International Evidence on Medical Spending

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Abstract

U.S. medical spending is high by measures including the level of spending, level of spending per capita, and level of spending as a share of GDP. U.S. medical spending growth is average by measures including the annual growth rate, annual growth rate per capita, and annual growth in spending as a percent of GDP. The volatility of U.S. medical spending growth is low by measures including the standard deviation, skew, and excess kurtosis.

Foreign healthcare systems, with a much larger government involvement, have not been able to control medical spending growth better than the U.S. with its mixed system. Foreign cost curves start at a lower level, but increase as quickly or even faster. In many countries, the variance around the trend is high, or a single trend over time does not exist. The implication is that it is difficult to find a foreign solution to the U.S.'s problems with high medical spending, and that the U.S. may be a world leader in terms of minimizing medical spending volatility.

If the U.S. healthcare cost curve comes to resemble that of other countries, the risk of long-tailed lines of insurance linked to the cost of medical care will increase. The healthcare cost curve is a macroeconomic process, so there may be no ways for insurers to bend their cost curve. Insurers may be able to use market solutions, such as prediction markets, inflation-indexed bonds, and futures contracts, to improve prediction and hedging of long-term medical spending growth. My recommendations for insurers are cognizance and caution when writing long-tailed lines of insurance linked to medical spending.

INTERNATIONAL MEDICAL SPENDING DATA

Unique aspects of U.S. medical spending

U.S. medical spending is high relative to spending in other countries. The healthcare sector is a larger share of the U.S. economy than any other economy. Since the U.S. economy is the largest, with one of the highest levels of income per capita, that means that the U.S. also spends the most per capita on medical care.

As U.S. medical spending continues to rise, it is unclear whether the rest of the world will follow. U.S. medical spending could continue to be idiosyncratic. The U.S. has the highest spending, so as long as the U.S. spending growth rate equals or exceeds that of other developed countries, the U.S. will always have the highest level of medical spending. The U.S.'s unusually large private healthcare sector could generate a highly volatile cost curve. If the U.S. truly is idiosyncratic, then the U.S. will have limited success in applying foreign solutions for controlling medical spending to the U.S. economy.

One difference between U.S. and foreign healthcare systems that could inform forecasts of cost control is the lack of universal health insurance. Other developed countries have universal or near universal healthcare. Studying the effect of universal coverage on healthcare cost curves in other countries could help us understand the effect of health insurance expansion in the U.S. Identification of the effect of the level of insurance on medical costs would require variation over time in the level of healthcare coverage in several countries. My data does not include such variation (see Table 1). Even in countries that changed to universal insurance relatively recently, other contemporaneous health policy changes and general issues of low numbers of observations make it almost impossible to observe how changes in coverage affect the growth rates for medical spending.

Country	**Year of implementation**	**Notes**
Austria	1965 (92% insurance)	Big jump in reported percentage in 1965, numbers continued to rise to 100%
Canada	Entire sample	
Finland	1964	One time jump to 100% in 1964
Iceland	Entire sample	
Ireland	1980	One time jump to 100% in 1980
Japan	Entire sample	
Norway	Entire sample	
Spain	1987 (97% insurance)	Spotty reporting; 1987 is the first year with near universal coverage reported
Switzerland	Continuous	Rises from 74% to 99% by 1987
U.K.	Entire sample	
U.S.	N/A	Flat at 84-85% from 1997-2008
Min	Pre-1960	
Max	N/A	

Table 1: Introduction of national healthcare system

One problem that the U.S. shares with other developed countries is that medical spending seems to be growing at a high rate. The notion of bending the cost curve implies a smooth function that generates future spending as a multiple of current spending (Orszag 2009). The terminology of medical trend is similar, implying a given rate of growth that actuaries must factor into the calculation of long-term liabilities that will continue until we reach a resistance point (Getzen 2007). It is difficult to find an example of a country that has hit the resistance point for healthcare as a share of the economy. Any decline in medical spending growth in the U.S. and other countries seems to be temporary or is associated with outside factors, such as economic contraction, rather than through efficiencies or cost cutting measures.

OECD data

The Organization for Economic Cooperation and Development (OECD) provides data on medical spending, demographics, and population health variables starting in 1960[1] (OECD 2010). I focus on 11 countries that have reported annual spending data since 1960. The countries are Austria, Canada, Finland, Iceland, Ireland, Japan, Norway, Spain, Switzerland, the United Kingdom, and the United States.

The OECD breaks down medical spending data by currency and by source. The spending data is available in the national currency unit of each country, on a dollar basis using annual exchange rates, on a dollar basis using the exchange rate in 2000, and on a purchasing power parity basis. The OECD reports data split out by funding source, including a breakdown of public and private medical spending. The OECD also provides spending per capita and as a share of GDP.

The main drawback of the OECD data is the variability of reporting across countries and change in reporting standards over time. The OECD takes the data as given by member countries, and then reports it without an extensive set of edits and checks. In addition, the OECD does not standardize what constitutes medical spending, nor does it promulgate mandatory reporting standards for the way different countries choose to break down the data (Ward 2005).

I difference out any time invariant differences between different countries' reporting standards in my rate of change calculations. For example, say that observed medical spending $\hat{S}$ is overestimated by 3% at time 0 and time 1 compared to the true level of spending S. In this case, the observed medical spending growth rate $\hat{\tau}_1$ is equal to the true growth rate τ_1 because the error is time invariant. See Equation 1 below.

$$\hat{S}_0 = 1.03S_0$$
$$\hat{S}_1 = 1.03S_1$$
$$\hat{\tau}_1 = \ln\frac{1.03S_1}{1.03S_0} = \ln\frac{S_1}{S_0} = \tau_1$$

Equation 1: Time invariant errors in spending

I also assume that errors or differences in reporting are not correlated with the reported rates of change or the distributions of the rate of change. This assumption is more difficult to justify, since it is entirely possible that countries that experience a large run-up in medical spending will change their reporting systems to collect and disseminate data that are more detailed. Given the small number of data points that I have, I do not have the degrees of freedom to make additional modifications to the data.

[1] Not all variables are available for the entire period 1960-2009, not all countries provide data going back to 1960 for each variable, and not every variable is reported annually since 1960—for instance, some are reported quadrennially.

High U.S. medical spending

Per capita spending data shows that over time there is no single trend for many countries. Figure 1 shows the spending of four countries, Iceland, Switzerland, the U.K, and the U.S., in each country's national currency unit. I graphed the spending on a log scale in order to make exponential rates of growth appear linear rather than curved. I chose the four countries as representative of different trends over time. Switzerland has the most even growth in medical spending. The U.K. has the median rate of spending growth. The experience of Iceland is like an S-curve with slower growth followed by faster growth and then slower growth again. The U.S. is just behind the U.K. in compound annual growth in medical spending. The graph does obscure the variation in trend rates that occurs during flat periods of exponential growth because of the scaling by national currency units.

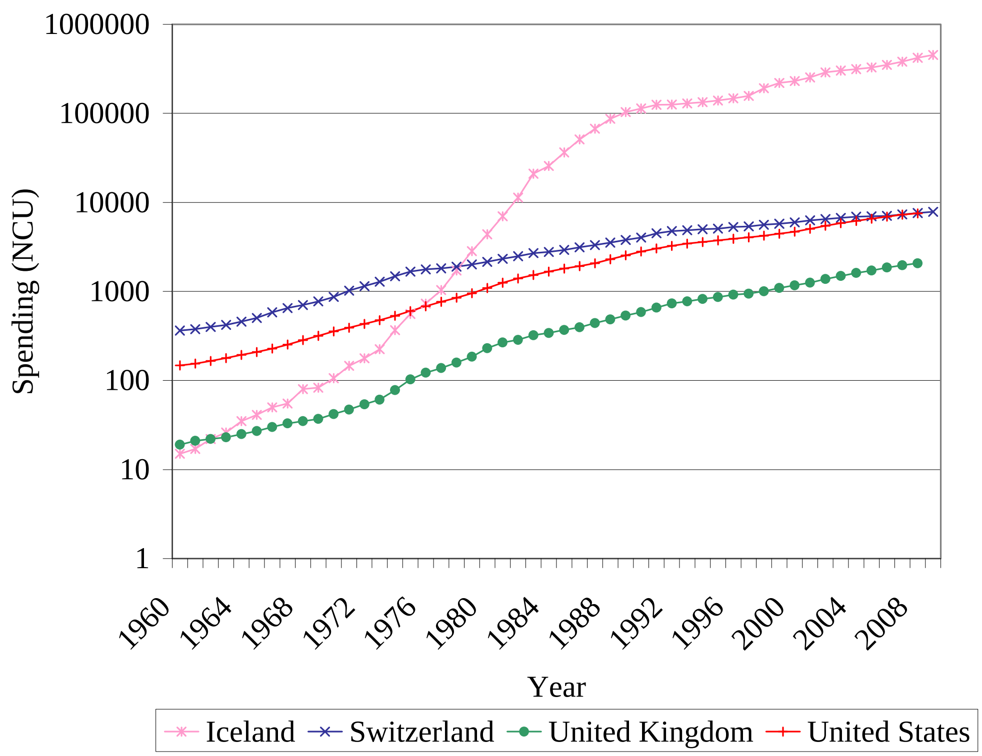

Figure 1: Medical spending in four OECD countries

Absolute spending may be less important for health policy than healthcare's share of the overall economy. Normalizing medical spending by nominal GDP also removes one of the problems with the spending data, which is that the use of national currency units can conflate medical spending changes with other macroeconomic changes (see Figure 2). On the other hand, the percent of GDP measure conflates GDP growth and medical spending growth, and the two variables have a complicated causal relationship (Amiri & Ventelou 2010). Insurance companies write policies based on medical spending rather than spending as a proportion of GDP, so predicting the share of GDP may not help in writing insurance.

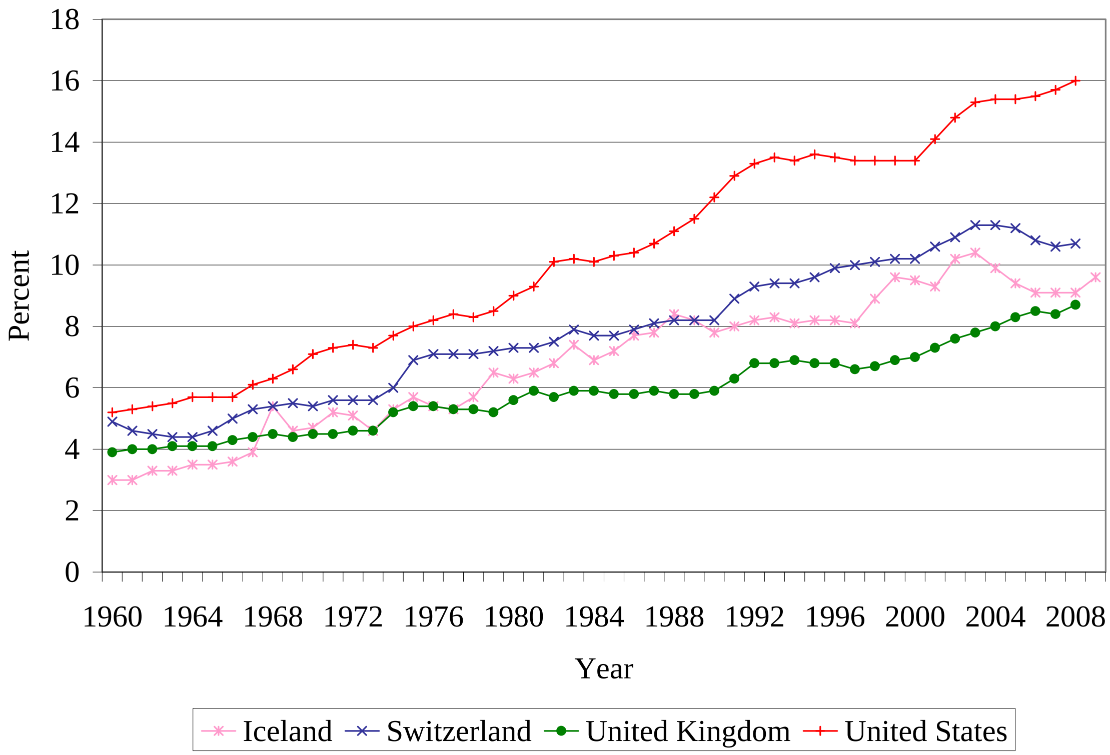

Figure 2: Medical spending as a share of GDP in four OECD countries

It is also unclear from a health policy point of view which variable to target. There is one view that rising medical spending as a share of GDP does not matter as long as GDP is rising. Medical care is a superior good, so we should expect it to rise as a share of rising incomes (Pauly 2003). The level of medical spending may be easier to target, for example with a "global budgeting" system where the amount of spending in a given year is fixed (Long & Marquis 1994). The problem with global budgeting is that unknowable factors, whether political, economic, or demographic, can induce a great deal of year-to-year volatility in spending. The volatility will in turn hamper planning as well as adversely affect insurance lines linked to medical spending. Higher growth rates may be acceptable to insurers if the trade-off is lower volatility in the spending growth rate.

INTERNATIONAL MEDICAL SPENDING TRENDS

Moderate U.S. spending growth

U.S. spending growth rates are average and they display a low volatility. The mean and standard deviation of U.S. spending are equal to or below the median over the 1961-2007 and the 1982-2007 periods. The skew and excess kurtosis of U.S. spending growth are below the median for the 1961-2007 and the 1982-2007 periods. The mean and standard deviation of spending growth for the median country have been more moderate recently than over the entire 1961-2007 period. The skew and excess kurtosis of spending growth for the median country have been more moderate recently than over the entire 1961-2007 period, so medical spending growth has continued to display low volatility, at least up until the beginning of the Great Recession (see Figure 3).

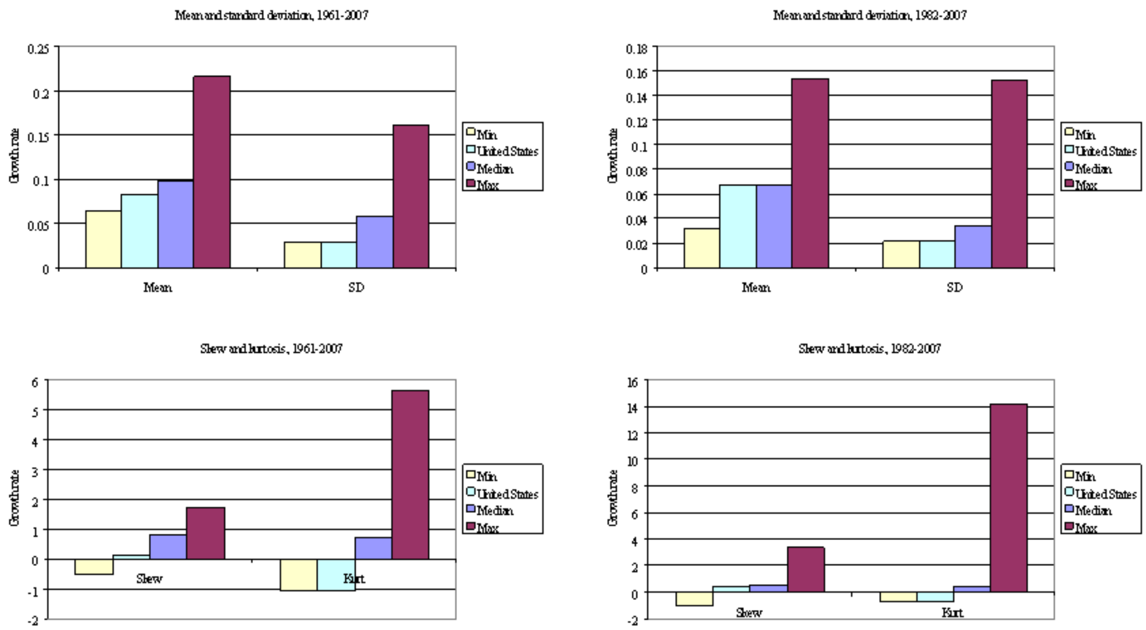

Figure 3: Summary statistics of spending growth

In Table 2, I summarize the mean, standard deviation, skewness, and excess kurtosis of spending growth rates on a continuous, logarithmic basis in all countries in my sample. The spending growth rates in the U.S. are within international norms. The U.S. rate of spending growth is low relative to other countries (tied for 8th overall with Austria and Canada), the standard deviation of the U.S. is the lowest of 11 countries, the skew is ranked 10th out of 11 countries (and lowest overall in absolute value terms), and the excess kurtosis is the lowest out of 11 countries. From an insurer's point of view, the relative risk associated with fluctuations in U.S. medical spending appears to be lower, especially given the relatively thin tails of the distribution.

Country	Mean	SD	Skew	Excess Kurtosis
Austria	0.08	0.06	1.57	5.81
Canada	0.08	0.04	0.24	0.26
Finland	0.10	0.06	-0.45	0.98
Iceland	0.21	0.16	0.74	-0.45
Ireland	0.12	0.07	0.93	0.81
Japan	0.09	0.08	1.25	1.34
Norway	0.10	0.06	0.80	0.93
Spain	0.15	0.09	0.86	0.65
Switzerland	0.06	0.04	0.88	0.18
U.K.	0.10	0.05	1.74	3.66
U.S.	0.08	0.03	0.10	-1.06
Min	0.06	0.03	-0.45	-1.06
Max	0.21	0.16	1.74	5.81

Table 2: Summary statistics of medical spending growth (national currency unit basis)

I adjust spending for a U.S. dollar exchange weighted value to show how much of the U.S.'s low medical spending volatility could be driven by the reserve status of the U.S. dollar (Krugman 1984). The currency adjustment reduces the range of statistics, but not the U.S.'s ranks in spending growth and volatility. The U.S. continues to have the lowest standard deviation and excess kurtosis, as well as one of the lowest average annual rates of growth in spending when dollar adjusted.[2]

One concern I have is that blending public and private spending drives the apparent low variability in the U.S. data. For insurers, private spending is more important than the rate of change in public spending. Public spending can still be important, especially if it causes the changes in private spending. For policymakers, the rate of change in public spending is more important than private spending. Private spending can still be important to policymakers, especially if it leads to political pressure to change the system.

In every system I studied, public growth rates exceed private growth rates.[3] It also appears that public spending is driving a great deal of the volatility in overall spending, or at least that public spending is more variable on several measures. The standard deviation of spending is higher for private than public spending in six out of nine countries, whereas in the U.S. and Finland, it is lower and the statistics are equal for Iceland. The skew and excess kurtosis in public systems is higher in many countries despite public spending being much larger. For the U.S., every statistic is higher for the public portion of spending, suggesting that public spending may be driving much of the volatility in U.S. medical trend (see Table 3).

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[2] Table available from the author on request.

[3] Canada did not report public/private breakouts of spending until 1971, while Switzerland did not report public/private breakouts of spending until 1986, so I excluded both from the analysis.

	Mean		SD		Skew		Excess Kurtosis	
Country	Public	Private	Public	Private	Public	Private	Public	Private
Austria	0.08	0.07	0.06	0.09	2.82	-1.26	11.38	7.43
Finland	0.11	0.09	0.08	0.06	-0.09	0.74	1.55	0.48
Iceland	0.22	0.20	0.17	0.17	0.59	-0.37	-0.69	2.51
Ireland	0.12	0.12	0.07	0.14	0.51	1.03	-0.16	6.11
Japan	0.09	0.07	0.08	0.14	1.12	0.90	0.84	3.19
Norway	0.11	0.10	0.06	0.34	0.70	2.94	0.38	12.28
Spain	0.15	0.13	0.13	0.15	1.91	0.98	5.89	3.44
U.K.	0.10	0.10	0.06	0.08	1.41	0.39	3.44	-0.62
U.S.	0.10	0.07	0.06	0.03	2.64	-0.05	9.41	-0.67
Min	0.08	0.07	0.06	0.03	-0.09	-1.26	-0.69	-0.67
Max	0.22	0.20	0.17	0.34	2.82	2.94	11.38	12.28

Table 3: Summary statistics of public and private medical spending growth (national currency unit basis)

It is also possible that medical spending volatility is merely a reflection of general volatility in the macroeconomy. One way to look at aggregate economic fluctuations is nominal GDP growth. The U.S. is one of the lowest volatility countries, with a mean growth rate on the lower end and the lowest standard deviation of growth rate. In addition, the skewness is low and the excess kurtosis is strongly negative, surpassed only by Japan. The U.S. could be a low volatility country, in which case there is no additional lesson for reducing the volatility in medical spending through health policy (see Table 4).

Country	Mean	SD	Skew	Excess Kurtosis
Austria	0.06	0.03	0.40	0.40
Canada	0.08	0.04	0.58	0.23
Finland	0.08	0.06	-0.34	1.23
Iceland	0.20	0.14	0.65	-0.48
Ireland	0.11	0.06	-0.71	2.55
Japan	0.07	0.06	0.33	-1.04
Norway	0.08	0.04	-0.59	1.43
Spain	0.11	0.05	-0.06	0.73
Switzerland	0.05	0.04	0.64	-0.12
U.K.	0.08	0.04	0.93	2.47
U.S.	0.07	0.02	0.40	-0.53
Min	0.05	0.02	-0.71	-1.04
Max	0.20	0.14	0.93	2.55

Table 4: Summary statistics of nominal GDP growth (national currency unit basis)

Another explanation for the volatility in spending could be demography. Unlike fiscal statistics, demography changes too slowly to explain the volatility in spending growth (White 2007). Most countries have had a slowly aging population as measured by the percent of population above age 65. Japan is the most rapidly aging country. All countries have a small standard deviation of rate of aging. The skews vary much more widely between countries, with the U.S. and Canadian skews closest to zero. There are also high excess kurtoses for a few countries, especially Ireland, reflecting the fact that most years of data contain zero change for the 65 and older population, with a few years of positive (or negative) growth. Measured by excess kurtosis, the U.S. is again a low volatility country from the perspective of aging (see Table 5).

Country	Mean	SD	Skew	Excess Kurtosis
Austria	0.01	0.01	-0.77	2.18
Canada	0.01	0.01	-0.09	-0.48
Finland	0.02	0.01	0.62	0.52
Iceland	0.01	0.01	-0.26	0.32
Ireland	0.00	0.01	3.44	17.80
Japan	0.03	0.01	-0.29	-0.56
Norway	0.01	0.01	-0.37	-1.27
Spain	0.02	0.01	-0.70	-0.19
Switzerland	0.01	0.01	1.50	4.37
U.K.	0.01	0.01	-1.33	4.54
U.S.	0.01	0.01	-0.13	-0.32
Min	0.00	0.01	-1.33	-1.27
Max	0.03	0.01	3.44	17.80

Table 5: Summary statistics of growth in population 65 and over

Modeling spending growth over time

Medical spending growth is hard to predict year-to-year using simple linear regression. For example, the R^2 on a regression of current year spending growth on prior spending growth is only 50%.[4] Regressions using data for a more recent period show less predictability, with an R^2 below 40%.

It is also unclear how far back we should be looking in trying to model medical spending growth. There are so few data points at our disposal, so it seems that more data is better. On the other hand, the U.S. healthcare system today is vastly different from the healthcare system of 50 years ago, so it is not clear whether we should use older data at all. Time series econometrics can help, but ultimately the decision of which data and model to use is a judgment call.

One problem with the time horizon I chose is the possibility that the time series of medical spending, or even medical spending growth, is nonstationary. Even accounting for a linear time trend, it would be difficult to believe that the average medical spending, and trends in spending, would not change over time because healthcare has changed so radically in all countries. In the U.S., the last 50 years have coincided with major medical innovation, the rise of private health insurance, the rise of public health insurance, and major demographic changes (Folland, Goodman, & Stano

[4] Calculated using U.S. data over the past 50 years.

2010). Similar developments have occurred in other developed countries, some of which have also experienced other major macroeconomic disruptions that may have affected medical spending.[5]

I test the stationarity of spending $\hat{S}$, spending growth $\hat{\tau}$, and one difference in spending growth $\Delta\hat{\tau} = \hat{\tau}_t - \hat{\tau}_{t-1}$. By inspection, it seems that no country has had a stationary time series in spending over the past 50 years (see Figure 1; other countries available by request). The plot of spending growth rates is tighter, although there are some outlier countries such as Iceland (see Figure 4). The plot of once differenced spending growth appears stationary for all countries, although it is more volatile for Iceland and the U.K. than Switzerland and the U.S. This suggests that, even accounting for nonstationarity, some countries have higher volatility in medical spending than others (see Figure 5).

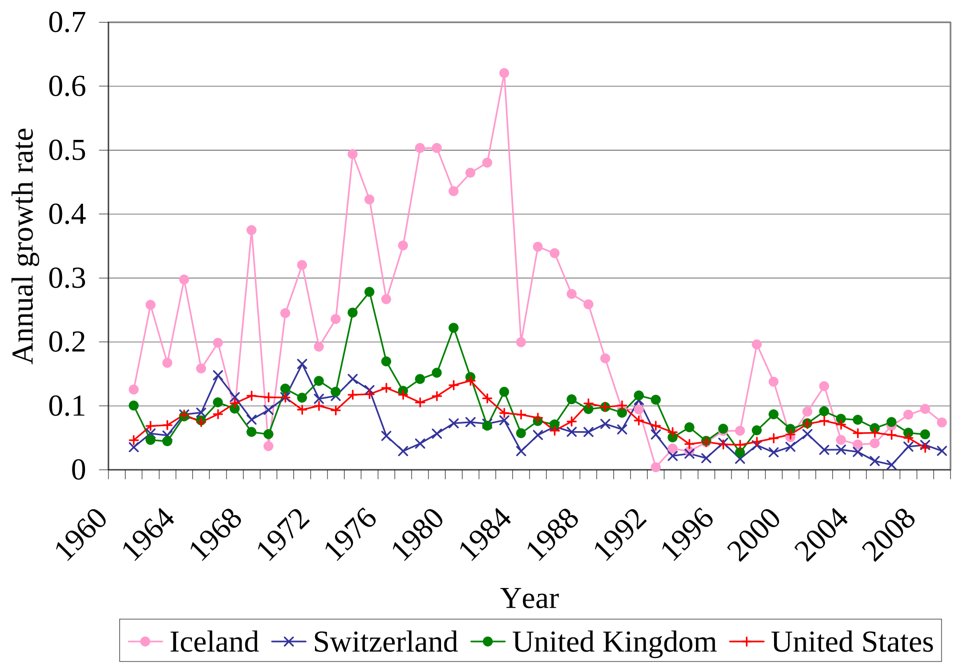

Figure 4: Medical spending growth in four OECD countries

[5] A consideration of financial crises is beyond the scope of this paper, but one example would be the IMF bailout of the U.K. in the 1970s.

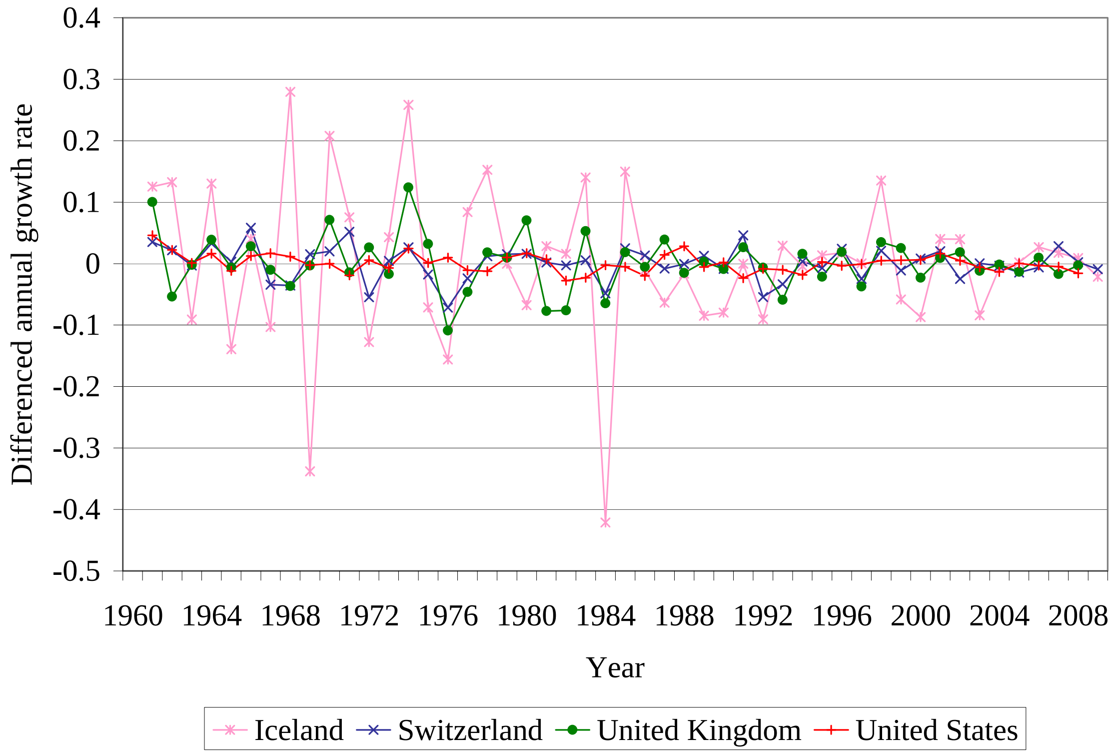

Figure 5: Once differenced medical spending growth in four OECD countries

A Dickey-Fuller test for unit roots suggests that five of the countries have stationary spending growth rates, while the other six have a unit root in spending growth. Among those countries where I fail to reject the null of a unit root is the U.S (see Table 6). Therefore, the observed high correlation between last year and current year spending growth may be an artifact of the nonstationarity of the time series. Japan is the only country with a stationary spending growth time series and high autoregressive element in spending growth. Japan gets close to the ideal of a country where past data is useful for forecasting future spending growth, and the correlation year-to-year is high.

Country	Spending	Spending growth	Δ Spending growth
Austria	1.00	<0.01	<0.01
Canada	1.00	0.30	<0.01
Finland	1.00	0.21	<0.01
Iceland	1.00	0.05	<0.01
Ireland	1.00	<0.01	<0.01
Japan	0.98	<0.01	<0.01
Norway	1.00	<0.01	<0.01
Spain	1.00	<0.01	<0.01
Switzerland	1.00	0.10	<0.01
U.K.	1.00	0.04	<0.01
U.S.	1.00	0.57	<0.01

Table 6: Dickey-Fuller test for unit root

Summary statistics for medical spending point to overall low relative volatility in the U.S. Summary statistics do not account for structural breaks, macroeconomic changes in other variables, demography, and the organization and financing of healthcare. The next step is to account for these changes within the framework of a time series regression. I decided to fit an autoregressive (AR) model because of the high degree of persistence in U.S. spending growth year-on-year. I chose an AR(1) model because of the small amount of data I have.

The main problem with fitting an AR(1) model to all the countries' data is the nonstationarity I observed. The time series for the level of spending in every country likely has a unit root. The graphs of spending for almost every country contain at least two trend lines if not more; to the extent that they do not, it is because the scaling of the graph obscures so much of the variation. The AR(1) parameter will be close to 1 not because spending is highly autoregressive and predictable but because the time series is nonstationary. Nonstationarity biases upward the statistical tests for the strength of correlations over time, such as t-tests. The result is that not only is the time series for spending misestimated, but any explanatory variables added to the AR(1) models are likely to show power to explain the growth in spending whether or not the relationship truly exists (Ferson, Sarkissian, & Simin 2003).

One way to deal with the problem of nonstationarity is through differencing. I fit the medical spending growth series directly for Austria, Ireland, Japan, Norway, and Spain, and I fit the once differenced spending growth rate for Canada, Finland, Iceland, Switzerland, the U.K., and the U.S.[6] The AR(1) parameter is 0.42 for Austria, 0.56 for Ireland, 0.72 for Japan, 0.30 for Norway, and 0.47 for Spain. In addition to the relatively low AR(1) coefficient, the p-value for Norway is 0.05, leading me to the conclusion that the summary statistics may be as good as, or better than, the AR(1) model when forecasting the growth rate in medical spending in Norway. More complicated time series

[6] Full AR(1) results are available upon request.

models are not appropriate in all cases.

Of all these countries, Japan is the one where forecasts of future growth using current and prior growth rates are the most informative. Planning for future medical spending budgets, and writing insurance based on medical claims, could be easier in Japan than in Austria, Ireland, Norway, and Spain, where future spending growth rates are less persistent.

The AR(1) results for spending growth and differenced spending growth series for countries with a unit root in spending growth show the importance of using the correct time series model. The AR(1) parameter for a regression of spending growth is 0.82 for Canada, 0.79 for Finland, 0.69 for Iceland, 0.74 for Switzerland, 0.66 for the U.K., and 0.91 for the U.S. The AR(1) parameter for once differenced medical spending growth is 0.14 for Canada, 0.14 for Finland, -0.48 for Iceland, -0.13 for Switzerland, -0.15 for the U.K., and 0.17 for the U.S. The p-value is high for Canada, Finland, Switzerland, and the U.K. so the AR(1) model may be inferior to simple summary statistics. The coefficient is negative for Iceland, Switzerland, and the U.K., so the time series of interest (medical spending growth) may return to a given level over time. The U.S. coefficient is small but significant, so the model is valid but may not help with long-term spending growth forecasts.

IMPLICATIONS FOR LONG-TAILED MEDICAL INSURANCE

Examples of long-tailed lines with medical exposure

Guaranteed renewable health insurance is one long-tailed insurance line specifically based on the risk of medical spending growth. Guaranteed renewable insurance includes a given medical trend factor for the life of the policy. Forecast errors that lead to higher than expected medical spending must come out of reserves, and can expose an insurer to ruin if reserves are not high enough. The guarantee of class average underwriting can be for 10 years or more at the time that the insurer forms the pool of insured lives, so a single year of forecast error can be very costly if it occurs in the early years of the contract (Lieberthal ND).

Workers compensation is a long-tailed line of property and casualty insurance that is exposed to the risk of medical spending growth. In the case of workers compensation insurance, the insurer must pay for the medical care arising from on-the-job injuries, potentially for a long period. As the standard of care changes, and becomes more expensive, the workers compensation insurer may have to provide benefits that meet the current standard of medical care, even if it is much better, and much more expensive, than care that was available at the time the policy was written, an effect called "social inflation" (Feldblum 1993).

Medical spending growth can have an even greater effect on excess casualty reinsurance. The reason is the "leveraged effect of limits on severity trend" (Werner and Modlin 2010, pp.117-118). Leverage comes from the fact that, for claims below the limit, the trend on excess claims is unobserved. When losses are high enough to trigger excess claims, losses jump from zero to a positive number, and the trend is undefined. Then, excess trend can either be above trend on total losses, or dampened below the trend on total losses, depending on what portion of the risk the reinsurer takes and whether there is an upper limit to the exposure (Keatinge 1989).

Example of a 10-year tail of claims

Take as an example an insurer who receives $12,000 in premiums up front for an insurance liability that is worth $10,005 in present value terms. The insurer expects to pay out the liability over 10 years (see Table 7). The insurer expects to pay out $863 at the end of year 1, rising an expected 7% per year on an annual compound basis in future years due to medical spending growth. The insurer calculated the expected claims in year 1 by observing that claims for a similar exposure were $807 in the prior year, and then inflating prior experience by the 7% forecast trend. The insurer uses a 3% discount rate and expects to earn 3% on invested reserves. The gross loading factor is 20%, which is worth $1,995 at time 0 and $2,681 (10 years compounding at 3%) at the end of year 10. The $2,681 is the final expected gross surplus before accounting for costs associated with the policy.

(A)	(B)	(C)	(D)	(E)
Year	Nominal claims	Discounted claims	Reserves	Surplus
0	0	0	10005	1995
1	863	838	9442	2055
2	923	870	8802	2117
3	988	904	8078	2181
4	1057	939	7263	2246
5	1131	976	6350	2313
6	1210	1013	5331	2382
7	1295	1053	4196	2453
8	1386	1094	2936	2527
9	1483	1137	1541	2603
10	1587	1181	0	2681
Totals	11923	10005		

Table 7: Base case insurance

Next, I assume that the insurer forecast year 1 incorrectly but the forecast claims in dollar terms for every other year remains the same. The trend for year 1 is 9%, which is 7% average U.S. trend plus 2%, one standard deviation of U.S. trend in the summary statistics. Instead of $863, the claims for year 1 are now $880, $17 higher. The claims for year 2 are still $923, and the claims for every other year after year 2 do not change (see Table 8).

In this case, the trend rates year-by-year are 9% in year 1, 5% in year 2, and then 7% thereafter. The trend is mean-reverting, and the only loss is because of the single year's higher payment and absence of investment returns on the deviation from year 1 experience. The adverse experience hardly makes a dent in the final gross surplus of the contract, which is $2,659, only $22 less than originally expected. The equivalent is the $17 deviation from expectations compounded nine years at 3%, which is $22. If the insurer had known ahead of time what the future would be, it would see that at the beginning of the contract the gross load was $1,979 rather than $1,995.

(A)	(B)	(C)	(D)	(E)
Year	Nominal claims	Discounted claims	Reserves	Surplus
0	0	0	10021	1979
1	880	854	9442	2038
2	923	870	8802	2099
3	988	904	8078	2162
4	1057	939	7263	2227
5	1131	976	6350	2294
6	1210	1013	5331	2363
7	1295	1053	4196	2434
8	1386	1094	2936	2507
9	1483	1137	1541	2582
10	1587	1181	0	2659
Totals	11940	10021		

Table 8: One bad year of 9% trend followed by base case claims thereafter

Next, I assume that changes in the level of spending are permanent. The year-by-year rates of medical trend are 9% in year 1, and then 7% in year 2 and thereafter. At the end of year 10, the gross surplus is only $2,400, which means that had the insurer known the future at time 0, it would have seen that the gross load was only 17% rather than 20%, and that a single-year deviation from experience knocked three percentage points off the anticipated loading factor. The true gross surplus at the beginning of the contract is $1,785 rather than $1,995 (see Table 9).

(A) Year	(B) Nominal claims	(C) Discounted claims	(D) Reserves	(E) Surplus
0	0	0	10215	1785
1	880	854	9641	1839
2	942	888	8988	1894
3	1008	922	8250	1951
4	1079	959	7419	2010
5	1155	996	6487	2070
6	1236	1035	5446	2132
7	1323	1076	4286	2196
8	1416	1118	2999	2262
9	1515	1161	1574	2330
10	1621	1206	0	2400
Totals	12175	10215		

Table 9: One bad year of 9% trend followed inflated by 7% trend thereafter

Finally, I assume that the spending growth rate is autoregressive, so that a single year's increase in spending growth rates leads to a permanent change in the level of spending growth. The year-by-year rates of medical trend are 9% in year 1, and then 7.5% in year 2 and thereafter. This could be because of an innovation that was very costly upfront and leads to continuing increases in costs that are above expectations.

At the end of year 10, the gross surplus is only $2,101, which means that had the insurer known the future at time 0, it would have seen that the gross load was only 15% rather than 20%. A single-year deviation from experience knocked five percentage points off the anticipated loading factor because the growth rate settles at a level that is 0.5 percentage points higher. The true gross surplus at the beginning of the contract is $1,564 (see Table 10). The persistence of higher trend takes an additional three percentage points off the anticipated gross loading factor beyond the effect of the single-year claims mistake compounded over the life of the insurance policy. If the time 0 expected gross load, including the reserves and the costs of underwriting, marketing, and capital, had been less than 15%, the insurer might have defaulted on the contract.

(A) Year	(B) Nominal claims	(C) Discounted claims	(D) Reserves	(E) Surplus
0	0	0	10436	1564
1	880	854	9869	1611
2	946	892	9219	1659
3	1017	931	8479	1709
4	1093	971	7640	1760
5	1175	1014	6694	1813
6	1263	1058	5632	1867
7	1358	1104	4443	1923
8	1460	1153	3116	1981
9	1570	1203	1639	2040
10	1688	1256	0	2101
Totals	12450	10436		

Table 10: One bad year of 9% trend followed by autoregressive spending growth of 7.5% trend thereafter

The forecast error problem is much worse if the insurer is writing excess reinsurance. Say that a reinsurer agrees to pay claims in excess of $9,266. This translates into expected payments of $2,657: $1,070 in year 9 and $1,587 in year 10. In present value terms, the reinsurer expects to pay out $2,001, and the reinsurer accepts $2,400 as the premium, which represents a 20% gross load.

Leverage comes in to the base case as year 10 nominal payments are 48% higher than year 9 payments. In the one bad year scenario, excess claims start in year 9, and are $13 more than expected on a present value basis, and the gross load falls to 19%. Year 10 nominal payments are only 46% higher than year 9 payments because year 10 payments cannot exceed $1,587 in year 10. In the one bad year followed by 7% trend example, excess claims start in year 9, and are $192 more than expected on a present value basis. Leverage causes the gross load to fall to 9%. Year 10 nominal payments are only 26% higher than year 9 payments because year 10 payments cannot exceed $1,621 in year 10.

The autoregressive trend example ends with a small deficit. In the autoregressive trend example, payments start in year 9 and are $403 more than expected on a present value basis. Year 10 nominal payments are 13% higher than year 9 payments. The expected 20% gross load with a 7% trend at the beginning of the contract was only $399, so the unexpected claims cause the contract to end with a 0% final gross load ($3 deficit). I summarize the full insurance case and present summarized results for the reinsurance case in Table 11.

Scenario	Naive premium	Total discounted claims	Final gross surplus	Time 0 gross surplus	Time 0 gross load
Full insurance					
Base case insurance	12000	10005	2681	1995	20%
One bad year of 9% trend followed by base case claims thereafter	12000	10021	2659	1979	20%
One bad year of 9% trend followed inflated by 7% trend thereafter	12000	10215	2400	1785	17%
One bad year of 9% trend followed by autoregressive spending growth of 7.5% trend thereafter	12000	10436	2101	1564	15%
20% excess reinsurance					
Base case insurance	2400	2001	536	399	20%
One bad year of 9% trend followed by base case claims thereafter	2400	2014	519	386	19%
One bad year of 9% trend followed inflated by 7% trend thereafter	2400	2193	278	207	9%
One bad year of 9% trend followed by autoregressive spending growth of 7.5% trend thereafter	2400	2403	-3	-3	0%

Table 11: Summary of full insurance and 20% reinsurance cases

Solutions to forecast errors in medical spending

Prediction markets have the potential to help insurance companies with long-tailed lines linked to medical spending. Currently, Intrade.com has contracts covering macroeconomic indicators including the unemployment rate, the U.S. federal budget deficit, and health reform indicators including such market prediction polls as "Individual mandate to be ruled unconstitutional by U.S. Supreme Court." There are three contracts on the individual mandate with different expiration dates: October 2011, December 2012, and December 2013 (Intrade.com 2011).

Prediction market contracts might be more appropriate for the less severe examples I have given of forecast errors. For a single year of adverse experience, the insurer could make a hedging bet each year and could factor the annual costs into the single premium through the reserve calculation. The main obstacles would be deciding how contract outcomes map onto forecast errors, and making sure that the prediction market is thick enough to allow for as much hedging as the insurer needs.

Dealing with the situation where spending is autoregressive would be much more difficult with prediction markets. The insurer would have to make a much larger bet on medical spending rising in the earlier rather than the later years of the contract in order to deal with compound investment losses. Dealing with the situation where spending growth is autoregressive is even more difficult using short-term prediction contracts. It would take an extreme amount of financial engineering to figure out how to use the single year bets to hedge multiple years of higher trend.

Asset markets could be a more appropriate way to handle the trend risk. Financial products that would be helpful include insurance-indexed futures and macro markets based on trading national income shares (Cox & Schwebach 1992; Shiller 1993). Indexed futures on health insurance would give any insurer with an exposure to rising medical claims the kind of hedge that they need. Unfortunately, health insurance futures have foundered along with most private futures markets for macroeconomic variables. Macro markets have also not succeeded widely yet,[7] but given the need for improved forecasting, there is reason to try again. It may be that the failure of markets to insure macroeconomic risks is due to market failure.

Inflation hedging and forecasting took a major leap forward in many countries after the introduction of inflation-indexed bonds called TIPS (Treasury Inflation-Protected Securities) in the U.S. (Chen & Terrien 2001). One proposal is for the government to reduce the basis risk between overall inflation and medical inflation by issuing TIPS indexed to specific portions of inflation, in this case medical care (Jennings 2006). Insurer's claims are generally linked to overall medical spending, not prices; insurers could not hedge increases in claims due to changes in the quantity with a TIPS bond. That said, TIPS give a market-based forecast of inflation that improves upon expert opinion alone, because markets can often aggregate information for forecasting better than individuals do.

If it is the case that only the government can backstop medical spending growth, it is not necessarily true that TIPS is the only or best way for the government to be involved. One possibility is that the government should focus on health policies and other interventions that would tame medical spending growth. The OECD data suggests that that effort has not been successful in the U.S. or other countries. The federal government could also provide reinsurance, say on health insurance claims for any individual that exceed $36,000 in a year (Antos, King, Muse, Wildsmith, & Xanthopoulos 2004). The reinsurance policy would not help other non-health insurers with medical claims, and might actually harm them if government reinsurance fuels greater medical spending growth.

Acknowledging unsolved problems

In 2009, negative GDP growth reduced the growth of medical spending to one of the lowest rates ever, but the percent of the economy devoted to medical care still grew (Martin, Lassman, Whittle, Catlin, & The National Health Expenditure Accounts Team 2011). In other words, even

[7] The Case-Shiller indices for real estate are an exception.

though the economy shrank, medical care continued to increase its share of the pie, which goes against the idea that medical care was increasing its share of the pie because it is a superior good. While one year does not prove or disprove any model, it shows the difficulty of forecasting spending growth based on so little data.

The good news is that over the long term, the growth rates in U.S. medical spending are not outrageous. Table 12 shows that medical spending growth is generally explainable by the combination of economic growth and population aging. The combination does not always add up perfectly. In addition, the evidence on the nonstationarity of many countries' medical spending growth indicates that differenced medical spending growth, rather than spending growth itself, may be the correct dependent variable. The point is that the cost curve is not an outrageous fact of the economy to be explained, but rather part of the macroeconomy of developed countries and the organization of their healthcare systems.

Country	Growth in medical spending per capita (%) (A)	Growth in GDP per capita (%) (B)	Growth in population 65 and older (%) (C)	Annual excess growth (%) (A–B–C)
Austria	0.08	0.06	0.01	0.01
Canada	0.08	0.08	0.01	-0.01
Finland	0.10	0.08	0.02	0.00
Iceland	0.21	0.20	0.01	0.00
Ireland	0.12	0.11	0.00	0.01
Japan	0.09	0.07	0.03	-0.01
Norway	0.10	0.08	0.01	0.01
Spain	0.15	0.11	0.02	0.02
Switzerland	0.06	0.05	0.01	0.00
U.K.	0.10	0.08	0.01	0.01
U.S.	0.08	0.07	0.01	0.00

Table 12: Components of medical spending growth[8]

The problem for newly created and existing insurers and reinsurers under the latest change to the U.S. healthcare system is daunting. The Patient Protection and Affordable Care Act will bring a new form of health insurer, the Accountable Care Organization, into existence. Accountable Care Organizations are integrated delivery systems that share risk with payers, and so will face the risk that unforeseen increases in medical spending will severely deplete or wipe out their capital base. The previous managed care explosion of the 1990s led to some reinsurance of capitated physician practices, but many practices were too small or too specialized to utilize reinsurance arrangements (Simon & Emmons 1997). Hospitals, with large and sophisticated risk management departments, may be more interested in utilizing reinsurance as part of their Accountable Care Organization

[8] Table style adapted from (White, 2007)

efforts, but may also have the market power to drive harder bargains. As a result, reinsurers will face an important opportunity to sell risk management to new healthcare organizations, but will have little prior data to rely on.

In the short term, it is important to keep spending levels, growth, volatility, and difficulties in forecasting future growth rates in mind when writing insurance. We should be upfront about the true duration of the liabilities of the policies we write, not only if things go well but also if they go badly. This may make more risks uninsurable than we previously thought, but it is better not to take on an uninsurable risk than expose policyholders to the possibility of firm ruin. The risks are especially great in the U.S., which will be undertaking massive healthcare system changes in the next three years with unforeseeable effects on the cost curve.

It is harder to determine what actions insurers should take over the medium and long term to manage the rate and volatility of spending growth. No country in my data was able to arrest the rate of growth in spending through the direct application of health policy. The best insurers can do is to accept the cost curve as it is and try to deal with their modeling challenges. It may be that the best that policymakers can work towards is economic growth, which can at least make medical spending affordable. Making changes to health policy does not always reduce spending, and could cause volatility that disrupts many types of insurance markets.

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