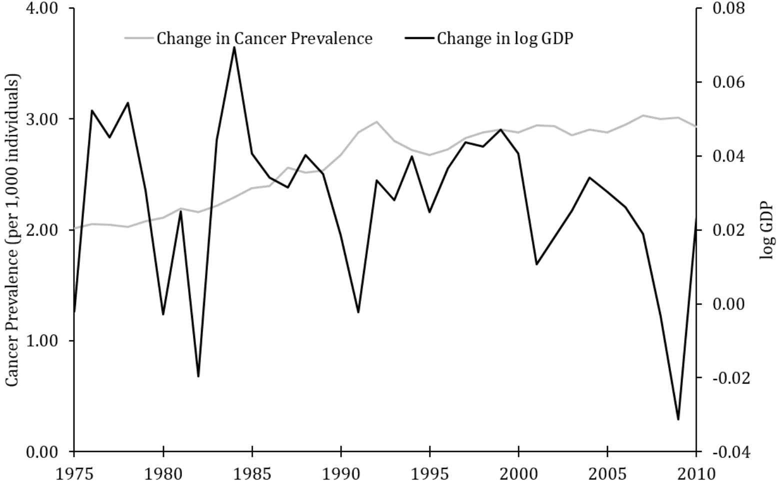
Our analysis focuses on the cyclicality of output

$$M_t = \left(\sum_{age,g} \frac{death_{age,g,t}}{pop_{age,g,t}} VSL_{age,g,t} s_{age,g,2000} \right) \left(\sum_{age,g} pop_{age,g,t} \right)$$

$$A_t = \left(\sum_{age,g} \frac{death_{age,g,t}}{pop_{age,g,t}} (\Delta VSL_{age,g,t}) s_{age,g,2000} \right) \left(\sum_{age,g} pop_{age,g,t} \right)$$

Our empirical implementation implies
$(VSL_{age,g,t}) \left(\sum_{age,g} pop_{age,g,t} \right)$ is acyclical

- Also implies A_t is acyclical
- Cyclicality of M_t is driven by the cyclicality of the death rate



Change in Cancer Prevalence
Change in log GDP
Cancer Prevalence (per 1,000 individuals)
log GDP
4.00
3.00
2.00
1.00
0.00
0.08
0.06
0.04
0.02
0.00
-0.02
-0.04
1975
1980
1985
1990
1995
2000
2005
2010

Reexamine the severity of past US recessions

Calculate peak to trough Mortality Adjusted GDP as

- Difference in actual output N_t minus trend value N_t^T
- Normalized by GDP

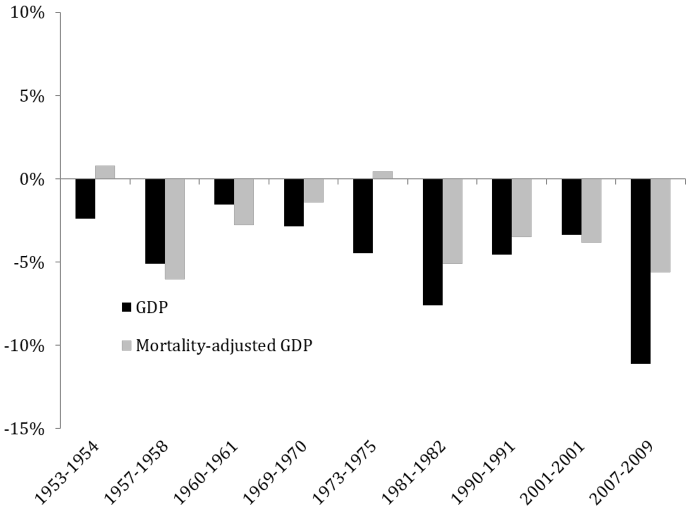
$$Peak - to - Trough = \frac{N_t - N_t^T}{Y_t^T}$$

Calculate trend mortality and GDP based on average growth rates

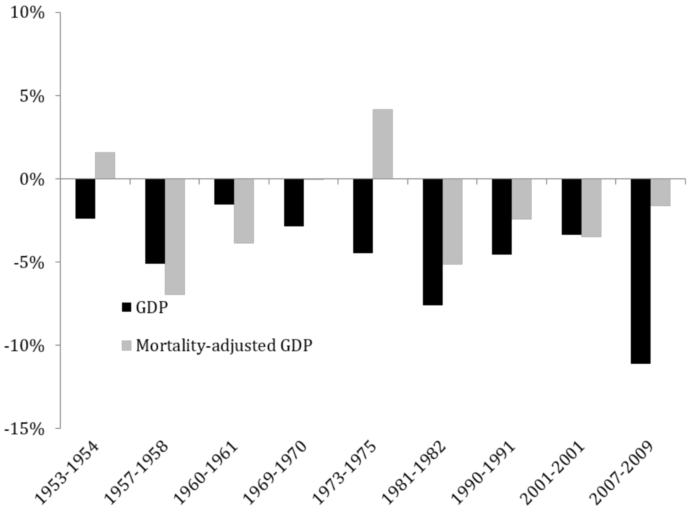
$$N_t^T = Y_{t-\tau}(1 + \overline{\Delta\%Y})^{\tau} - Y_{t-\tau}(1 + \overline{\Delta\%M})^{\tau} - A_t$$

where τ is the length of the recession

Mortality Adjusted GDP



Mortality Adjusted GDP



Cyclicality of Mortality Adjusted GDP

Its well established that mortality co-varies positively with unemployment

- Ruhm (2000), Gerdtham and Ruhm (2006), etc

Reconfirm and build on these results looking at mortality and GDP

- Mechanism drives the cyclicality of mortality adjusted GDP

$$\Delta \ln Mortality_t = \beta_0 + \beta_1 \Delta \ln GDP_t + \beta_2 t + \epsilon_t$$

Age Group	(1)	(2)	(3)	(4)
All	0.41***	0.27***	0.24***	0.21**
	(0.08)	(0.08)	(0.08)	(0.09)
65+	0.76***	0.32***	0.29***	0.23**
	(0.12)	(0.10)	(0.10)	(0.10)
25-64	0.10	0.14	0.15	0.19*
	(0.15)	(0.09)	(0.09)	(0.10)
0-24	0.19	0.21	0.20	0.16
	(0.19)	(0.13)	(0.13)	(0.14)
Time Trend	X	X		X
AR(1) Correction		X		
First Differences			X	X

Decompose GDP, Mortality, and Mortality Adjusted GDP into trend and cycle components

$$Y_t = exp(y_t^T + y_t^C),\ M_t = exp(m_t^T + m_t^C)$$

where

$$\mathrm{E}\left[Y_t | y_t^T\right] = exp\left(y_t^T\right),\ \mathrm{E}\left[M_t | m_t^T\right] = exp\left(m_t^T\right)$$

Mortality Adjusted GDP is defined as

$$N_t = Y_t - M_t - A_t$$

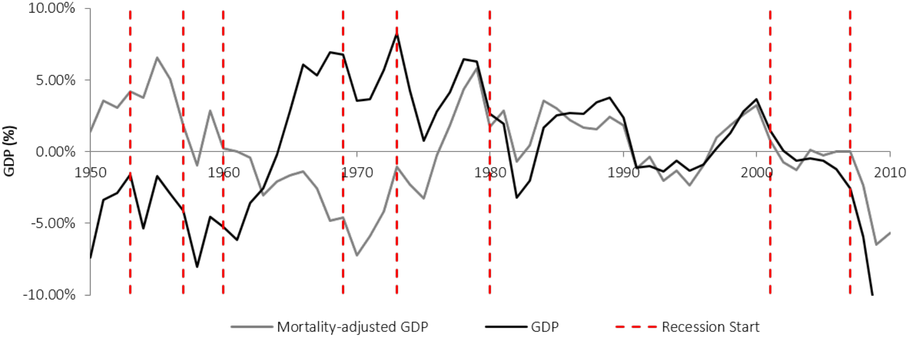
Cyclical component of mortality adjusted GDP and GDP

$$N_t^C = N_t - \left[exp\left(y_t^T\right) - exp\left(m_t^T\right)\right]$$

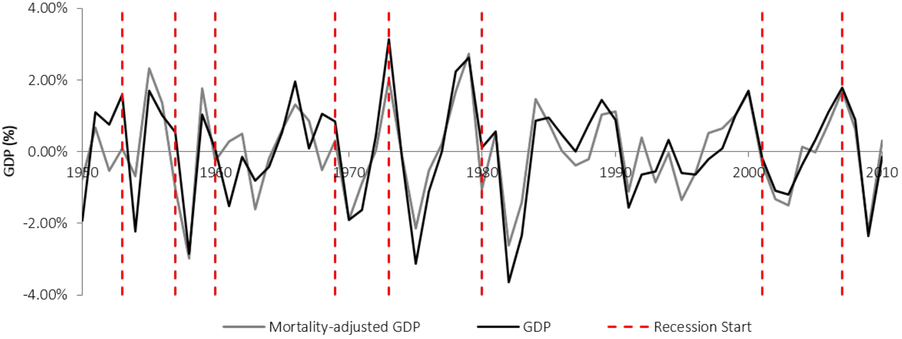
$$Y_t^C = Y_t - \left[exp\left(y_t^T\right)\right]$$

Recover trend using the HP Filter and a log-linear trend

Cyclicality of Mortality Adjusted GDP



Cyclicality of Mortality Adjusted GDP



Cyclicality of Mortality Adjusted GDP

Volatility of Measured Output

Measure	$Std.Dev.\sigma-$Cycle	$\sigma-$Cycle	$\sigma-$Trend
GDP	4.42%	1.41%	3.98%
Mortality-adjusted GDP	3.04%	1.21%	2.60%
Log Linear Trend	X		
HP Filter		X	X

Robustness and Extensions

Methodology can be extended to account for morbidity

- Need time varying VSL estimates or
- Prevalence data for diseases

Results hold for other developed countries: ▸ International Results

- Examine 21 OECD countries
- Mortality adjustment...
  - Reduces severity of recessions by 2pp
  - Reduces volatility of output by 40%

Conclusions

- Construct a new measure of output that incorporates changes in health
- Examined macroeconomic fluctuations in the US over the past 60 years
- Because mortality tend to be pro-cyclical, fluctuations in standard GDP are in part offset by human depreciation
  - Booms are not as valuable because of increased mortality
  - Recessions are not as bad because of lower mortality
- Fluctuations in economic output are milder than commonly measured
  - Adjusting for mortality reduces the severity of recessions by 2pp
  - Adjusting for mortality reduces the volatility of GDP by 15-30%

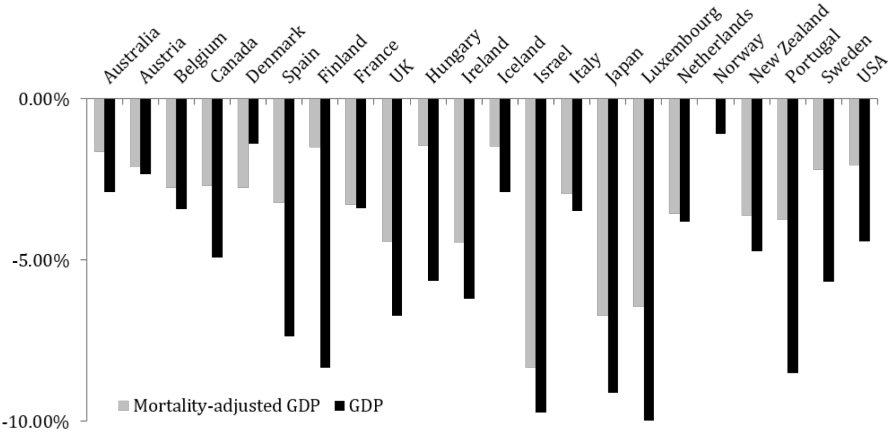
- Human capital investments
  - Stock replenishment: fertility and immigration/emigration
    - Cyclicality of fertility: Butz and Ward 1979; Mocan 1990; Ahn and Mira 2002
  - Skill/Knowledge human capital: Ehrlich 2007
    - Countercyclical investments: Dellas and Sakellaris 2003
    - Loss of human capital during unemployment: Rum 1987, Jacobsen et al. 1993, Dechter 2014
- Gradual changes in human depreciation
  - Morbidity
  - Demographic changes
- Quantative welfare effects of counter-cyclical fiscal policies

Adjusting International Recessions for Health

We replicate the preceding peak to trough analysis

- Unbalanced sample of twenty-one other developed countries
- Recessions across countries are dated using an algorithm in-line with Jorda, Schularick, and Taylor (2011), Claessens, Kose, and Terrones (2011) and Bry and Boschan (1971) .
- Assume that the elasticity of VSL with respect to income is one.

Adjusting International Recessions for Health
Peak to Trough



Adjusting International Recessions for Health

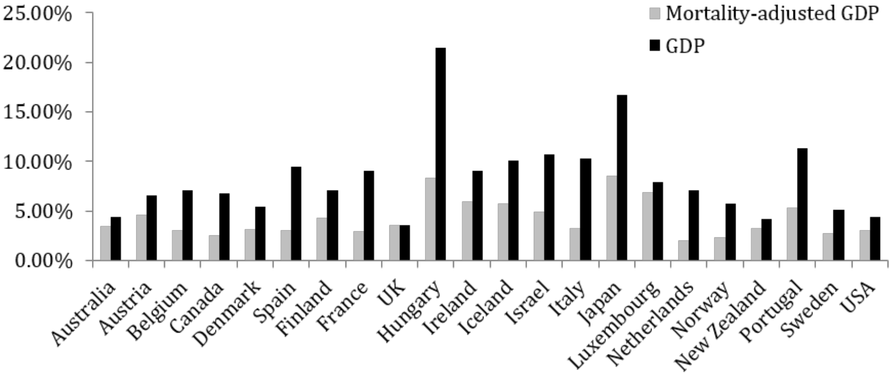
Country	GDP	Mortality Adjusted GDP
Australia	-2.90%	-1.65%
Austria	-2.34%	-2.11%
Belgium	-3.42%	-2.75%
Canada	-4.93%	-2.70%
Denmark	-1.40%	-2.75%
Finland	-8.35%	-1.51%
France	-3.40%	-3.30%
Hungary	-5.65%	-1.45%
Iceland	-6.21%	-4.45%
Ireland	-2.90%	-1.49%
Israel	-9.72%	-8.33%
Italy	-3.47%	-2.96%
Japan	-9.13%	-6.72%

Adjusting International Recessions for Health

Country	GDP	Mortality Adjusted GDP
Luxembourg	-9.99%	-6.46%
Netherlands	-3.82%	-3.56%
New Zealand	-1.09%	0.45%
Norway	-4.72%	-3.61%
Portugal	-8.52%	-3.75%
Spain	-7.38%	-3.23%
Sweden	-5.67%	-2.20%
United Kingdom	-6.74%	-4.43%
United States	-4.43%	-2.06%

Adjusting International Output for Health

Volatility of Output



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