The Inforum LIFT Model with an Application for Health Care

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Abstract

The inter-industry macroeconomic approach to economic modeling attempts to provide both the dynamics and high-level accounting of the macro models and the industry structure featured in the general equilibrium approach. The Long-term Interindustry Forecasting Tool, hereafter called LIFT, model is Inforum's (Inter-industry FORecasting at the University of Maryland) version of this approach for the U.S. economy.

The LIFT model is unique among large-scale models of the U.S. economy. It combines an interindustry input-output (I-O) formulation with extensive use of regression analysis, to employ a "bottom-up" approach to modeling. Parameter estimates for structural equations largely are based on time-series regressions and the LIFT model simulates the economy year-by-year, allowing analysts to examine both the ultimate economic impacts of policy changes or economic shocks and the dynamics of the economy's adjustment process over time.

This paper provides a brief description of the LIFT model and provides an important example of its application by investigating the structural and fiscal implications of a continuation of "trend increases" in long-term health expenditures over the next 75 years. The model illustrates various ways that relative non-health and health demands, supplies and prices can, and cannot, be reconciled over the long term.

Introduction

Empirical structural models offer a fruitful approach to understand an economy. In the first place, their construction and use forces analysts to examine each and every part of the economic process. Further, they test whether the understanding of the parts adds up to an understanding of the whole. Once a model is built, the presentation of its structure and empirical results motivate and focus economic discussions by economists and non-economists alike. Economic forecasts, good or bad, never fail to attract interesting analysis and opinions from any group of informed observers. Careful and honest use of models has even been known to be useful to economists, business managers, or government officials for quantitative analysis and decision making.

To be more specific, the development and use of structural empirical economic models must be derived and implemented to facilitate the mission of the model's users. For this purpose, these models have at least three very practical applications:

1. Economic models provide a useful venue for assembling economic and social data -- the raw material for reports and studies -- in a comprehensive databank used for assessment and analysis.

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2. Economic models can assist the construction of economic projections. They help leverage the historic record to determine future trends, and they provide a comprehensive and consistent framework to assess the assumptions and structures underlying an economic forecast.

3. Using the historical record or a baseline forecast as context, economic models are used for simulation and counterfactual analysis to produce alternate projections and/or to evaluate policy measures or exogenous economic shocks.

Over the past two decades, the Inforum LIFT model has been used to investigate the structural and fiscal implications of a continuation of trend increases in long-term health expenditures over the next 75 years. The model illustrates various ways that relative non-health and health demands, supplies and prices can, and cannot, be reconciled over the long term.

The LIFT Model of the U.S. Economy

The inter-industry- macroeconomic approach to economic modeling attempts to provide both the dynamics and high-level accounting of the macro models and the industry structure featured in the general equilibrium approach. The Inforum LIFT model is a version of this approach for the U.S. economy. It is a 97-sector representation of the U.S. national economy that combines an interindustry input-output (I-O) formulation with extensive use of regression analysis, to employ a "bottom-up" approach to macroeconomic modeling. That is, the model works like the actual economy, building the macroeconomic totals from details of industry activity, rather than distributing predetermined macroeconomic quantities among industries. The production sectors of the LIFT model are shown in Table 1.

This bottom-up technique possesses several desirable properties for analyzing the economy. First, the model describes how changes in one industry, such as increasing productivity or changing international trade patterns, affect related sectors and the aggregate quantities. Second, parameters in the behavioral equations differ among products, reflecting differences in, for instance, consumer preferences, price elasticities in foreign trade, and industrial structure. Third, the detailed level of disaggregation permits the modeling of prices by industry, allowing one to explore the causes and effects of relative price changes.

Despite its industry basis, LIFT is a general equilibrium model, using bottom-up accounting to determine macroeconomic quantities consistent with the underlying industry detail. It includes more than 800 macroeconomic variables consistent with the National Income and Product Accounts (NIPA) and other published data. Within the model, these variables are determined consistently with the underlying industry detail. This macroeconomic "superstructure" contains key functions for household savings behavior, interest rates, exchange rates, unemployment, taxes, government spending, and current account balances. Like many aggregate macroeconomic models, this structure is configured to make LIFT exhibit "Keynesian" demand driven behavior over the short-run, but neoclassical growth characteristics over the longer term. For example, while monetary and fiscal policies and changes in exchange rates can affect the level of output in the short-to-intermediate term, in the long term, supply forces -- available labor, capital and technology -- will determine the level of output.

Table 1: Producing Sectors of the Lift Model of the U.S. Economy

1 Agriculture, forestry, & fisheries

Mining
2 Metal mining
3 Coal mining
4 Natural gas extraction
5 Crude petroleum
6 Non-metallic mining

Construction
7 New construction
8 M & R construction

Non-Durables
9 Meat products
10 Dairy products
11 Canned & frozen foods
12 Bakery & grain mill product
13 Alcoholic beverages
14 Other food products
15 Tobacco products
16 Textiles and knitting
17 Apparel
18 Paper
19 Printing & publishing
20 Agric fertilizers & chemicals
21 Plastics & synthetics
22 Drugs
23 Other chemicals
24 Petroleum refining
25 Fuel oil
26 Rubber products
27 Plastic products
28 Shoes & leather

Durable Material & Products
29 Lumber
30 Furniture
31 Stone, clay & glass
32 Primary ferrous metals
33 Primary nonferrous metals
34 Metal products

Non-Electrical Machinery
35 Engines and turbines
36 Agr., constr., min & oil equip
37 Metalworking machinery
38 Special industry machinery
39 General & misc. industrial
40 Computers
41 Office equipment
42 Service industry machinery

Electrical Machinery
43 Elect. industry equipment
44 Household appliances
45 Elect. lighting & wiring eq
46 TV's, VCR's, radios
47 Communication equipment
48 Electronic components

Transportation Equipment
49 Motor vehicles
50 Motor vehicle parts
51 Aerospace
52 Ships & boats
53 Other transportation equip

Instruments & Miscellaneous Manufacturing
54 Search & navigation equip
55 Medical instr & supplies
56 Opthalmic goods
57 Other instruments
58 Miscellaneous manufacturing

Transportation
59 Railroads
60 Truck, highway pass transit
61 Water transport
62 Air transport
63 Pipeline
64 Transportation services

Utilities
65 Communications services
66 Electric utilities
67 Gas utilities
68 Water and sanitary services

Trade
69 Wholesale trade
70 Retail trade
71 Restaurants and bars

Finance & Real Estate
72 Finance & insurance
73 Real estate and royalties
74 Owner-occupied housing

Services
75 Hotels
76 Personal & repair services
77 Professional services
78 Computer & data processing
79 Advertising
80 Other business services
81 Automobile services
82 Movies & amusements
83 Private hospitals
84 Physicians
85 Other medical serv & dentists
86 Nursing homes
87 Education, social serv, NPO

Miscellaneous
88 Government enterprises
89 Non-competitive imports
90 Miscellaneous tiny flows
91 Scrap & used goods
92 Rest of the world industry
93 Government industry
94 Domestic servants
95 Inforum statistic discrepancy
96 NIPA statistical discrepancy
97 Chain weighting residual

Health Care Related
22 Drugs
55 Medical instr & supplies
56 Opthalmic goods
83 Private hospitals
84 Physicians
85 Other medical serv & dentists
86 Nursing homes

Another important feature of the model is the dynamic determination of endogenous variables. LIFT is an annual model, solving year by year, and incorporates key dynamics that include investment and capital stock formation. For example, investment depends on a distributed lag in the growth of investing industries and international trade depends on a distributed lag of foreign price changes. Moreover, parameter estimates for structural equations largely are based on time-series regressions, thereby reflecting the dynamic behavior of the economic data underlying the model. Therefore, model solutions are not static, but instead project a time path for the endogenous quantities. In other words, the LIFT model simulates the economy year-by-year, allowing analysts to examine both the ultimate economic impacts of projected health care policies and expenditures and the dynamics of the economy's adjustment process over time.

Finally, the LIFT model is linked to other, similar models with the Inforum Bilateral Trade Model (BTM). Countries included in this system include the U.S., Japan, China, and the major European economies. Through this system, sectoral exports and imports of the U.S. economy respond to sectoral level demand and price variables projected by models of U.S. trading partners. In summary, the LIFT model is particularly suited for examining and assessing the macroeconomic and industry impacts of the changing composition of consumption, production, foreign trade, and employment as the economy grows through time.

A schematic diagram of LIFT is shown on Figure 1. The interindustry framework underlying the model is composed of five blocks: final demand, supply, factor income, prices and the accountant. The first block of LIFT uses econometric equations to predict the behavior of real final demand (consumption, investment, imports, exports, government). The components are modeled at various levels of detail. For example, aggregate consumption is the sum of 92 consumption products. Demand by product, with product sectors consistent with the *A* matrix, is determined using bridge matrices to convert final demand to the commodity level. Following Wilson (2001), this equation is specified as:

$$f_{97\times1} = H^{c}_{97\times92}c_{92\times1} + H^{eq}_{97\times55}eq_{55\times1} + H^{s}_{97\times19}s_{19\times1} + i_{97\times1} + x_{97\times1} - m_{97\times1} + g_{97\times1}.$$

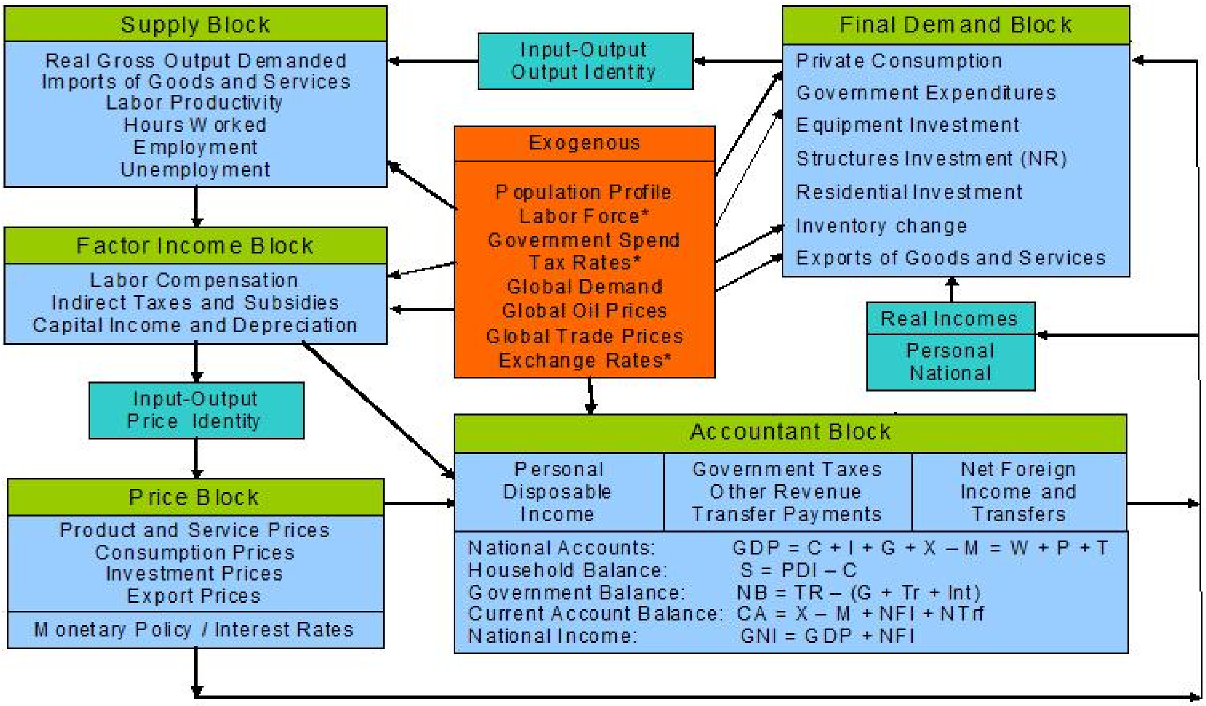
where *H* represents a bridge matrix for the various components: consumption, equipment investment by purchasing industry, expenditures by type of structures, inventory change, exports and imports, and government spending.

In the supply block, these detailed demand predictions then are used in an input-output production identity to generate real gross output demanded:

$$q = Aq + f$$

where *q* and *f* are vectors of output and final demand, respectively, each having 97 elements, and where A is a 97x97 matrix of input-output coefficients. Input-output coefficients and the bridge matrix coefficients vary over time according to historical trends evident in available data, and, in some cases, using assumptions about how technology and tastes might develop in the future (Almon 2008).

Figure 1: LIFT Model Schematic Diagram



Commodity prices are determined in a similar fashion. In the factor income block, econometric behavioral equations predict each value-added component (including compensation, profits, interest, rent, and indirect taxes) by industry. Labor compensation depends on industry-specific wages which are determined by industry-specific factors as well as overall labor conditions. Profit margins are dependent on measures of industry slack (excess supply or demand) and, for tradable sectors, international prices. Depreciation depends on capital stock. Indirect taxes and subsidies are imposed, in most cases, through exogenous ad-valorum rates on overall nominal output.

The industry value added determined above is allocated to production commodities using a make matrix. Then the fundamental input-output price identity combines value added per unit of output with unit costs of intermediate goods and services to form an indicator of commodity prices:

$$p' = p'A + v'$$

where p and v have 97 elements to represent production prices and unit value added, respectively. This identity ensures that income, prices, and output by sector are directly related and are consistent. In turn, relative prices and income flows are included as independent variables in the regression equations for final demand, creating simultaneity between final demand and value added.

As noted above, LIFT also calculates all of the major nominal economic balances for an economy: personal income and expenditure, the government fiscal balance (at both the federal and state and local government levels), and the current account balance. It also contains a full accounting for population, the labor force and employment. This content is important for scenario-building, because it indicates the consistency between economic growth determined on the product side with the inflation and income components computed on the factor income side. Thus the model allows us to examine how alternative microeconomic conditions or policies will affect other aspects of the economy.

The rich detail of the model supports a wide array of simulations that can be used for impact analysis and to address policy questions, including analysis of shocks to particular industries. Because the input-output structure allows a bottom-up approach to modeling the macro economy, macroeconomic results fully are consistent with simulated industry disruptions.

The current model is the fourth discrete version of a modeling framework that has been in continuing existence since 1967. Since its inception, LIFT has continued to develop and change. We have learned more about the properties of the model through working with clients, and in doing our own simulation tests. We have learned about the behavior of the general Inforum type of model, from work with our partners in other countries. Finally, through many experiments, we have learned that many principles of economics, while attractive theoretically, are difficult to implement practically. We will continue to experiment, and share ideas, and bring the models closer to our vision of what they should be.

Using LIFT to Analyze Long-term Health Care Projections

As a result of its dynamic and bottom-up framework, LIFT is uniquely suited to explore the economic relationships between health care expenditures and the overall economy. LIFT's underlying sectoral and industrial detail help to illuminate the structural implications of long term projections for health and non-health industries and sectors. In Table 1 the health related sectors are listed as a group at the bottom of the right hand column. As the relative demand for health care grows, employment and investment to the health care sector will increase disproportionately, affecting the overall structure of the economy. In addition, LIFT's rigorous consistency between the real and nominal sides of the economy help assess the sustainability of any given health care projection. For example, because it tracks household, government and international balances, any given projection of health care expenditures must be reconciled with an income source, whether that is wages, taxes, or foreign borrowing.

Typically, U.S. health care analysis in the United States is placed in the context of the National Heath Expenditures (NHE) accounts compiled by the center for Medicaid and Medicare Services (CMS). When one hears, for example, that health care expenditures are currently at 17 percent of GDP, the numerator is drawn from the total of the NHE account. This historical data breaks down health consumption by type of health service (physicians, dentists, hospitals, etc.) and also include supporting expenditures for health-care related capital equipment, structures, research and administration (including insurance administration). For each concept the NHE contains nominal, real, and price index data.

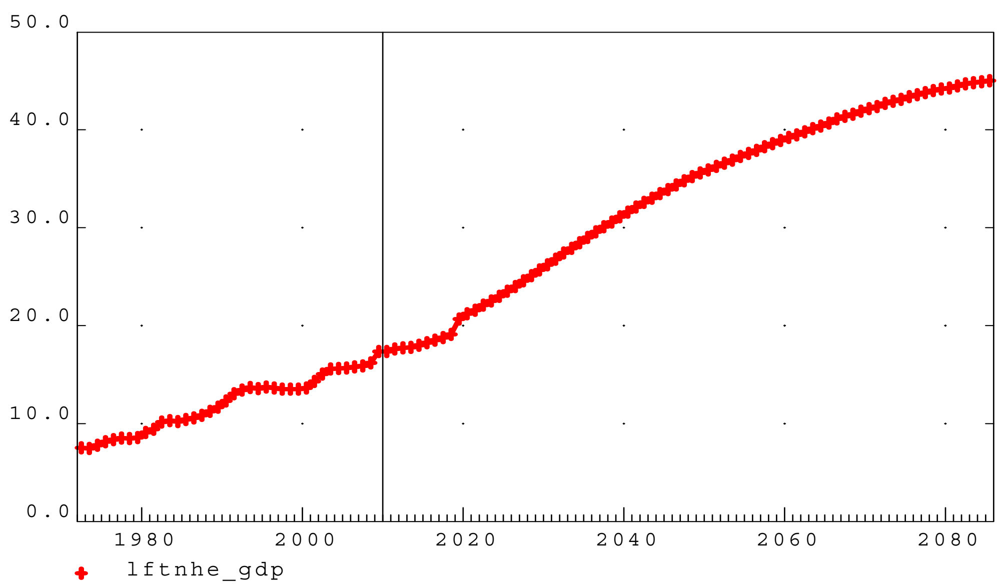
LIFT contains full National Income and Product Account (NIPA) detail for household expenditures for health care which map neatly to the bulk of the NHE. LIFT also contains categories of government and investment spending for health care as well, which enables a complete crosswalk of the model's NIPA accounting with the NHE, in both real and nominal terms. Therefore, and given simulation of the LIFT model provides explicit accounting for NHE. This capability is useful in many applications.

For example, each year CMS analysts forecast the NHE pattern over the next 10 years. These projections can be overlaid into an existing LIFT projection scenario to develop estimates for direct and indirect industry production requirements including the demand for labor, capital and intermediate inputs. Alternatively, LIFT can provide independent forecasts for NHE components based on the income, demographics, and government health expenditures of any given scenario. Indeed, a recurring role for LIFT is to assess the structural and fiscal implications of the 75 year Medicare Trustees Report.

In the Trustee's calculation, Medicare and Medicaid spending is expected to be driven by the rate of NHE. Most analysts familiar with Trustee report projections are acquainted with a curve which projects the share of current price NHE in nominal GDP over 75 years. From a share of almost 18 percent in 2010, this share grows to 45 percent by 2085, the end of the forecast period (Figure 1). The evolution of this ratio is based on the Trustees' assumption that percentage growth in nominal NHE exceeds growth in nominal GDP growth by a mean of about 1.8 percentage points in the near term. This rate of "excess cost growth" (the x in GDP + x) falls gradually but steadily over time to reach about 0.1 by 2085.

This deceleration in the rate of excess cost growth is popularly known as "bending the curve." Everyone engaged in this conversation seems to understand that the curve must ultimately be "bent" because perpetual excess cost growth implies that NHE would eventually be greater than GDP, which is impossible. Indeed, a standard assumption is that excess cost growth would eventually fall to zero or less, so that the share of NHE in GDP might stabilize or even fall. Optimists hope that this can happen sooner rather than later. Pessimists are less sure.

Figure 2: Share of National Health Expenditures in GDP: 1972 - 2085



As implausible as any 75 year forecast might seem, this long-term projection framework accomplishes an important task. Like any economic forecast the baseline Trustees estimates provide a structured and consistent vision given the many underlying assumptions of growth, preferences, behavior, and policy. It can then spur discussion and research concerning which behaviors, policies, or other developments might be instrumental in "bending the curve."

A decrease in excess cost growth means that one or both of two events must occur. First, excess medical inflation (i.e., the increase in health care product and services prices relative to GDP inflation) can fall if relative medical sector productivity (labor of MFP) growth permanently increases from sluggish historical trend (as measured). Much of the discussion surrounding bending the curve focuses on just such a phenomena. For instance, advocates of greater consumer participation through larger deductibles and cost sharing feel that market pressure on health care providers will induce greater efficiency in the sector. Supporters of a single payer system feel that the elimination of layers of administration costs could boost productivity.

Second, excess health expenditure (i.e., the growth of real health expenditure relative to the growth of real GDP) could fall as consumer preferences or government priorities changes. For this trend to occur requires no more than the typical economic assumption that the marginal utility of health expenditures will fall as these expenditures increase relative to non-health spending. In other words, the elasticity of real health expenditures to real income – which currently exceeds one – falls as the nation's budget share of health expenditures rises.

The Trustees' report does not identify the decomposition of health care expenditure growth between the volume and price components. However, underlying CMS excess cost projection is a CGE model which does include a utility function which explicitly models these two effects and then uses different assumptions for the function's parameters to provide different paths for the NHE share curve (Borger, Rutherford and Won, 2007). Because of its detail and accounting, LIFT is also able to incorporate different decompositions of volumes and prices.

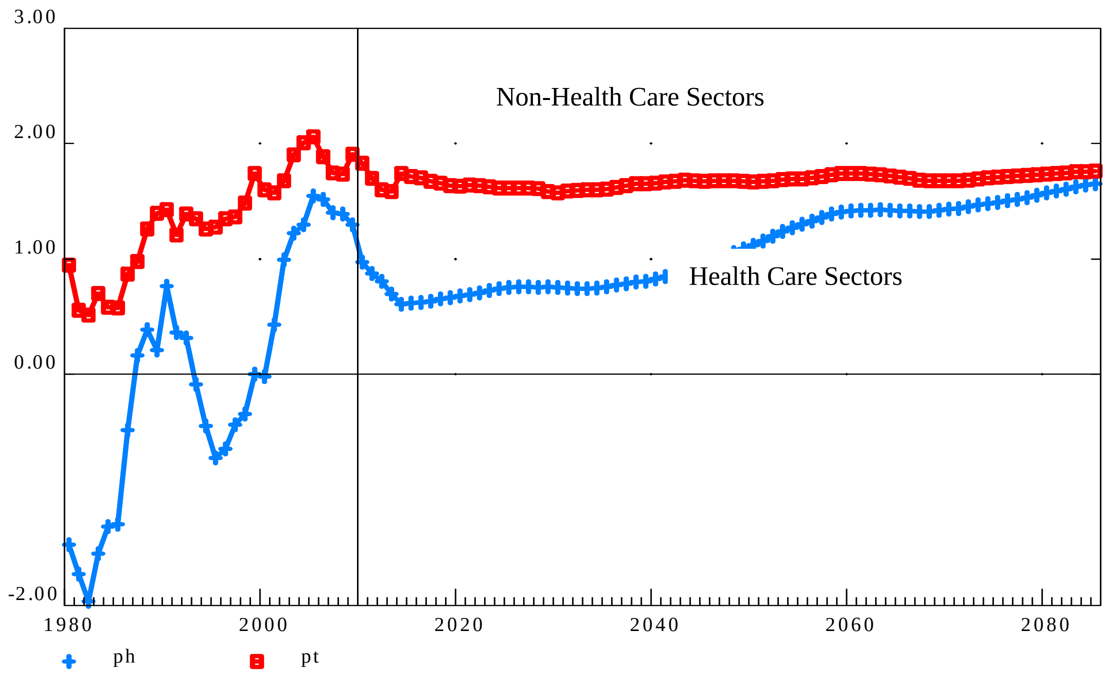
In any case, the Trustees' projection of the GDP share of health expenditure assumes that the growth in real and nominal GDP is given, or exogenous. In other words, the growth in the share of health care in GDP does not impact GDP growth itself. In reality, the exogeneity of GDP in the face of different health care shares can be challenged for at least two reasons.

First, assuming as above that health care financing migrates continually toward the public sector then government tax collection would have to climb significantly. Such revenue might be collected in a way that reduces economic efficiency, through ever higher marginal income taxes or through corporate income taxes for instance. Therefore, the acceleration of such taxes could results in the withdrawal of labor or capital from the economy compared to a lower tax environment generating lower economic growth than what might occur otherwise. Presumably, such reductions could be avoided by using non-distortionary revenue sources such as consumption taxes.

Another, more intrinsic problem with exogenous GDP growth is that, as measured, the productivity growth of health services has lagged the productivity growth of the rest of the economy. This trend is shown for labor productivity growth in Figure 3. Because of this differential, it is conceivable that a steady shift of expenditures toward medical services might actually reduce the trend growth of GDP. In other words, by taking real GDP growth as given, the Trustee's may be overestimating potential GDP growth and underestimating the health care expenditure share.

Illustrating this interaction is one area where the LIFT model comes in. How can the economy accommodate such a dramatically increasing share of health care? This is where the LIFT model comes in. In one version of the 75 year forecast, LIFT pegs the rate of GDP growth exogenously in line with the Trustees' assumption. To square the rising health care budget share with the assumed GDP growth the model must assume that the productivity growth of the health sector converges to average productivity growth of the rest of the economy (Figure 3). This assumption might be reasonable if one believes strongly that market or administrative pressures could produce much larger efficiency-enhancing technical change in the sector.

Figure 3: Average Productivity Growth in Health Care Sectors vs. Non-Health Care Productivity Growth



Alternatively, LIFT can also consider an analysis where GDP growth is endogenous and dependent on developments in the health sector. One scenario assumes that the historic patterns of relative productivity growth continue and convergence does not occur. Compared the Trustees' baseline case, expansion of activity and employment in health care would have to drag real GDP growth below the initial estimate. Indeed, notwithstanding full employment, consumption of non-health goods would be much lower than the above case and might even fall in the long run.

In summary, we see that a rigorous examination of the plausibility of health care projections needs a model with an economy-wide and dynamic framework including detailed accounting of both demand and production volumes and relative prices. In addition, macroeconomic accounting for government, households and current account balances also help to reveal the sustainability of any long run forecast.

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