Health Care Financing Administration

THE IMPACT OF TECHNOLOGICAL CHANGE ON HEALTH CARE COST SPENDING: AN EVALUATION OF THE LITERATURE

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Abstract: The impact of medical technology on growth in health care spending has long been a subject of vital interest, particularly in the context of long-term projections of health spending, which must address the issue of the applicability of historical trends to future periods. The objective of this paper is to estimate an approximate range for the contribution of technological change to growth in health spending based on a review of recent literature, and to evaluate factors which might modify this impact in the future. Based on the studies reviewed, we estimated that approximately half of growth in real per capita health care costs is attributable to the introduction and diffusion of new medical technology for the 1940-90 period, within an estimated probable range of 38 to 62 percent of growth.

*Key Words***:** medical technology, health costs, research and development

In health care research, the impact of medical technology on health care cost increases has always been a great unknown. Yet 81 percent of the leading health economists agreed with the statement, “The primary reason for the increase in the health sector’s share of GDP over the past 30 years is technological change in medicine”.[1] Of course, in most areas of the economy a rapid pace of technological advance is regarded as a good thing. That this is not the case for medical care reflects a second point of consensus. Throughout much of history, imperfections in medical care markets have failed to provide incentives for the cost-effective provision of medical services, encouraging the development and diffusion of innovations beyond the point that would prevail under competitive market conditions. Low out-of-pocket costs for medical care due to insurance coverage, combined with patients’ lack of full information on the services they consume encourage the provision of medical care to a point where the marginal benefit of treatment to the patient is small relative to its marginal cost.

Growing attention to the role of technological change in driving growth in health spending, and to the costs and benefits associated with new medical innovation reflects an acknowledgement of the long-term dilemma posed by historically unsustainable rates of growth in medical costs, combined with an increasing consensus that technological advance is a major factor in driving this growth. The current acceleration in health spending growth - following the quiescent period accompanying the spread of managed care - brings troubling implications for the long-term viability of our current system of financing and provision of health services. Understanding the magnitude of technology’s historical contribution to growth in costs is vital to the analysis of the future path of medical spending.

Based on evaluation of macroeconomic estimates, we conclude that technological change accounts for approximately half (within a “probable” range of 38 to 62 percent) of growth in real per capita health spending, conditional on assumptions. However, even as we conclude that the spread of new medical technology is the major factor in explaining growth, important questions remain. First, a primary issue surrounding the rapid growth in health care costs is not the fact of such growth, but the possibility that it reflects an inefficient use of resources that would be more valuable to society if applied elsewhere. To what extent is spending on the development and application of new technologies justified by the benefits it conveys? Research is beginning to attempt to value the benefits conveyed by new technologies, both to determine whether these benefits have exceeded costs and to evaluate where the marginal benefits of new

1 Fuchs, V.R., “Economics, Values, and Health Care Reform”, *American Economic Review*, 86:1-24, 1996.

spending are likely to be greatest. Second, to the extent that some spending on new technologies is inefficient, how can the current incentives be altered so as to encourage a more appropriate consideration of cost effectiveness? A major impetus to recent research on these issues is recent rapid institutional change in the delivery of health services – particularly the rise of managed care. Resulting changes in incentives surrounding the development and introduction of new technology have the potential to alter both the future direction of medical innovation and the path of growth in health spending.

Our objective in this paper is to compile an estimate of a probable range for the magnitude of the historical contribution of technological change to medical spending growth based on the body of existing macroeconomic, residual-based estimates, augmenting this work where possible based on additional research.

I. Macro-Economic Estimates: How Important is Technological Change?

Growth in health spending has exceeded annual growth in GDP by an average of 2.2 percentage points for the period from 1940 through 1998, driving the share of the economy's resources devoted to health sharply upwards. The search for an explanation of this persistent trend has a correspondingly long history. While the development and diffusion of new medical technology has always been recognized as a factor in health spending growth, the growing consensus that technology is the primary driver in real per capita health spending is more recent.

Spending on new medical technology includes growth associated with the process of diffusion of medical innovations following their initial introduction, to a point of saturation where no further diffusion occurs in the absence of changes in other factors. Data considerations effectively rule out the direct measurement of technology's role on aggregate health care spending. For this reason, estimates of the magnitude of the impact of technology on health spending fall largely into two categories. First, macro-economic estimates rely on an indirect approach, attempting to estimate the contribution of technology to growth by accounting for the contribution of all other factors that influence health spending. Second, estimates based on analysis of the change in treatment patterns for a sample of patients over time address the impact of specific technologies, for specific diagnoses within episodes of care. Given their focus on tracking the use of technology for a population of patients with a given diagnosis, these studies also cannot capture the effects of diffusion of new procedures to broader populations. While such studies provide critical insights into the nature of technology's contribution to growth, a high degree of variability in the conclusions across diagnosis and time period rules out generalization to an aggregate level.

Evaluation of the contribution of technological change to aggregate growth must therefore rest primarily on studies based on the macro-economic residual approach, which provide the only comprehensive estimates of the contribution of technology to growth in spending. However, a review of the methodology involved in the compilation of such estimates indicates that they must be applied with care. Any estimate based on the attribution of a residual after accounting for other factors will be sensitive to the identification of factors contributing to growth, as well as to the numerous assumptions necessary to evaluate the role of each factor. In addition, these estimates convey no information as to the nature of the process through which technology influences costs. One important objective of this review is to evaluate this sensitivity of residual-based estimates to the underlying assumptions, and the degree of uncertainty associated with each of the major assumptions. Based on this discussion, we produce our own estimate of the probable range for the contribution to technology to growth.

Ideally, macro-economic estimates of the residual growth attributable to technological change produce an estimate of the growth in health spending that would have occurred if medical technology had remained static. Suppose medical technology was frozen at a given point in time – what rate of growth in health spending would result from change in non-technology factors? Such factors include rising demand for medical services due to population growth and aging, the changing breadth and nature of health insurance coverage, rising real incomes, economy-wide inflation, and medical price inflation above economy-wide rates. Isolating the effects of technology requires that we appropriately and convincingly account for the contribution of all non-technology factors driving growth in health costs.

In estimating the contribution of technological change by this method, our primary objective is to produce a summary measure of the importance of technological change in explaining growth. This is a useful device for assessment of the particular issue at hand – the importance of technological change in driving aggregate health spending growth at a pace which is ultimately unsustainable. However, in understanding the process through which this effect occurs, it is important to note that this contribution is dependent upon incentives inherent in financial and institutional structures within the health sector.[2] In addition, to the extent that there are interactions among the variables which influence health spending growth, this

2 Weisbrod, Burton, 1991. Weisbrod, B.A. "The Health Care Quadrilemma: An Essay on Technological Change, Insurance, Quality of Care, and Cost Containment,≅ *Journal of Economic Literature*, June 1991, Vol. XXIX(2): 523-552.

methodology includes these effects in the estimated contribution of technological change as well. In certain cases, such effects may be important in magnitude. For example, broader and more generous insurance coverage can be expected to have important effects on the development and diffusion of new medical technology.[3] These effects will be subsumed in the estimated residual, as will the effects of rising incomes on the demand for new technologies. In evaluating the probable contribution to long-term projections of growth, understanding the effects of institutional change and interactions among factors contributing to growth becomes important.

Macroeconomic Residual-based Estimates

The decomposition of health spending growth into factors accounting for growth has long been applied as a tool to evaluate the relative importance of such factors. Early studies include Klarman, Rice, and Cooper (1970) and Freeland and Schendler (1983).[4] However, the focus of these earlier studies was an accounting decomposition of the fraction of growth attributable to measurable influences on growth such as economy-wide inflation, medical inflation, population growth, and population aging. The effect of behavioral factors contributing to growth in demand for medical care was not addressed. It was recognized that the growth captured by the residual incorporated the effect of many different factors, however, no attempt was made to attribute the residual to technology or to any combination of other factors. Technological change and the increasing breadth and depth of insurance coverage encouraged by tax-deductibility of employer-provided health benefits were both considered to have played a major role in the consistently rising share of GDP devoted to health spending. However, estimates of the contribution of rising insurance coverage differed by a factor of ten, allowing for the persistence of a wide range of positions.[5]

The current growing consensus that technological change is likely the critical factor in explaining health-spending growth consistently above GDP growth has solidified over the past fifteen years. Much of this trend in thought reflects improved information on other important factors contributing to growth. A

3 Peden and Freeland 1998. Peden, E.A. and Freeland, M.S. "An Analysis of Insurance Effects on Medical Spending: 1960-1993,≅ *Health Economics*, 1998, 7:671-687.
4 Klarman, H.E., Rice, D.P., Cooper, B.S., et al. *Sources of Increase in Selected Medical Care Expenditures, 1929-1969*, Social Security Administration, Office of Research and Statistics, Staff paper No. 4, April 1970.
Freeland, M.S. and Schendler, C.E. "National Health Expenditures: Growth in the 1980's: An Aging Population, New Technologies, and Increasing Competition,≅ *Health Care Financing Review*, March 1983, Vol. 4(3):1-58.
5 Manning, W.G., Newhouse, J.P.,Duan, N., Keeler, E., Leibowitz, A., and Marquis, M.S., "Health Insurance and the Demand for Medical Care: Evidence from a Randomized Experiment", *American Economic Review*, Vol. 77, No.3, June 1987.

major factor contributing to this trend was the availability of improved estimates for key parameters based on the results of the Rand Health Insurance Experiment (HIE), a randomized experimental study of the impact of insurance coverage on health spending and composition at the household level.[6] The design of the study allowed researchers to control for the effect of selection effects on the usage of services across insurance plans with differing cost-sharing requirements. Thus the HIE produced estimates of the price elasticity of demand for health services which were widely accepted as an accurate gauge of the sensitivity of household demand for medical care to variations in price. This estimate was a necessary building block for behavioral estimates of technology's contribution to growth based on the residual approach.

The results of the HIE indicated that rising health insurance coverage probably accounted for only a modest fraction of growth in real per capita health spending. The price elasticity of –0.1 to –0.2 generated by the HIE indicated that consumers of health services were less sensitive to the price paid out-of-pocket for care than had previously been thought. Thus, the decline in effective out-of-pocket price paid by consumers for these services could not explain the corresponding rapid growth in demand in the post-war period. As this estimate effectively holds technology constant, these results do not rule out a potentially larger contribution to growth from insurance coverage from a potential interaction effect between rising insurance coverage and the development and diffusion of new technologies. It does imply that the declining share of costs paid by consumers on an out-of-pocket basis cannot by itself account for a substantial share of growth in health spending.

A second factor contributing to growth in health spending, rising real income, was also estimated to account for only a small fraction of growth in real health spending. However, the income elasticity found by the HIE was quite small; richer households consumed only very slightly more medical care. The bulk of the increase in real spending could not be explained by either of these major factors. While the study does not attempt to identify all possible non-technology factors contributing to growth, Manning et al (1987) concluded that the contribution of these two major factors is so small as to leave the large majority of growth in real per capita health spending unexplained. The authors posited that technological change was the probable principal factor in explaining the large residual.

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6 Manning, W.G., Newhouse, J.P.,Duan, N., Keeler, E., Leibowitz, A., and Marquis, M.S., "Health Insurance and the Demand for Medical Care: Evidence from a Randomized Experiment", *American Economic Review*, Vol. 77, No.3, June 1987.

Recent estimates attempt to systematically identify all behavioral factors contributing to growth and to establish an approximate magnitude for each. However, as noted above, for some important assumptions there is yet no consensus. The position taken on major issues in the health economics literature (e.g. income elasticity of demand, relative price inflation in medical services) can result in widely varying estimates of residual growth. We discuss the degree of uncertainty associated with each of these assumptions. Based on our discussion, we approximate a probable range for each, and an estimate for the contribution of technology that is conditional on these assumptions.

Two recent studies (Newhouse(1992) and Cutler(1995)) attempt a systematic decomposition of health spending growth, expanding their estimates to incorporate at least an approximate impact for all important behavioral factors contributing to growth in health spending.[7] Each of these studies acknowledges the uncertainty inherent in the residual-based methodology, given the continued lack of clear consensus on several of important parameters. For this reason, both papers conclude with only rough estimates of the magnitude of technology's contribution to growth. Newhouse finds that "(non-technology factors) account for well under half – perhaps under a quarter of the 50-year increase in medical care expenditure", thus concluding that the remaining one-half to three-quarters of growth is attributable to the introduction of new technologies.[8] Cutler attempts to produce a lower bound for technology's contribution, selecting the high end of his feasible range for each non-technology factor. He concludes than a minimum of half the growth in real per capita spending for 1940-90 can be attributed to technological change.[9]

Cutler's lower bound for the impact of technology (50 percent) is below Newhouse's broad range, but not inconsistent in magnitude given that it represents a lower bound.(Table 1) However, the similarity of the conclusion also masks major differences in assumptions for income and price effects that are substantial in magnitude, but which tend to be offsetting. While both studies share many elements of methodology and base their estimates on parameters largely drawn from the same research, their estimates of growth in

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[7] Newhouse, J.P. "Medical Care Costs: How Much Welfare Loss?" *Journal of Economic Perspectives*, Summer 1992, 6(3):3-21.
Cutler, D.M. *Technology, Health Costs, and the NIH*, Harvard University and the National Bureau of Economic Research. Paper prepared for the National Institutes of Health Economics Roundtable on Biomedical Research, September 1995.
8 Newhouse, 1992. Newhouse, J.P. "Medical Care Costs: How Much Welfare Loss?" *Journal of Economic Perspectives*, Summer 1992, 6(3):3-21.
9 Cutler, D.M. *Technology, Health Costs, and the NIH*, Harvard University and the National Bureau of Economic Research. Paper prepared for the National Institutes of Health Economics Roundtable on Biomedical Research, September 1995.

health spending attributable to some of the factors differ substantively.

Major differences in the magnitude of estimates between these two studies derive from three factors contributing to growth: 1) relative medical price inflation, 2) rising real incomes, and 3) avoidable administrative costs. Differences in the estimated effect of the first two factors stems from recognized flaws in medical price data and from a continued lack of consensus on key underlying parameters. In addition, differences associated with the avoidable administrative costs (included by Cutler but not by Newhouse) reflect the sensitivity of residual based estimates to the identification of differing lists of potential factors contributing to growth, where the magnitude of the impact of such factors is highly uncertain.

TABLE 1
Research on Causal Factors Accounting for Growth in Real per Capita Health Care Spending
(Estimated percentage change, 1940-90)

	Newhouse		**Cutler**	
	Percent change	Contribution to growth	Percent change	Contribution to growth
Health spending	790%		780%	
Aging	15% [1]	2%	14% [5]	2%
Insurance	81% [2]	10%	100% [6]	13%
Income growth	<180% [3]	<23%	37% [7]	5%
Relative medical price inflation	0% [4]	0%	147% [8]	19%
Avoidable administrative expense	Not included in study		101% [9]	13%
All non-technology factors	<276%	<35%	399%	51%
Attributed to technological change		**>65%** [10]		**49%** [11]

1. Estimate for 1950-87: relative spending for population over 65 years and population 19-64 years based on application of age distribution of expenditures from the 1987 National Medical Expenditure Survey (NMES) to change in age distribution.
2. Estimate for 1950-80 extrapolated to cover 1940-90 based on application of price elasticity to decline in out-of-pocket share of spending for 1940-90. Price elasticities from HIE experiment were –0.1 to -0.2.
3. Low end of range for income elasticities based from HIE, and implies 35% of increase attributable to rising income. High end of range based on macro-economic time-series cross-sectional estimates across countries, and implies 234% of increase attributable to rising income. Newhouse estimates an elasticity of "under one", implying a less than 180% increase attributable to rising income.
4. Based on the statement that "a true productivity measure might even go up at or in excess of economy-wide rates…it is not clear that much of the expenditure increase should be attributed to this factor" (Newhouse(1992)).
5. Estimate for 1940-90, applying relative spending for over-65 population and 19-64 population based on 1977 NMES to change in age distribution.
6. The difference between Newhouse and Cutler estimates reflects rounding upwards by Cutler; the methodology is the same.
7. Cutler uses an estimated price elasticity of -0.2 based on Rand experiment – equivalent to low-end of Newhouse range.
8. Based on assumption that productivity growth in health is zero, implying long-term growth in relative prices of 2 percent.
9. Based on estimate of 8 percent for avoidable administrative expense for 1983 (Himmelstein and Woolhandler, (1991)), assuming zero avoidable expense in 1940.
10. Based on Newhouse's discussion, expressed as an approximate point estimate.
11. Lower bound for contribution of technological change.

A Probable Range for the Contribution of Technological Change to Growth

Our objective in this paper is to produce an estimate for a probable range for the impact of technology on health care spending based on the Newhouse and Cutler studies as a starting point. Contingent on our evaluation of the underlying assumptions for eachof the factors contributing to growth (Table 2) we estimate about half of growth in real per capita health spending is attributable to changing technology, within a range of 38 to 62 percent. Relative to the lower bound of 49 percent estimated by Cutler, this range primarily reflects a higher estimate for the income elasticity of demand for health care and a separate accounting for relative factor price inflation. Relative to the higher estimated range estimated by Newhouse, our estimate reflects a lower estimated range for relative productivity growth (resulting in a higher contribution to growth in health spending), plus the inclusion of allowances for relative factor price inflation and avoidable administrative expense.

TABLE 2
Summary of Assumptions on Causal Factors Accounting for Growth in Real per Capita Health Care Spending
(Share of growth attributable to selected factors, 1940-90)

	Newhouse	Cutler	Smith, Heffler, Freeland
Aging	2%	2%	2%[1]
Insurance	10%	13%	10%[2]
Income growth	<23%	5%	11-18%[3]
Relative medical price inflation	0%	19%	11-22%[4]
Avoidable administrative expense		13%	3-10%[5]
Supplier induced demand/ defensive medicine	0%	0%	0%[6]
All non-technology factors	<35%	51%	38-62%
Growth attributed to technological change	**>65%**	**49%**	**38-62%**

1. Consistent with Newhouse/Cutler assumptions
2. Consistent with Newhouse/Cutler assumptions
3. Assumes income elasticity (technology held constant) falls within a range of 0.5-0.8.
4. Range based on assumption that productivity growth in health falls between zero and half the economy-wide rate and that between 25% and 75% of relative factor price inflation is attributable to rising rents.
5. Assumes that between 25% and 75% of avoidable administrative expense as estimated by Himmelstein and Woolhandler(1991) represents growth between 1940 and 1990. This reflects our assessment that the estimate itself is subject to upward bias, and the probability that some avoidable administrative expense occurred in 1940.
6. Consistent with Newhouse/Cutler assumptions.

The key points of difference across the estimates in Table 2 lie in the contribution of three factors in health spending growth: 1) relative price of medical care, 2) income, and 3) avoidable administrative expense. Below we discuss each of these factors in detail, as well as provide some additional information on the other factors.

The effects of changes in income and relative price on demand for medical care are clearly central to health economics, however, there is yet no solid consensus on the importance of these effects for growth at an aggregate level. The idea of a contribution to growth from inefficient increases in administrative expense has only more recently been raised as a factor in health spending growth, principally by those who feel that growing requirements for provider supervision and documentation of services are not an effective use of resources.

Medical Price Inflation

A major difficulty encountered in estimating the contribution of technological change based on the macro-economic residual method is the accurate measurement of medical price inflation. Without such measures, it is impossible to distinguish increased costs due to technological advances from higher prices paid for existing health services or increases due to inefficiency and low productivity in the provision of medical services. Accurate, quality-adjusted measures of transaction prices are unavailable for the scope and time frame required.

The most widely used measure of medical prices is the Consumer Price Index (CPI) for all medical care, which has many deficiencies for the purpose of deflating national health expenditures. Historically, the CPI-medical care has not controlled adequately for changes in quality or accurately measure transaction prices that include discounts. Given rapid change in the nature of medical care, it is difficult to choose units of measurement that either remain the same over time, or for which we can accurately account for changes in quality. Historically, the CPI-medical has tracked charges for items such as hospital room charges and physician consultations. However, the services included in these "items" are highly variable. To the extent that treatment in acute-care settings includes more services per inpatient day at a rising level of technical sophistication, an increase in the "price" is likely to reflect increases in both quantity and quality, and is therefore biased upwards.[10] A new approach is embodied in the producer price indexes for health care, which focus on the actual payment for the episodes of treatment for specific diagnoses and payers. However, the history of these indexes extends over less than ten years.

There have been three basic approaches to address this problem. The first approach is to use the CPI-medical with caveats as to the possible direction of mismeasurement. The second approach, used by Braden, Cowan, Lazenby, et al(1996) in periodic estimates produced by the Health Care Financing Administration, is to substitute an index of input prices for those sectors where the CPI is believed to be most subject to bias. This corrects for many of the problems with overestimation, but as an input price does not reflect the effects of productivity growth and changes in profit margins.

The third approach, applied by both Newhouse and Cutler, argues that the price data is so fundamentally flawed as to be unusable. Since the relative rate of productivity growth largely dictates relative price inflation in the long run, a defensible assumption on relative productivity growth can be substituted for

10 Triplett, J.E., *Measuring the Prices of Medical Treatment*, The Brooking Institution, 1999..

relative price growth. This approach must necessarily rely heavily on judgment, since direct evidence on this point is scarce. What this approach does offer is the ability to establish a probable range for the effects of productivity growth while avoiding the measurement problems associated with the CPI, which some believe overstates medical price inflation by as much as two percentage points.

Because relative productivity growth in medical services is an area of much uncertainty, the range associated with this assumption is wide.   This is a major point of difference between the Newhouse and Cutler estimates.   Both studies attempt to select a reasonable range for relative productivity growth in medical care relative to the economy as a whole. But if medical prices are so flawed as to be unusable, this also precludes any direct measurement of productivity growth.   Estimates of relative growth in productivity must therefore be based on judgment and theory on relative productivity in services, and the peculiarities of the medical sector.

Newhouse argues that "a true productivity measure might even go up at or in excess of economy-wide rates." This assessment is based on the argument that innovation has often acted to reduce the cost of treatment. Examples he cites include the shift of services out of inpatient hospitals to lower-cost settings, and the reduction of the need for costly services through the development of new drugs.   This raises an interesting issue. Price inflation reflects productivity growth, which in turn reflects technological change. However, if we are attempting to isolate the effect of technological change on spending, the effects of cost-reducing medical innovation should arguably be excluded from price, so as to be incorporated in the residual. While some gains in productivity may be attributable to non-technology factors (e.g. some major part of the shift out of inpatient settings can be attributed to changing financial incentives), much can also be attributed to changing medical technologies (e.g. non-invasive procedures such as laparoscopic surgery which can be performed on an outpatient basis, and new drugs.

Cutler argues that productivity growth in health can be expected to be lower than the economy-wide average, given that: 1) it is labor-intensive, and 2) demand elasticity for medical care is low consistent with the Baumol "cost disease" model.[11] Given the lack of specific evidence on the degree to which productivity growth will be slower in health care, he assumes a lower bound of zero productivity growth. This estimate implies that output growth will be proportional to additional inputs of labor and capital, while the efficiency with which these inputs are used will not improve over time. Both product and

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[11] Baumol, W.J. , "Containing Medical Costs: Why Price Controls won't Work", *The Public Interest*, Fall 1988, 37-53.

process innovations not involved in the actual provision of medical services are likely to improve productivity over time (e.g. information technology), so that this is a convincing lower bound for productivity growth. A reasonable expectation is that productivity growth in medical services, defined as the efficiency with which unchanged treatment options can be delivered, is likely to be above zero, but well below the economy-wide average.

A second relevant issue for relative growth in medical prices is the question of relative growth in factor prices. Relative growth in input prices and in factor productivity represent two separate influences on relative price. Changing factor prices and the efficiency with which these factor inputs are used both contribute to relative medical price inflation. This suggests that a combination of these two approaches may be the preferable method.

Given inefficiencies in markets for medical care – including the prevalence of cost-based reimbursement over much of the relevant history, it is possible that factors of production may receive higher compensation than would be the case in a competitive market environment (rents). If increasing rents are paid to factors of production over time, this would explain some part of the increase in health spending. Over the period from 1950 through 1985, relative wages of workers with less than a high school degree in the health sector increased at a rate of 0.6% per year, from 15% below the rest of the economy to 7% above the rest of the economy.[12] For the much briefer period for which data is available for physicians, their net income grew at a pace well above the economy as a whole.[13] A part of the increase in wage differentials can be attributable to rising skill levels. However, the existence of a positive differential at the end of the period indicate the potential for a contribution from rising premiums above a competitive market wage.

Since relative price inflation is determined by relative factor price inflation and relative productivity growth, we can obtain an estimate of an appropriate range for the contribution of rising prices by combining estimated growth in input prices with assumptions on productivity growth. As a lower bound, we assume that productivity growth for health care is half of the economy-wide average. As an upper bound we assume that health productivity is zero. This combination of relative productivity growth and factor price inflation implies that relative medical price inflation accounts for between of 11 to 22 percent

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[12] Fuchs, Victor. *The Future of Health Policy*, Harvard University Press, Cambridge, *1993*.

[13] Fuchs cites a figure of 8.1% for physicians versus 5.5% for all private nonagricultural for 1977-87. Data from AMA since this time indicates a continued growth differential, although it has narrowed somewhat recently.

of growth in constant dollar per capita health care for the 1940-1990 period.

Income Effects

Real per capita income more than doubled from 1940 to 1990. How much would health spending have increased as a result of this change in income in the absence of technological change? Differences in the assumed range for the magnitude of the income effect is a second major point of difference between the Newhouse and Cutler estimates. Newhouse assumes that the income elasticity of demand for medical care will be "well under one" (within a range of approximately 0.2 to 1.3). Cutler relies on a point estimate at the low end of this range (0.2) as a lower bound for the effect. As a lower bound, this estimate is consistent with the Newhouse range, but has the effect of substantially increasing the implied role of technology captured in the residual.

Empirical estimates of the income elasticity of demand for health services vary substantially, as Newhouse's broad range implies. Estimates based on variation across individual households (e.g. the HIE estimate of 0.2) tend to be quite low relative to macroeconomic estimates based on either international cross-country data, on national time series, or a combination of both. Time-series cross-country estimates tend to cluster around one, ranging from just under one to as high as 1.5.[14] Earlier estimates based on international cross-country data without a time series component tend to be well above one.[15] Most recent estimates are based on time-series cross-sectional data across the OECD economies, and tend to include two way fixed effects (controlling for variation across both time and country). This change in data and methodology has tended to produce estimates near very close to 1.0.[16]

For the purpose of estimating the growth attributable to technology as a residual, we need to obtain an income elasticity of demand for medical care which holds the state of medical technology constant. Estimates based on time series data incorporate the effect of technological change. For this reason, we

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14 Getzen, T.E., "Health Care is an Individual Necessity and a National Luxury: Applying Multilevel Decision Models to the Analysis of Health Care Expenditures", *Journal of Health Economics*, Vol.19, No.2: 259-270, 2000.

15 Newhouse, J.P., "Medical Care Expenditures: A Cross-national Survey", Journal of Human Resources, 12(1): 115-125, 1977.

Leu, R., "The Public-Private Mix and International Health Care Costs", in Culyer, A., Jonsson, B. (eds.) *Public and Private Health Services*, Blackwell, London, 1986.

16 Getzen, 2000. Getzen, T.E., "Health Care is an Individual Necessity and a National Luxury: Applying Multilevel Decision Models to the Analysis of Health Care Expenditures", *Journal of Health Economics*, Vol.19, No.2: 259-270, 2000.

would expect these estimates to be well above estimates based solely on micro data. However, even cross-country time-series estimates based on aggregate data across countries return estimates that are close to one, far higher than estimates based on household data.

What explains this discrepancy? Economists generally prefer estimates based on microeconomic data, due to well-known problems of interpretation associated with aggregated data. However, in this particular case, the role of third-party payment alters income elasticity at the household level; as most patients are insulated from all but a small fraction of the costs of their treatment, their choice of treatment is not strongly influenced by income. A second problem with micro-level estimates stems from the fact that income elasticities based on household data are restricted to estimating the relationship between out-of-pocket spending and household incomes. Such spending accounts for well under half of all health spending. In particular, given the standard use of out-of-pocket maximum limits as a feature of insurance coverage, such estimates can be expected to exclude virtually all inpatient care, as well as outpatient care above the out-of-pocket maximum. This is particularly important given the highly skewed nature of medical expenditures, where a small fraction of recipients of care account for a disproportionately high fraction of medical spending. The Rand HIE, for example, included a stop-loss provision for all participating households, which would be expected to bias the income elasticity downwards.[17] Under this circumstance we would ideally need to look at variation in spending and income across closed insurance pools. However, the probability of large spillover effects across pools makes it impossible to define distinct pools. Macroeconomic estimates offer the advantage that they estimate the income elasticity at a level of aggregation which more closely approximates the entire insurance pool.

Given that we are concerned with the relationship between growth in health spending and income at this aggregate level, it also seems appropriate to rely most heavily on macroeconomic estimates based on national-level, international cross-country. As mentioned, recent estimates have indicated an income elasticity close to one. However, two issues modify this conclusion. First, such cross-country estimates are influenced upwards by the inclusion of the United States, whose high health share of GDP is an outlier in a small number of sample observations and may be partially attributable to non-income factors correlated with income. Second, our expectation is that the applicable income elasticity with technology held constant should fall well below time-series based estimates. Several recent time series estimates near one suggest that the range for income elasticity with technology held constant should fall below this

17 Newhouse, J.P. *Free for All: Lessons from the Rand Health Insurance Experiment*, Cambridge, MA: Harvard University Press, 1993.

point (Blomqvist and Carter (1997), Gerdtham and Jonsson (1991), Hitiris and Posnett (1992)).[18] Based on these considerations, we selected a range of 0.5-0.8 to approximate income elasticity with technology held constant.

Avoidable Administrative Expenses

An additional major difference between the Newhouse and Cutler estimates is the substantial fraction of growth attributed (as an upper bound) to growth in avoidable administrative expense. Research on this point is scarce – the single estimate referenced by Cutler as an upper bound is the only attempt to produce an aggregate estimate, and is widely regarded as on the high end of the plausible. The scarcity of research on this point makes the establishment of an acceptable range difficult.

One issue that this difference raises is the possible impact of incorporating additional non-technology factors for which data is scarce and available estimates are subject to a high degree of uncertainty. This is relevant not only to the precise importance of the phenomenon in question, but also whether this factor is sufficiently widely regarded as appropriate to require inclusion in a residual-based estimate. Because of the high degree of uncertainty, reasonable bounds for the potential contribution of avoidable administrative expenses (or other controversial factors such as supplier-induced-demand) must be extremely broad in order to encompass the range of opinions. If our objective is to establish a probable lower bound for the contribution of technology, then all such factors must be included. However, our principal objective here is to establish a useful "probable" range for technology's contribution. This implies that we may be better off excluding factors that are not widely recognized as important contributing factors to growth, while presenting our estimate with this caveat. For our probable range, we incorporated an estimate of 25-75% of the estimated contribution implied by Cutler's estimated upper bound.

Rising Health Insurance Coverage

Conventional wisdom has long attributed a major role to expanding insurance coverage as a critical factor

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in health spending growth. However, price elasticities based on the HIE imply that the expansion of insurance coverage explains less than 15 percent of growth over the 1940-1990 period. The Rand HIE estimates are based on variation across households with insurance of varying generosity of coverage.

Note that this estimated price elasticity is not strictly accurate in the current context. First, it implies that increasing insurance coverage is felt solely as a reduction in the average cost-sharing experienced by consumers. The declining out-of-pocket share of health spending over the period from 1940 throu 1990 actually reflects two separate effects. First, there has been (on average) an increase in the fraction of the population covered by health insurance. Second, coverage is increasingly generous, with deductibles and cost-sharing accounting for a declining share of spending over time. The effects of the mix of (on average) broader and deeper coverage may not be well approximated by estimates based on a primarily cross-sectional analysis of households with differing depth of coverage. Exploration of these issues is beyond the scope of this paper.

Demographics

Population aging is a factor that is widely regarded as a major influence on health spending growth over time. However, the current consensus among health economists is that this is a relatively minor explanatory factor in health spending growth over the historical period. The standard methodology for the approximation of the changing age-gender composition of the population is to rely on a base-year distribution across age-gender cohorts. Assuming that the distribution remains constant over time, population data by age and cohort, weighted by the relative spending of each group in the base year distribution, implies a contribution of changing demographic composition to growth in health spending over time. Both Newhouse and Cutler apply a variant of this method, attributing about 2% of growth in health spending to this factor. We used a slightly more detailed base-year composition, however, the effect is very close in magnitude to the Newhouse/Cutler estimates. Again, however, by using a fixed base-year distribution, this estimate intentionally holds technology constant, thus excluding any potential interaction effect between technological change and aging. If costly new medical technology tends to disproportionately address the health problems of the aged, this could increase the contribution of population aging on growth through an interaction effect included in our residual.

Summary

Our analysis of the foundations of existing macroeconomic residual-based estimates supports the conclusion that technological change is the major factor underlying the consistent increase in the health share of GDP. We find that technological change accounts for a probable range of 38 to 62 percent of total growth in real per capita income. Based on the midpoint of this range, this suggests that in the absence of technological change, growth in real per capita health spending for 1940-98 would have averaged about 2.5% per year, only slightly higher than growth in real per capita GDP (near 2.0%).

Given continued uncertainty on the contribution to health spending growth of such major factors as relative productivity growth and income elasticity, it is clear that a residual-based approach can produce only a rough approximation of the actual magnitude of technology's contribution to growth. Perhaps even more importantly, the residual includes, by definition, any interaction effects among these factors and technology, including feedback effects between rising insurance coverage and the incentives for the development and diffusion of new technology that it may create. Estimates based on this approach are necessarily based on the position taken on these key issues, and should be applied with recognition of their contingent nature.