The Supply Side of Health Care in a Dynamic Context

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Abstract: Total nominal US health care spending as measured in the National Health Expenditure Accounts (NHEA) reached nearly $3.5 trillion in 2017, or about 17.9 percent of GDP. This relationship is a demand side measure, relating health care expenditures in final demand to total final demand, which is equal to GDP. GDP is also measured as the sum of value added by industry. Other attempts to measure the health care share of value added have resulted in much lower shares than the demand side measure. In a previous paper[1] we traced the sectoral contributions to health care supply within an input-output (IO) framework, for the year 2012. In this paper we update and extend this analysis in current prices, from 1997-2017. We investigate the impacts of changes in industry structure, international trade and sectoral productivity on the relative contributions of industries to health care supply.

1 Introduction

In 2017, the Centers for Medicare and Medicaid Services (CMS) estimated that slightly less than $3.5 trillion was spent on health care related goods and services[2]. This total health care spending, called National Health Expenditure (NHE) is the topline figure in the National Health Expenditure Accounts (NHEA) compiled by CMS. The size of health care expenditures has risen from 5 percent of GDP in 1960 to almost 18 percent in 2017 and this share is projected to continue to rise[3].

Nevertheless, surprisingly little is known about the structural economic detail of health care industry production in terms of gross output, value added, and employment. The NHE-to-GDP ratio reflects the demand side of the economy. It is also important to understand the supply side. Supply side analysis incorporates information on the "upstream" industries contributing to health care. These upstream industries are industries that provide goods and services inputs to the industries directly providing health care, and it is important to understand their contribution. This analysis also accounts for the share of resources provided through imports.

To date, there is little research concerning the total primary factor requirements of satisfying health care demand, in particular the labor requirements. Yet an understanding of such requirements can shed a greater light on the sustainability of spending trends.

The present study provides a comprehensive accounting of health care production, building on an earlier study that was completed in 2014, and referenced above. Our starting point is health care demand as defined by the NHEA. To translate these expenditures into supply by industry, we convert the NHEA dollar-based figures to corresponding NIPA-based final demand categories, and then use standard input-output (IO) accounting to determine the value-added and labor requirements by industry. More specifically, we use modified versions of the Bureau of Economic Analysis' industry and input-output accounts to provide health care supply estimates

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[1] See two papers by Werling, et al. (2014).

[2] Martin, et al. (2019).

[3] Sisko, et al. (2019)

including: 1) the direct and indirect gross output requirements by commodity, 2) the direct and indirect imports by commodity, 3) value added by industry, and 4) employment requirements by industry. This framework provides analytic capabilities to provide better understanding of the supply side of health care, thus improving not only our understanding of the past but also our ability to anticipate needs and developments.

The paper is organized as follows. In the first section below, we describe the NHEA and show that such demand-side accounting alone does not provide information on the resource requirements of health care production. The second section summarizes the available data sources and their limitations, and it describes the input-output methodology used to determine the gross output requirements of satisfying health care demand. In the next section we provide the most salient results of the analysis, that is, the industry-level value added and employment associated with providing health care. These findings are compared to other recent works concerning health care employment. We conclude with an agenda for future research.

2 Health Care in the Broader Economy

2.1 Health Care Demand

As the nation continues to struggle with decisions concerning the provision and financing of health care, an oft-cited symptom of problems is that "the cost of health care is rising too fast." This conclusion is based at least partly on the observation that the growth of nominal expenditures for health care goods and services almost always exceeds the increase of nominal gross domestic product (GDP). Figure 1 shows the growth rate of total nominal NHE versus the rate of nominal GDP from 1960. Before 2009, NHE growth outstripped GDP growth almost every year, often by a wide margin. This difference in growth rates is often called "excess health care cost." Only from 1994 to 2000, and more recently from 2009-2012, has the rate of NHE growth been similar to GDP growth.

The proportion of NHE to GDP is typically the metric used as the share of the the health care sector on the overall economy. Figure 2 shows that since 1960 expenditures have grown from about 5 percent of GDP to about 17.3 percent by 2009. From 2009 to 2014, the share was flat. Since then, it has risen to 17.9 percent in 2017. The increase in the share is of course related to the differences in growth rates shown in Figure 1. It is an open question whether the increase in health care of total expenditures eventually will displace other desirable purchases of goods and services. The increasing share of health care has been observed to steadily curve upwards, due to the fact that health care expenditures have had a higher growth rate than GDP. The question of "bending the curve" of health care costs refers to the two growth rates in Figure 2 approaching parity.

Health care expenditures in the NHEA are defined as the total private consumption, capital investment, and government expenditures for health care goods and services. The NHEA contain health care expenditure data for different types of goods and services expressed in current dollars, as shown in Table 1. The health care expenditures normally used for analysis are adjusted neither for general inflation nor for relative price changes.

An important feature of the NHEA is that they correspond to the expenditure definition of GDP used in the National Income and Product Accounts (NIPA). This version of *GDP* is formed as the sum of personal consumption (*C*), gross private investment (*I*), government consumption and investment (*G*), and exports (*X*) minus imports (M):

$$GDP = C + I + G + X - M \quad (1)$$

As noted above, NHEA expenditures comprise portions of *C*, *I*, and *G* and are valued at the prices paid by the final purchasers.

In 2017, total personal health care (PHC) was $2.96 trillion, or about 85 percent of total NHE, and it is the most important line item in the NHEA. As indicated in Table 1, PHC itself is composed of 10 types of goods and services, such as physician and clinical services and prescription drugs. Including the share of premiums paid by their employers, consumers lay out a substantial amount (nearly $230 billion in 2017) for the net cost of private health insurance (premiums minus claims). Both PHC and net premiums are classified in the NIPA as personal consumption (*C*). The other sources of demand in the NHEA come from private investment in capital equipment and structures (I*)* and from federal, state and local government consumption and investment spending for health administration, research, and public health activities (G*)*.

The Bureau of Economic Analysis provides a different but similar accounting for health care expenditures within the context of the national income and product accounts (NIPA). Kornfeld and others[4] have provided a description of both sets of accounts with details on the differences. Especially in terms of the big and broad categories of spending such as ambulatory care, hospitals, and insurance, the figures are very similar across the BEA and CMS health care demand accounts. Neither account, however, contains supply side data.

[4] Hartman, Kornfeld and Catlin (2010).

Figure 1. Growth in Nominal NHE and GDP, 1961-2017

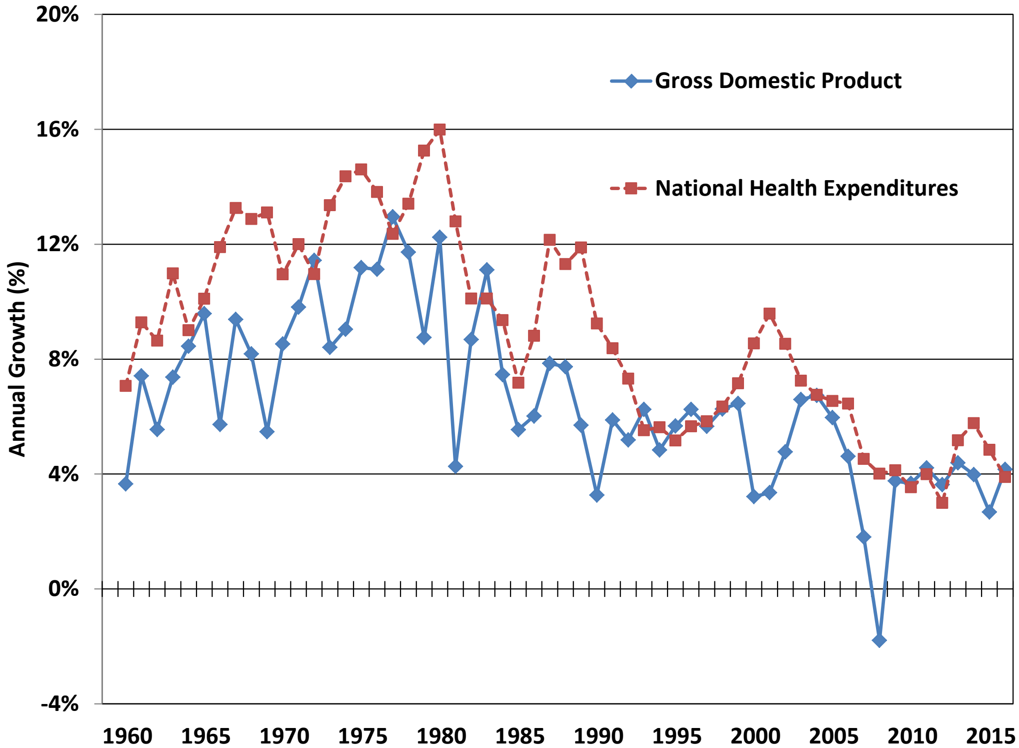


Figure 2. Nominal NHE as a Percent of GDP, 1960-2017

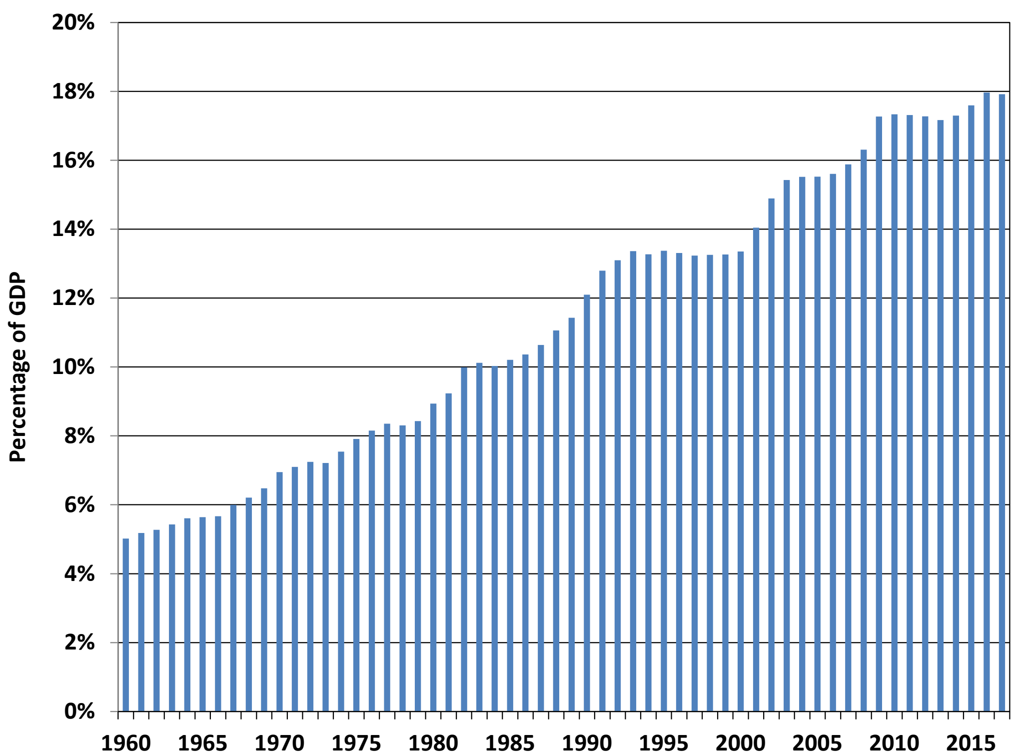


Table 1. National Health Expenditures, 1960-2017

	Billions of U.S. dollars					Annual percent growth		
	1960	1980	1998	2012	2017	1960-2017	1998 - 2012	1998 - 2017
Gross domestic product (GDP)	**542.4**	**2,857.3**	**9,062.8**	**16,197.0**	**19,485.4**	**6.6**	**4.2**	**4.3**
National health expenditures (NHE)	**27.2**	**255.3**	**1,201.5**	**2,798.0**	**3,492.1**	**9.1**	**6.2**	**6.1**
NHE as percent of GDP	5.0	8.9	13.3	17.3	17.9	2.3	1.9	1.7
Personal health care	23.3	217.0	1,025.6	2,367.4	2,961.0	9.0	6.2	6.1
Hospital care	9.0	100.5	374.9	902.5	1,142.6	9.0	6.5	6.4
Physician and clinical	5.6	47.7	256.5	557.1	694.3	9.0	5.7	5.7
Dental services	2.0	13.3	53.6	109.7	129.1	7.7	5.2	5.0
Other professional services	0.4	3.5	33.4	76.4	96.6	10.3	6.1	6.1
Home health care	0.1	2.4	34.1	78.3	97.0	14.2	6.1	6.0
Nursing home care	0.8	15.3	79.1	147.4	166.3	10.0	4.5	4.2
Other health services	0.4	8.4	55.6	139.1	183.1	11.4	6.8	6.8
Prescription drugs	2.7	12.0	88.5	259.2	333.4	9.0	8.0	7.6
Other nondurables	1.6	9.8	28.6	53.9	64.1	6.8	4.6	4.6
Durable medical products	0.7	4.1	21.4	43.7	54.4	8.0	5.2	5.3
Net cost of private health insurance	1.0	9.3	49.9	166.1	229.5	10.2	9.0	8.8
Government administration	0.1	2.8	13.3	34.2	45.0	12.8	7.0	7.0
Public health activities	0.4	6.4	37.5	77.2	88.9	10.3	5.3	4.9
Research	0.7	5.4	21.5	48.4	50.7	8.0	6.0	4.9
Equipment	0.3	5.8	29.9	55.2	61.3	9.8	4.5	4.1
Structures	1.5	8.6	23.7	49.5	55.6	6.7	5.4	4.8
Deflators (100=2012)								
GDP deflator	16.6	42.3	75.3	100.0	107.9	3.4	2.1	2.0
Health care price deflator	6.3	21.7	67.5	100.0	105.8	5.2	2.8	2.5
Billions of 2012 dollars								
Real GDP	3,260.1	6,758.4	12,040.9	16,197.0	18,053.4	3.1	2.1	2.3
Real health care expenditures	434.1	1,175.7	1,780.5	2,798.0	3,299.3	3.7	3.3	3.5

CMS National Health Expenditures Data: 1960 - 2017, and BEA NIPA.

2.2 Health Care Supply

The demand-side information given by the NHEA is extremely useful and important. However, as we will show in this paper, the supply side is also important for many reasons. To understand the full impact of health care spending on value added and employment, we need to trace back the expenditures to the supplying industries, including accounting for imports. For example, out-of-pocket or insurance-financed expenditures for physician services comprise the revenue of the physician sector. These revenue data do not show how much physicians pay for supplies, utilities, and outside services. They do not provide the wage and capital income received by physicians, their employees, their landlords, their bankers, and government. Since they reflect demand and not supply, the NHEA do not provide information on the magnitude and composition of health care employment.

In national income accounting, GDP is either the sum of final expenditures (demand), or the sum of factor income or value added (supply) by industry. In the physician sector, total value added may be calculated by deducting intermediate purchases for supplies, utilities, and services from revenue. Value added includes labor compensation (*W*), capital income (*P*, including profits, rent, interest, and depreciation), and net indirect taxes (*T*, including production and imports taxes minus subsidies) paid by the industry.

The supply side measure of GDP can be expressed as:

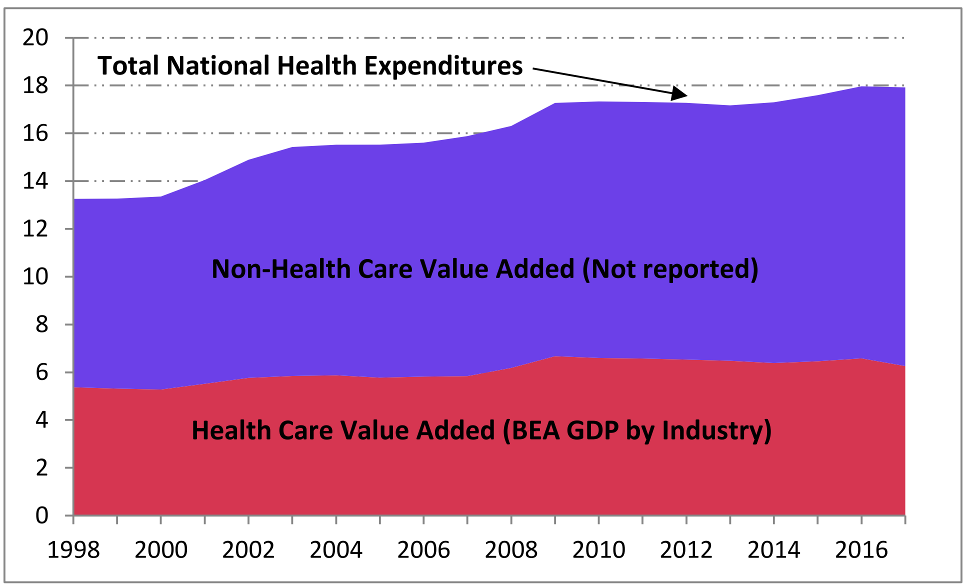
$$GDP = \sum_j VA_j = \sum_j (W_j + P_j + T_j) \quad (2)$$

Since all expenditures (demand) ultimately are someone's income (supply) then these apparently different measures are equal:

$$GDP = C + I + G + X - M = \sum_j VA_j \quad (3)$$

For the U.S. economy, industry-level value added data are published as the "GDP by Industry Accounts" by the BEA. In addition to total value added by type, the industry accounts also contain industry figures for nominal and real output and total and full-time equivalent (FTE) employment. Of the 71 unique industries identified in these accounts, only three of them are "health care industries" *per se*: 1) Ambulatory health care services and 2) Hospitals; and 3) Nursing and residential care facilities. The combined value added (supply) of these three sectors was 6.3 percent of GDP in 2017, well short of health expenditures' (demand) share of 17.9 percent of GDP. The respective shares are shown in Figure 3. BEA also provides employment estimates for the 71 value added industries. The three main health care sectors combined for 10.1 percent of economy-wide employment in 2017, still well short of the expenditure share.

Figure 3. Total NHE and Health Care Industry Value Added (Percent of GDP)



One reason for the difference between health care value added and total NHE is that some important health care activities that contribute to the provision of health care occur in other industries. Among these are pharmaceutical manufacturing which is combined with the broader chemicals industry, electro-medical and therapeutic apparatus manufacturing which is part of computer and electronic products, and medical equipment and supplies manufacturing which is part of miscellaneous manufacturing. However, even when we use other data to estimate value added for these more detailed industries the measure of total supply still does not approach the total demand as measured by the NHEA. What is then the cause of this difference? There are three main components:

First, final demand expenditures for health care supply not only the income of health care direct providers (physicians and staff) but also cover input costs and expenses of the health care sector. Examples include purchases of energy, materials, and services. Production of these so-called intermediate inputs also generates income, or value added, in the industries that supply them. For instance, when a hospital purchases electricity, part of the bill pays workers in the electric utility sector (thus increasing value added) and some of it is used to purchase materials like coal. In turn, a portion of the expenditure for coal is used to pay miners for their labor, thus increasing value added in the coal industry. In this way, satisfaction of health care demand requires value added across the entire supply chain, even in seemingly unrelated industries such as coal mining. We can track the required upstream purchases and the associated value added via "interindustry" accounting methods that are reflected by input-output tables. These tables show, for instance, the purchases of electricity by hospitals in absolute terms, and they can be used to calculate electricity purchases in proportion to total hospital revenue.

A second component of health care expenditures that is not paid to health care suppliers is the margins garnered by wholesalers and retailers that distribute medical goods and services. These are particularly significant for prescription drugs and other medications and for medical supplies and equipment. Additional margins go to the transportation sectors that transfer supplies from factory or port to wholesalers and to retailers.

Finally, domestic supply will fall short of demand because of imports. Foreign suppliers satisfy some demand for health care, some directly, but mostly indirectly. For example, in 2017 about 37.5 percent of U.S. demand for pharmaceutical products is satisfied through imports. We will return below to further discussion of imports.

In summary, the health care demand figures supplied by the NHEA do not provide information concerning the commodity production, import penetration, and industrial income and employment composition of health care supply. While health care supply includes obvious sectors such as hospitals and doctors, demand also is satisfied indirectly by almost every sector of the economy, including agriculture, mining, construction, and entertainment services.

In the following sections, we will develop an input-output (IO) framework to provide better understanding of the supply side of health care. In this framework, health care goods and services are produced not only in the hospital or doctor's office, but also by the accountant who balances the doctor's books and the utility that supplies electricity to the office. The IO calculations therefore identify which industries contribute the value added for both health industries and upstream suppliers.

Similarly, the IO framework can calculate the allocation of labor among health and non-health care sectors. For instance, if a large and growing segment of the retail sector is devoted to the distribution of health care goods and services, then should an equivalent proportion of retail employment be assigned to health care when calculating comprehensive health care employment levels?

The results from these calculations are important because they provide a consistent accounting of the health care supply side that allows us to trace changes in factor payments and employment through time. In turn, the historical accounting can provide an important indication of the sustainability of health care growth in the future.

3 Brief Description of the LIFT Model

Much of the work at Inforum involves the Long-term Interindustry Forecasting Tool (LIFT), a dynamic interindustry model of the U.S. economy. LIFT is also a macroeconometric model that determines macroeconomic quantities that are consistent with the underlying industry detail. Most relevant for this study is the model's database that contains a full input-output (IO) structure populated with time series data that generally are consistent with the published BEA Input-Output, GDP by Industry, and NIPA data.

The core of the LIFT model consists of the multisectoral quantity and price relationships. Detailed variables are aggregated to obtain the aggregate macroeconomic product and income versions of GDP. LIFT models the expenditure side of the national accounts by commodity. This includes econometric forecasts for personal consumption, construction, equipment investment, inventory change, and exports and imports. Government spending categories are projected exogenously, mostly in real terms.

A given specification for final demands results in a solved value of output by industry. Labor productivity equations and equations for average hours worked allow for the calculation of hours and employment, given a certain output projection. Wage equations by industry translate hours worked into labor compensation. Other value added equations forecast profit-type income, depreciation and indirect taxes by industry. Nominal value added per unit of real output is then used to solve the price model, which generates a solution for prices by industry.

A block of the model called 'The Accountant' aggregates sectoral variables, and also calculates the various identities that form the household, business, government and external sectors of the national accounts. Miscellaneous variables such as interest rates are also forecast in the Accountant.

The core of this LIFT database is a historic time series of 121 x 121 commodity IO tables with consumption, investment, government, export, and import final demand data from 1997 through 2017. These tables have been developed from the BEA annual tables and the 2007 benchmark IO table, but the LIFT data set contains more detail for health care demand and supply compared to those provided by the BEA annual input output tables. Such detail is essential for our study of demand and production of health care services and of pharmaceuticals, electromedical machinery, and medical equipment and supplies. In addition to the supply and demand by commodity sector, the LIFT model also features industry output, value added, and employment for the BEA 71-industry classification, together with the annual "make" matrices to link commodity output with industry output. The LIFT model thus is particularly suited for the present study, as its framework reflects the standard input-output methodology employed in this paper, and it rests on a database that is consistent with the published data cited earlier.

In the LIFT database, GDP, final demand aggregates, and other macroeconomic information, as well as industry employment levels, are provided by the NIPA. BEA also publishes annual industry output levels and value added by industry for 71 industries from 1997 through 2017. Additional input-output detail was published in the 2007 benchmark tables. The input-output data sets include bridge tables that map final demand (i.e. consumption by types of consumer goods and services, equipment and software investment by purchasing industry, and construction spending by type of structure) to the commodities that comprise the purchased goods and services.

For each year of a forecast, the model iterates between these main components until it has reached a solution. The model solves annually and a typical forecast interval is from 10 to 35 years, but it can be run to 2100 or longer. LIFT is dynamic, in that many of the equations include lagged effects or relations using first differences. Although the model is "bottom-up" in that detailed data is used to form the macro-aggregates, they may be controlled from the top down if necessary, to force consistency with another macro model forecast, or with *a priori* assumptions.

A more detailed description of the LIFT model is provided in Appendix A.

4 Methodology

4.1 Compare NHE and NIPA Expenditure Levels

Because the NHEA provides the foundations for total health care spending measures and the NIPA and BEA industry data provide the statistical basis for constructing the supply account, we should identify the relationships between the data sets and be aware of inconsistencies. Table 2 shows correspondences in 2017 between the NHE categories and the closest NIPA/LIFT concept(s). We use these correspondences to guide the translation of the NHEA based health care demand to final demand by commodity in the LIFT model.

The first in this translation is to allocate the NHEA values for Personal health care, which is the largest component of the NHEA. The total for 2017 was $2,961 billion. Most of the expenditures for Personal health care can be found corresponding to one or more categories of Personal consumption expenditures (PCE) in the NIPA. NHEA Personal health care and NIPA PCE are very similar in concept. The data from each source represent transactions between individuals and providers, including expenditures paid through private insurance and government programs like Medicaid and Medicare. The categories reported in NHEA are similar to those of the NIPA, but there are important differences. The sum of these NIPA PCE categories for 2017 is $2,846.8 billion, so that NHEA is about $115 billion larger than NIPA PCE health. A large part of this difference is in Hospital care, where NHEA shows $1,142.6 and NIPA shows $1,050.3, a difference of $92.3 billion. Part of this difference is due to the fact that NHEA also records expenditures at government hospitals.

The BEA (2012) reconciliation suggests that the NHEA physician and clinical expenditures are spread across several categories of NIPA PCE including physician offices and other professional medical services. In table 2, NHEA expenditures for Physicians and clinical amount to $694.3 billion, whereas the NIPA figure for Physicians is $529.5 billion. Following the reconciliation done by BEA, we also allocate the $36.8 billion from the NIPA PCE category Medical laboratories, and $140.4 billion of Specialty outpatient care centers, which is part of PCE category 50 in LIFT (Other professional medical services). This brings the total for the NIPA correspondence to $706.7, which is closer to the $694.3 in NHEA.

To understand the role played by the correspondence to the allocation of expenditures by LIFT commodity, we will examine the BEA PCE bridge, which is adopted for the LIFT model. The PCE bridge is a matrix (121x83) showing the makeup of each of the PCE spending categories in terms of IO commodities. Some of these commodities are goods, some are services, and some are trade and transportation margins. For example, table 3 shows the column 31 (Pharmaceuticals) in that matrix, for 2017. Of the total PCE spending of about $508.1 billion on Pharmaceuticals in 2017, $272.6 billion went to manufacturers of Pharmaceuticals, a share of .5694, or 56.9%. Four types of retail stores are identified in LIFT, and Pharmaceuticals are distributed in three of them. The largest component of trade margins ($106.2 billion) went to Other retail, which includes Pharmacies and drug stores, and Non-store retailers. The third largest item in the column is Wholesale trade, which received a margin of about $101.8 billion from the sales of Pharmaceuticals in 2017. Other smaller components of the column include Petroleum and coal products, Other chemicals and various transportation margins. When the LIFT model runs, the values for PCE by category are passed through a coefficient matrix that is derived from the PCE bridge, and this matrix distributes the total spending by PCE category to LIFT commodity.

Table 2. Partial Reconciliation of NHE categories, and related NIPA/LIFT categories, 2017

NHE Title	*NHE*	*NIPA*	*NIPA Title (Lift Correspondences)*	Difference (NHE-BEA)
NHE Total	**3,492.1**			
Personal health care	2,961.0	2,846.8		114.2
Hospital care	**1,142.6**	**1,050.3**	Hospitals (PCE 51)	92.3
Physician and clinical	**694.3**	529.5	Physicians (PCE 46)	-12.4
		36.8	Medical laboratories (PCE 49)	
		140.4	Specialty Outpatient care facilities (PCE 50 part)	
		706.7		
Dental services	**129.1**	**131.1**	Dentists (PCE 47)	-2.0
Other professional services	**96.6**	78.0	Other professional medical services (less specialty centers)(PCE 50 part)	0.0
		18.6	Therapeutic appliances, eyeglasses, contacts (PART PCE 16)	
		96.6		
Home health care	**97.0**	105.0	Home health care (PCE 48)	0.0
		-8.0	Move some PCE 48 to Other health, residential and personal care	
		97.0		
Nursing home care	**166.3**			3.6
		55.9	Nonprofit nursing homes' services to households (part PCE 52)	
		124.6	Proprietary and government nursing homes (part PCE 52)	
		-17.8	(PCE 52 in Other health, residential and personal care)	
		162.7		
Other health, residential and personal care	**183.1**	8.0	Home health care (PCE 48)	37.3
Nursing homes		17.8	Moved from Nursing homes (PCE 52)	
Drugs		120.0	Moved from Prescription drugs (part PCE 31)	
		145.8		
Prescription drugs	333.4	452.0	Prescription drugs (part PCE 31)	1.4
		-120.0	(PCE 31 in Other Health, residential and personal care)	
		332.0		
Other nondurables	**64.1**	5.8	Other medical products (PCE 32)	2.0
		56.3	Non-prescription drugs (part PCE 31)	
		62.1		
Durable medical products	**54.4**	73.0	Therapeutic appliances, eyeglasses, contacts (PCE 16)	0.0
		-18.6	Move to Oth prof serv ?)	
		54.4		
Net cost of private health insurance	**229.5**	**192.6**	Net health insurance (69)	36.9
Government administration	45.0		Mapped directly to commodities federal defense (116), federal nondefense (117) and state and local government, using CMS historical data.	
Public health activities	88.9		Map directly to commodities: 15% to federal nondefense, and 85% to state and local government	
Research	50.7		Map directly to commodities: 12% to Scientific research and development services (89), 75% to federal nondefense, and 13% to state and local government.	
Equipment	61.3	91.8	Equipment investment of Ambulatory health care (EQI 58) and Hospitals (EQI 59)	-30.5
Structures	55.6	36.0	Health care structures investment (CST 8)	19.6

For the calculation of commodity final demand corresponding to the NHEA, we have constructed a similar bridge for the 17 components of NHEA. This bridge, which we call the NHE final demand bridge, has 121 rows and 16 columns. The NHE final demand bridge column for Prescription drugs uses the coefficients from the Pharmaceuticals column (31) of the PCE bridge. The NHE final demand bridge column for Physicians and clinical is constructed as a weighted average of the PCE bridge columns for Physicians (46), Medical laboratories (49) and Specialty outpatient care centers (51), using the weights of the PCE subcomponents from table 2. Some of the components of NHEA are modeled using only one PCE bridge column, and several others follow the procedure used for Physicians and clinical, where two or more columns are weighted.

This method, though not a full reconciliation of NHEA and NIPA, brings the two data sets into fairly close alignment. Hospitals, which is the item with the largest discrepancy, is passed through directly to the Hospitals commodity (LIFT 103), since the bridge has only one element.

Table 3. Pharmaceuticals Column of the LIFT PCE Bridge, 2017

#	Commodity	Level	Coefficient
24	Petroleum and coal products	435.7	0.0009
26	Pharmaceuticals	272,558.7	0.5694
27	Other chemicals	107.3	0.0002
58	Wholesale trade	101,803.6	0.2127
60	Food and beverage stores	15,634.8	0.0327
61	General merchandise stores	5,013.6	0.0105
62	Other retail	106,212.6	0.2219
63	Air transportation	590.6	0.0012
64	Rail transportation	21.1	0.0000
65	Water transportation	21.5	0.0000
66	Truck transportation	5,685.4	0.0119
68	Pipeline transportation	38.2	0.0001
	Total	**508,123.0**	

Within Personal health care, aside from Hospitals, there remain $21.9 (114.2 – 92.3) billion of discrepancies, which are predominantly in Other health, residential and personal care ($37.3.7 billion) and Physicians and clinical (-12.4 billion).

A large item, not included in the NHEA aggregate of Personal health care, is the Net cost of private health insurance, which is $229.5 billion in 2017. The corresponding PCE category is Net health insurance, which is $192.6 billion in 2017, a discrepancy of 36.9 billion. This is passed entirely to the LIFT commodity Insurance (80).

Three categories of NHEA have been mapped directly to LIFT commodities. These are Government administration, Public health activities and Research, which are mapped as described in table 2.

The remaining categories are Health care equipment and structures investment. The equipment investment component of the NHEA is the value of new capital equipment (including software) purchased or put in place by the medical sector. It does not include equipment investment by pharmaceutical manufacturers, medical equipment producers, or retail establishments such as pharmacies. The capital equipment investment measure includes all capital equipment purchased by medical establishments, and therefore it is not limited to medical machinery or equipment but includes, for example, vehicles and computers. There is a matrix in LIFT called the *equipment investment bridge*, which shows the equipment assets by commodity which are purchased to supply investment for each industry. We use a weighting of the columns of Ambulatory health care (58) and Hospitals (59) from this matrix to distribute the NHEA expenditures through the NHE final demand bridge.

In the NHEA, structures investment consists of the value of new construction, additions, alterations, and major mechanical or electrical upgrades put in place by the two main industries within the medical sector, the Ambulatory health care and Hospital sectors. While the measure includes doctors' offices and nursing homes, it excludes, for example, pharmacies and other commercial buildings that are not part of the two main medical sectors. Another matrix, called the *construction bridge*, distributes construction investment by type of building to LIFT commodity. Column 8 (Health care structures investment) of this matrix is used to form the column in the NHEA final demand bridge for Health care structures.

4.2 Translate Final Demand by NHEA Category to Final Demand by Production Commodity

The NHEA final demand bridge is constructed for each year that LIFT is run, whether over the historical interval (1997 to 2017) or in a forecast. The coefficients of the bridge change over time. They are based on the LIFT PCE, equipment investment and construction investment bridges, which change over time. Also, the shares used to weight the columns of these bridge matrices change.

Although the entire bridge matrix can be displayed for any year, the end result of this stage of the calculations is the row sum of the matrix, called NHE final demand by commodity, which represents the total spending, whether domestic or imported, for each of 121 commodities, due to the NHEA spending by 16 categories.

Table 4 shows, in the left-most column for each year, the direct health care demand levels from the NHEA as distributed among input-output production commodities for 1998, 2012 and 2017, including the compound annual growth rates between the two years.[5] The commodities are ranked by the size of health care direct demand in 2017. The greatest expenditure category is for health care services such as Hospitals ($1,142.6 billion in 2017), Offices of physicians ($492.7), Pharmaceuticals ($267.1), and Nursing and residential care facilities ($254.2). Final demand for Other retail ($134.0 billion) and wholesale ($122.4) trade are also large. Think of the pharmacies on every corner and in every grocery store, including the services of the pharmacist inside. Among the largest sectors, the fastest growing commodity demands from 1998 to 2017 are for Wholesale trade (9.0%) and Insurance (8.4%).

[5] There are 121 commodities in the LIFT model, but only the 20 commodities with the greatest NHE demand are shown.

Table 4. Direct NHE Final Demand by LIFT Commodity

	Billions of Dollars									Annual Percent Growth					
	1998			2012			2017			1998 - 2012			1998 - 2017		
	Health care direct demand	Direct imports	Domestic direct demand	Health care direct demand	Direct imports	Domestic direct demand	Health care direct demand	Direct imports	Domestic direct demand	Health care direct demand	Direct imports	Domestic direct demand	Health care direct demand	Direct imports	Domestic direct demand
Total national health expenditures	**1,201.5**	**21.4**	**1,180.1**	**2,798.0**	**96.5**	**2,701.5**	**3,492.1**	**123.1**	**3,369.0**	**6.2**	**11.4**	**6.1**	**5.8**	**9.7**	**5.7**
LIFT Commodity															
103 Hospitals	374.9	1.2	373.7	902.5	3.1	899.5	1,142.6	3.8	1,138.8	6.5	7.0	6.5	6.0	6.3	6.0
96 Offices of physicians	187.3	0.0	187.3	398.9	0.0	398.9	492.7	0.0	492.7	5.5		5.5	5.2		5.2
26 Pharmaceuticals	80.0	13.8	66.2	199.6	66.6	133.0	267.1	88.8	178.3	6.8	11.9	5.1	6.6	10.3	5.4
104 Nursing and residential care facilities	109.3	0.0	109.3	221.8	0.0	221.8	254.2	0.0	254.2	5.2		5.2	4.5		4.5
80 Insurance	49.9	1.0	49.0	166.1	11.3	154.8	229.5	11.0	218.5	9.0	19.1	8.6	8.4	13.6	8.2
62 Other retail	46.4	0.0	46.4	109.3	0.0	109.3	134.0	0.0	134.0	6.3		6.3	5.7		5.7
99 Outpatient care centers	51.6	0.0	51.6	103.6	0.0	103.6	133.8	0.0	133.8	5.1		5.1	5.1		5.1
97 Offices of dentists	54.3	0.0	54.3	111.0	0.0	111.0	130.9	0.0	130.9	5.2		5.2	4.7		4.7
58 Wholesale trade	23.7	-0.6	24.3	98.0	-2.4	100.3	122.4	-3.2	125.6	10.7	10.2	10.7	9.0	9.1	9.0
101 Home health care services	40.7	0.0	40.7	95.0	0.0	95.0	119.0	0.0	119.0	6.2		6.2	5.8		5.8
98 Offices of other health practitioners	49.3	0.0	49.3	88.7	0.0	88.7	111.6	0.0	111.6	4.3		4.3	4.4		4.4
117 Federal government nondefense	26.5	0.0	26.5	61.9	0.0	61.9	71.7	0.0	71.7	6.2		6.2	5.4		5.4
56 Medical equipment and supplies, dental labs, ophthalmic goods	14.7	1.6	13.2	33.5	6.3	27.2	37.8	8.6	29.2	6.1	10.5	5.3	5.1	9.4	4.3
118 State and local general government	14.8	0.0	14.8	31.1	0.0	31.1	37.3	0.0	37.3	5.4		5.4	5.0		5.0
100 Medical and diagnostic laboratories	12.8	0.0	12.8	27.9	0.0	27.9	34.7	0.0	34.7	5.7		5.7	5.4		5.4
102 Other ambulatory health care services	10.2	0.0	10.2	27.8	0.0	27.8	33.7	0.0	33.7	7.4		7.4	6.5		6.5
13 New construction	13.1	0.0	13.1	29.8	0.0	29.8	33.5	0.0	33.5	6.0		6.0	5.1		5.1
44 Electromedical and electrotherapeutic apparatus	10.0	1.7	8.4	21.4	4.8	16.6	27.3	6.5	20.8	5.6	7.8	5.0	5.4	7.4	4.9
60 Food and beverage stores	4.6	0.0	4.6	13.0	0.0	13.0	15.7	0.0	15.7	7.6		7.6	6.6		6.6
61 General merchandise stores	1.9	0.0	1.9	7.4	0.0	7.4	8.4	0.0	8.4	10.0		10.0	8.0		8.0

Source: Inforum LIFT Model Calculations with BEA IO Data

4.3 Calculate Domestic Health Care Commodity Demand

Health care direct demand in this table is equal to the row sum of the NHEA final demand bridge for each year. To distinguish the activities of the domestic supply chain, we separate the final demand that will be satisfied through imports. Direct imports are determined for each commodity by multiplying the average import share of domestic demand for each commodity by the corresponding domestic demand level. Then,

$$f^d = f - f^m \tag{4}$$

where f^d is a vector of health care expenditure by commodity from domestic sources, f is the vector of total commodity demand as described above, and f^m is the health care direct imports by commodity.

Table 4 shows the direct imports in each year's second column. For most of the health care services sectors, imports are trivial or nonexistent, but they are significant for pharmaceuticals. In 2017, out of \$267.1 billion of pharmaceutical demand, \$88.8 billion was imported, an import share of 33.2%. In 2017, total health care direct demand was \$3,492.1 (the same as the NHEA total). The imported component was \$123.1 billion, so the average share of imports was 3.5 In contrast, the NHE import share for 1998 was about 1.8%. The difference between total demand and demand for import, domestic final demand across commodities, is shown for each year in the third column of Table 4.

4.4 Calculate the Domestic Total Gross Output Requirements by Commodity

To determine the level of domestic production that is consistent with net final domestic health care demand by commodity (denoted as vector f^d), we employ the input-output accounting identity[6]:

$$q^d = A^d q^d + f^d \tag{5}$$

where q^d is a vector of the gross domestic outputs required to produce f^d, and where A^d is an $n \times n$ matrix of coefficients ($a_{i,j}$) representing the domestic sales of each row (*i*) product used in the production of one unit of the column product (*j*). The total gross output requirements are inclusive of all intermediate costs and the value added required by the commodity production. The input-output matrix A^d indicates the "recipe" for production of a dollar's worth of output, where the ingredients are assembled from available domestic commodities. It indicates that in 2017, for example, Hospitals (103) used 1.4 cents of Legal services (86) per \$1 of hospital revenue, and Physicians' offices (96) used 3.7 cents of Insurance services (80) for every \$1 worth of output. Thus, the product $A^d q^d$ indicates intermediate inputs, that is, the quantities of materials, utilities, and purchased services employed in the production process for producing the vector q^d. In the current calculation, we solve for the production levels q^d that are required to satisfy net final demand levels f^d, including the corresponding intermediate input requirements, as:

$$q^d = (I - A^d)^{-1} f^d \tag{6}$$

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[6] For more information on input-output methods, an extensive review of the subject is available in Miller and Blair (2009).

4.5 Compute Indirect Import Requirements

A second import "leakage" of demand results from the imported content of indirect production. For example, domestically made medical imaging equipment contains foreign-produced components. These indirect imports are calculated by multiplying the intermediate import coefficients matrix by total domestic requirements.

$$m^{indirect} = A^m q^d \tag{7}$$

4.6 Compute Direct and Indirect Domestic Output Requirements

The vector q^d elements are the "total domestic gross outputs requirements" by commodity for producing NHE. As is customary in input-output economics, we define a vector of *direct* domestic gross output by production commodity that is equal to the final demand by commodity (i.e. $q^{direct} = f^d$). Then we can determine the "indirect requirement" ($q^{indirect}$) vector as the difference between total production and direct production requirements:

$$q^{indirect} = q^d - q^{direct} \tag{8}$$

Indirect requirements are the materials and services that are purchased for intermediate use in the production of health care commodities. An example is the electricity employed to power a hospital. Of course, additional production is needed to support provision of the materials and services employed in direct production of health care, such as the coal that is needed to produce electricity used by hospitals. The chain of upstream activities is accumulated in indirect production.

Table 5 provides direct, indirect, and total "health care" commodity output for the years 1998, 2012 and 2017 and the compound average annual growth rate between those years. The commodity sectors are ranked by total output requirements (the third column for each year) in 2016. Note that direct output figures (the first column for each year) are the same as the domestic direct demand in table 5 (the third column for each year). In terms of total output, the largest sectors are those with the largest direct demands such as hospitals, physician offices, and insurance. As is typical in the U.S. IO tables, total "duplicated" output requirements are about 1.6 times the amount of final demand[7].

Table 5 shows that the two largest health care sectors have minimal indirect output. However, indirect production requirements (the second column for each year) are important for Insurance ($257.6 billion in 2017), Other real estate ($248.8 billion), Administrative and support services ($192.1), Management of companies and enterprises ($133.0), and Other professional, scientific and technical services ($114.9). Obviously, these all are large input suppliers to the health care industries. Insurance has large amounts of both direct and indirect of production.

[7] Duplicated output refers to the fact that some output enters into several stages of production. For example, rubber is produced, and counted once as output. Some rubber is used in the production of tires, which is counted again as output. Finally, the value of the tires enters into the production of automobiles, and so the value of the rubber is counted three times. Because of this duplication, the total value of output of all sectors is larger than total final demand (GDP), by about 60 percent. This duplicated output is sometimes called "double counting". However, the employment and value added required to produce output is only counted once, and so is additive across sectors.

Table 5. Total, Direct and Indirect Gross Output Requirements for Supplying NHE

	Billions of dollars									Annual percent growth					
	1998			2012			2017			1998-2012			1998-2017		
	Direct domestic output	Indirect output	Health care total domestic output	Direct domestic output	Indirect output	Health care total domestic output	Direct domestic output	Indirect output	Health care total domestic output	Direct domestic output	Indirect output	Health care total domestic output	Direct domestic output	Indirect output	Health care total domestic output
Gross commodity output	1,180.1	747.8	1,927.9	2,701.5	1,650.4	4,351.9	3,369.0	2,117.5	5,486.5	6.1	5.8	6.0	5.7	5.6	5.7
Multiplier			1.6			1.6			1.6						
LIFT Commodity															
103 Hospitals	373.7	0.2	373.9	899.5	0.5	899.9	1,138.8	0.6	1,139.4	6.5	6.8	6.5	6.0	6.4	6.0
96 Offices of physicians	187.3	0.0	187.3	398.9	0.0	398.9	492.7	0.0	492.8	5.5	6.8	5.5	5.2	5.6	5.2
80 Insurance	49.0	53.1	102.0	154.8	181.7	336.5	218.5	257.6	476.1	8.6	9.2	8.9	8.2	8.7	8.4
104 Nursing and residential care facilities	109.3	0.1	109.4	221.8	0.4	222.3	254.2	0.4	254.6	5.2	8.1	5.2	4.5	5.1	4.5
83 Other real estate	0.1	67.5	67.6	0.2	179.4	179.6	0.3	248.8	249.1	6.5	7.2	7.2	6.0	7.1	7.1
58 Wholesale trade	24.3	44.1	68.5	100.3	65.6	166.0	125.6	83.5	209.1	10.7	2.9	6.5	9.0	3.4	6.1
26 Pharmaceuticals	66.2	24.1	90.2	133.0	19.6	152.6	178.3	26.0	204.3	5.1	-1.4	3.8	5.4	0.4	4.4
93 Administrative and support services	0.1	56.9	57.0	0.2	133.7	133.9	0.3	192.1	192.3	5.6	6.3	6.3	5.5	6.6	6.6
62 Other retail	46.4	0.6	47.1	109.3	1.2	110.5	134.0	0.7	134.6	6.3	4.4	6.3	5.7	0.1	5.7
99 Outpatient care centers	51.6	0.0	51.6	103.6	0.1	103.6	133.8	0.1	133.9	5.1	6.0	5.1	5.1	5.1	5.1
92 Management of companies and enterprices	0.0	33.8	33.8	0.1	100.4	100.5	0.1	133.0	133.2	8.2	8.1	8.1	7.2	7.5	7.5
97 Offices of dentists	54.3	0.0	54.3	111.0	0.0	111.0	130.9	0.0	130.9	5.2	7.0	5.2	4.7	5.9	4.7
101 Home health care services	40.7	0.0	40.7	95.0	0.0	95.0	119.0	0.0	119.0	6.2		6.2	5.8		5.8
91 Other professional, scientific and technical services	0.1	35.0	35.0	0.1	85.5	85.6	0.1	114.9	115.1	5.5	6.6	6.6	5.2	6.5	6.5
98 Offices of other health practitioners	49.3	0.0	49.3	88.7	0.0	88.7	111.6	0.0	111.7	4.3	5.8	4.3	4.4	5.1	4.4
117 Federal government nondefense	26.5	0.0	26.5	61.9	0.0	61.9	71.7	0.0	71.7	6.2		6.2	5.4		5.4
90 Advertising	0.1	25.8	25.8	0.1	53.9	54.0	0.1	70.1	70.2	4.5		5.4	4.2		5.4
56 Medical equipment and supplies, dental labs, ophthalmic goods	13.2	18.1	31.3	27.2	32.1	59.3	29.2	32.2	61.3	5.3	4.2	4.7	4.3	3.1	3.6
77 Banks, credit cards and finance	0.1	26.8	26.9	0.1	42.9	43.0	0.2	54.7	54.8	2.9	3.4	3.4	2.9	3.8	3.8
102 Other ambulatory health care services	10.2	4.1	14.3	27.8	13.4	41.2	33.7	17.3	51.0	7.4	8.8	7.9	6.5	7.9	6.9
Other commodities	77.7	357.6	435.3	167.8	740.0	907.8	195.8	885.6	1,081.4	5.7	5.3	5.4	5.0	4.9	4.9

Source: Inforum LIFT Model Calculations with BEA IO Data

Of the LIFT commodities shown in Tables 4 and 5, Pharmaceuticals has the highest share satisfied by imports. Table 6 shows the relation of imports to total final demand and total domestic output of Pharmaceuticals. The first 3 lines of Table 6 show the total health care direct demand, direct imports, and domestic direct demand. In addition to direct demand, there are another $26 billion of indirect demand for Pharmaceuticals provided domestically in 2017, to bring total domestic output for Pharmaceuticals to $204 billion. In addition to the direct imports of $88.8 billion in 2017, another $18.1 billion of imports are used to satisfy indirect demand, so that total imports for NHE are $106.9 billion. The last line of table 2a shows the import share for Pharmaceuticals, which nearly doubled between 1998 and 2012, but declined slightly by 2017 .

Table 6. Pharmaceuticals Supply, Domestic and Imported

	1998	2012	2017
Health care direct demand	80.0	199.6	267.1
Direct imports	13.8	66.6	88.8
Domestic direct demand	66.2	133.0	178.3
Indirect domestic output	24.1	19.6	26.0
Total domestic output	90.2	152.6	204.3
Indirect imports	7.1	13.7	18.1
Total imports	20.9	80.3	106.9
Import share (percent)	17.3	33.4	33.2

Source: LIFT model calculations

In addition to direct retail purchases of prescription drugs, a significant amount of intermediate pharmaceutical purchases are used to satisfy final demand in several health care industries. For example, in 2017, $11.5 billion of Pharmaceuticals were purchased by Hospitals and $3.4 billion were purchased by Offices of physicians. Table 7 summarizes the main health care sectors purchasing Pharmaceuticals as indirect demand. This health care indirect demand amounts to about $19 billion in total in 2017. There are an additional $7 billion of indirect purchases from other sources, bringing total domestic output of Pharmaceuticals required for NHE to $204.3 billion. Although examples of indirect purchases of Pharmaceuticals occur in industries such as outpatient care centers and medical diagnostic labs, the vast majority of these additional indirect purchases are sales of Pharmaceuticals within the Pharmaceutical industry.

Table 7. Distribution of Health Care Indirect Purchases of Pharmaceuticals

Sector	Name	2012	2017
96	Offices of physicians	2,625	3,417
97	Offices of dentists	296	363
98	Offices of other health practitioners	870	1,131
99	Outpatient care centers	592	793
100	Medical and diagnostic laboratories	384	506
102	Home health care services	398	527
102	Other ambulatory care services	145	182
103	Hospitals	8,541	11,485
104	Nursing and residential care facilities	540	645
	Subtotal	14,391	19,049
	NHE final demand	133,004	178,314
	NHE plus health care indirects	147,395	197,363
	Other indirect	5,245	6,970
	Total direct plus indirect	152,640	204,333

Source: NHE and LIFT model calculations

4.7 Determine Total Industry Gross Output Requirements

The input-output calculations presented so far have been on a product, or commodity, basis. Commodities refer to goods and services rather than to the industries that make them. Because each industry can make a variety goods and services, for production analysis it is more theoretically sound and empirically accurate to use product-to-product tables rather than product-to-industry tables. Value added and employment, however, are characterized and reported by BEA for 71 *industries*. We employ the LIFT model "make" matrix to translate production by commodity into gross production by industry. This matrix is adapted from the annual BEA IO tables, and it identifies for each industry (row) the quantity of each product (column) produced. Converting it to a share matrix *D* and multiplying it by the total requirements output vector provides an estimate gross health care output by the 71-industry BEA classification:

$$q^{industry} = Dq^{d} \tag{9}$$

4.8 Health Care Related Value Added and Employment by Industry

4.8.1 Health Care Value Added

Once health care total gross output by industry has been calculated, health care value added is derived for each industry (hva_j) by multiplying the total gross output requirements for each industry by the corresponding historical value added-to-industry output ratios taken from the BEA GDP-by-industry accounts:

$$hva_j^{industry} = \frac{va_j^{bea}}{q_j^{bea}} \times q_j^{industry} \tag{10}$$

In this way, we separate health-care related industry revenue into value added by industry ($hva_j^{industry}$) and payments for intermediate goods and services. Table 8 shows the figures by industry for 1998, 2012 and 2017 for all major industries and for the sub-industries with the largest value added. These numbers represent the wage, capital, and indirect tax income generated, directly and indirectly, by industries as they respond to satisfy the demand for health care.

Of course, the largest sources of value added in health care are the two principal health care sectors. In 2017, Ambulatory health services generated $631.2 billion, which was 3.3 percent of GDP. Hospitals and nursing and residential care generated $607.6 billion of value added, or 3.1 percent of GDP. This accounting is not complete, however. For example, if the NHEA counts pharmaceutical manufacturing and distribution as part of the "health care economy," shouldn't the value added and employment generated by those industries also be counted on the supply side? What about the value added and employment associated with the suppliers of those sectors?

Table 8 shows the full accounting for value added, including indirect suppliers. For instance, manufacturing contributed $248.6 billion of value added to health care in 2017, which includes pharmaceutical manufacturing. Wholesale and retail trade had $136.7 and $133.0 billion, respectively, of value added associated with health care provision. Wholesale and retail trade together accounted for 1.5 percent of GDP. The insurance industry in 2017 produced $297.0 billion of health care value added, and the broader finance, insurance, real estate, and rental and leasing sector contributed $479.4 billion. Professional and business services contributed $373.4 billion. State and local government administration and enterprises (including publically owned hospitals and other health facilities) contributed $181.8 billion, another 0.9 percent of GDP.

Table 8. Domestic Health Care Value Added by Industry

	Health care value added by industry							
	1998		2012		2017		1998 - 2012	1998 - 2017
	Billions of dollars	Percent of GDP	Billions of dollars	Percent of GDP	Billions of dollars	Percent of GDP	Growth rate	
Gross domestic product	9,089.2	100.0	16,155.3	100.0	19,390.6	100.0	4.2	4.1
National health expenditures	1,201.5	13.2	2,798.0	17.3	3,492.1	18.0	6.2	5.8
Total domestic health care value added	1,138.0	12.5	2,520.5	15.6	3,155.9	16.3	5.8	5.5
Industry								
Agriculture, forestry and fishing	3.3	0.0	6.9	0.0	7.7	0.0	5.5	4.7
Mining	2.9	0.0	14.5	0.1	12.2	0.1	12.3	7.9
Utilities	11.6	0.1	20.3	0.1	25.0	0.1	4.1	4.1
Construction	15.3	0.2	36.0	0.2	43.3	0.2	6.3	5.6
Manufacturing	111.1	1.2	194.9	1.2	248.6	1.3	4.1	4.3
Durable manufacturing	39.2	0.4	73.1	0.5	84.2	0.4	4.5	4.1
Nondurable manufacturing	71.8	0.8	121.8	0.8	164.5	0.8	3.8	4.5
Wholesale trade	49.5	0.5	111.4	0.7	152.7	0.8	6.0	6.1
Retail trade	50.3	0.6	109.6	0.7	135.0	0.7	5.7	5.3
Transportation	16.3	0.2	34.3	0.2	48.0	0.2	5.4	5.8
Information	25.2	0.3	51.3	0.3	70.6	0.4	5.2	5.6
Finance, insurance, real estate, rental and leasing	122.1	1.3	326.0	2.0	479.4	2.5	7.3	7.5
Insurance carriers and related activities	62.7	0.7	178.8	1.1	297.0	1.5	7.8	8.5
Professional and business services	105.9	1.2	272.2	1.7	373.4	1.9	7.0	6.9
Education, health care and social assistance	493.3	5.4	1,080.1	6.7	1,242.5	6.4	5.8	5.0
Ambulatory health services	254.4	2.8	538.2	3.3	631.2	3.3	5.5	4.9
Hospitals	168.7	1.9	402.4	2.5	458.5	2.4	6.4	5.4
Nursing and residential care facilities	69.0	0.8	136.5	0.8	149.1	0.8	5.0	4.1
Arts and recreation	2.5	0.0	5.8	0.0	7.7	0.0	6.2	6.1
Accommodation and food services	8.3	0.1	19.4	0.1	26.6	0.1	6.3	6.4
Other services, except govt	12.9	0.1	21.9	0.1	27.2	0.1	3.8	4.0
Government administration and enterprises	107.8	1.2	215.9	1.3	256.1	1.3	5.1	4.7
Federal general government	23.1	0.3	49.3	0.3	57.6	0.3	5.6	4.9
State and local general government	76.4	0.8	153.9	1.0	181.8	0.9	5.1	4.7

Source: Inforum LIFT Model Calculations with BEA IO Data

Since the economy's Gross Domestic Product (GDP) is the sum of value added across industries, total value added is an important figure for measuring the impact of any given industry on the overall economy. In a closed economy (with no foreign trade), input-output algebra holds that the sum of value added required to supply any given amount of final demand will be equal to that final demand. In an open economy, however, some final demand and intermediate demand "leaks" abroad and is satisfied by the "import of value added" from other countries. These imports are financed either by exports or by foreign borrowing. In any case, we should expect that sum of value added will fall short of the sum of the corresponding final demand.

In total, the health care value added grew by an average of 5.5 percent per year, increasing from $1,138.0 billion in 1998 to $3,155.9 billion in 2017. The domestic value added dedicated to health care production was 12.5 percent of GDP in 1998 and 16.3 percent in 2017.

4.8.2 Health Care Employment Requirements

Health care employment by industry is calculated by multiplying industry total output requirements by the corresponding industry employment-to-output ratios. In addition to the BEA industry full and part-time employment by industry, the LIFT model industry employment adds self-employed workers. This segment of employment is particularly important for health care industries such as physicians and dentists offices. Equation 11 shows the calculation of health care employment:

$$hemp_j^{industry} = \frac{emp_j^{lift}}{q_j^{bea}} \times q_j^{industry} \qquad (11)$$

The results for major industries and for the largest sub-industries are shown in Table 9. Note that the definition used for total employment is civilian and military employment, which was 160,774 in 2017. Ambulatory health care services and Hospitals, nursing, and residential care facilities created about 11.3 million jobs in 1998 and 16.5 million jobs in 2017. These health care sectors employed about 10.3 percent of civilian workers in 2017, up from about 7.9 percent in 1998.

The rest of Table 9 provides figures for the broader definition of health care employment. In 2017, for instance, 1.1 million manufacturing jobs supported health care consumption and investment. This represents 8.6 percent of the 12.7 million jobs in the manufacturing sector. Retail trade contributed about 2 million jobs, as did Finance insurance and real estate. Health care related jobs in professional and business services were about 3.8 million. The input-output analysis also allocates upstream jobs to agriculture (93,000 for 2017), mining (19,000), and utilities (46,000). Government employment devoted to health care was about 2.6 million in 2017; many of those were devoted to public health activities, particularly state and local hospitals that employed 990 thousand people, according to the BLS.[8]

[8] See the Bureau of Labor Statistics' Employment, Hours, and Earnings database.

Table 9. Health Care Employment by Industry

	Health care employment by industry							
	1998		2012		2017		1998-2012	1998-2017
	Jobs (thousands)	Percent of employment	Jobs (thousands)	Percent of employment	Jobs (thousands)	Percent of employment	Growth rate	
Total U.S. civilian & military employment	141,902	100.0	148,481	100.0	160,774	100.0	0.3	0.7
Total domestic health care employment	21,435	15.1	28,396	19.1	31,583	19.6	2.0	2.1
Industry								
Agriculture, forestry and fishing	77	0.1	79	0.1	93	0.1	0.2	1.0
Mining	19	0.0	20	0.0	19	0.0	0.6	0.1
Utilities	43	0.0	43	0.0	46	0.0	-0.1	0.4
Construction	321	0.2	450	0.3	466	0.3	2.4	2.0
Manufacturing	1,151	0.8	1,010	0.7	1,103	0.7	-0.9	-0.2
Durable manufacturing	544	0.4	543	0.4	561	0.3	0.0	0.2
Nondurable manufacturing	607	0.4	467	0.3	542	0.3	-1.9	-0.6
Wholesale trade	508	0.4	674	0.5	794	0.5	2.0	2.4
Retail trade	1,321	0.9	1,834	1.2	1,953	1.2	2.4	2.1
Transportation	287	0.2	378	0.3	499	0.3	2.0	3.0
Information	200	0.1	198	0.1	215	0.1	-0.1	0.4
Finance, insurance, real estate, rental and leasing	1,150	0.8	1,756	1.2	2,083	1.3	3.1	3.2
Insurance carriers and related activities	635	0.4	1,113	0.7	1,364	0.8	4.1	4.1
Professional and business services	2,190	1.5	3,146	2.1	3,785	2.4	2.6	2.9
Education, health care and social assistance	11,336	8.0	15,224	10.3	16,605	10.3	2.1	2.0
Ambulatory health services	4,569	3.2	6,558	4.4	7,511	4.7	2.6	2.6
Hospitals	3,923	2.8	5,154	3.5	5,578	3.5	2.0	1.9
Nursing and residential care facilities	2,784	2.0	3,424	2.3	3,416	2.1	1.5	1.1
Arts and recreation	56	0.0	76	0.1	94	0.1	2.2	2.8
Accommodation and food services	341	0.2	551	0.4	700	0.4	3.5	3.9
Other services, except govt	393	0.3	482	0.3	512	0.3	1.5	1.4
Government administration and enterprises	2,045	1.4	2,475	1.7	2,617	1.6	1.4	1.3
Federal general government	228	0.2	286	0.2	303	0.2	1.6	1.5
State and local general government	1,684	1.2	2,034	1.4	2,147	1.3	1.4	1.3

Source: Inforum LIFT Model Calculations with BEA IO and NIPA Data

According to the calculations summarized in table 9, the aggregate number of health care associated jobs was about 31.6 million in 2017, up from 21.4 million in 1998. In terms of total U.S. civilian and military jobs, health care employment grew by an annual average of 2.1 percent during the period, compared to 0.7 percent for general employment. The health care share of employment rose from 15.1 percent in 1998 to 19.6 percent in 2017.

Using our methods, we can determine the main types of jobs that create the output of the Pharmaceuticals industry. Interestingly, none of these jobs would be considered health care employment using a direct health definition. In addition to jobs in the chemical manufacturing industry, there are several other types of jobs that contribute to total prescription drug spending including other types of manufacturing, wholesale trade, retail trade, transportation, ambulatory health services, and hospitals. In fact, these types of jobs are consistent with the occupational matrix for Pharmaceuticals that BLS published recently for 2016. Table 10 shows that the main types of jobs connected with this industry were chemists, life scientists, machine operators, office support, maintenance & repair, management, and top executives. As in most industries, the employment by occupation in the Pharmaceutical industry is very concentrated. Our aggregation of the BLS matrix contains about 200 occupations. In 2017, the 90 thousand employment in the Other category is the total of 180 occupations not included in the top 20.

Table 10. Pharmaceuticals Employment by Top Occupations
Thousands of Jobs

Rank	Occupational Title	1998	2012	2017
1	Packaging, filling, coating and spraying workers	22.2	24.3	26.1
2	Office and administrative support occupations	21.5	23.6	25.3
3	Business operations specialists	16.3	17.9	19.2
4	Chemists	14.4	15.8	17.0
5	Life scientists	13.4	14.7	15.8
6	Mixing and blending machine setters, operators, and tenders	12.2	13.3	14.3
7	Inspectors, testers, sorters, samplers, and weighers	11.4	12.5	13.4
8	Life, physical, and social science technicians	11.1	12.2	13.1
9	Installation, maintenance, and repair occupations	10.8	11.8	12.7
10	Chemical equipment operators and tenders	9.2	10.0	10.8
11	Other management occupations	8.9	9.7	10.5
12	First-line supervisors of production and operating workers	8.4	9.2	9.9
13	Industrial engineers	5.4	6.0	6.4
14	Top executives	4.8	5.3	5.7
15	Industrial production managers	4.3	4.7	5.1
16	Other operations specialties managers	4.0	4.4	4.7
17	Sales and related occupations	4.0	4.4	4.7
18	Financial specialists	3.8	4.2	4.5
19	Laborers and freight, stock, and material movers, hand	3.8	4.2	4.5
20	Chemical plant and system operators	3.1	3.4	3.7
	Other	76.4	83.8	90.0
	Total	**247.2**	**271.0**	**291.1**

5 Summary of Demand vs. Supply Results

A macroeconomic summary of the supply side accounting is provided by Table 11. A close examination of these figures helps to enhance the understanding of the process, its implications, and its weaknesses. The first line shows total NHE in nominal dollars and the annual growth rates. Total nominal expenditures grew by an average compound annual rate of 5.6 percent from 1998 to 2017, reaching 17.9 percent of GDP in 2016.

The fourth line in Table 11 shows that direct demand for imports increased by 9.7 percent per year, growing from 1.8 percent of NHE in 1998 to 3.5 percent in 2017. Recall that Table 4 showed that about $75 billion, or 75 percent, of the $101 billion increase in total direct imports is attributed to Pharmaceuticals. The last column of table 4 shows that final health care demand from domestic production grew by an average of 5.7 percent per year, lagging overall NHE growth a bit because of import penetration. It still reached 17.3 percent (3369.0/19,485.4) of GDP by 2017.

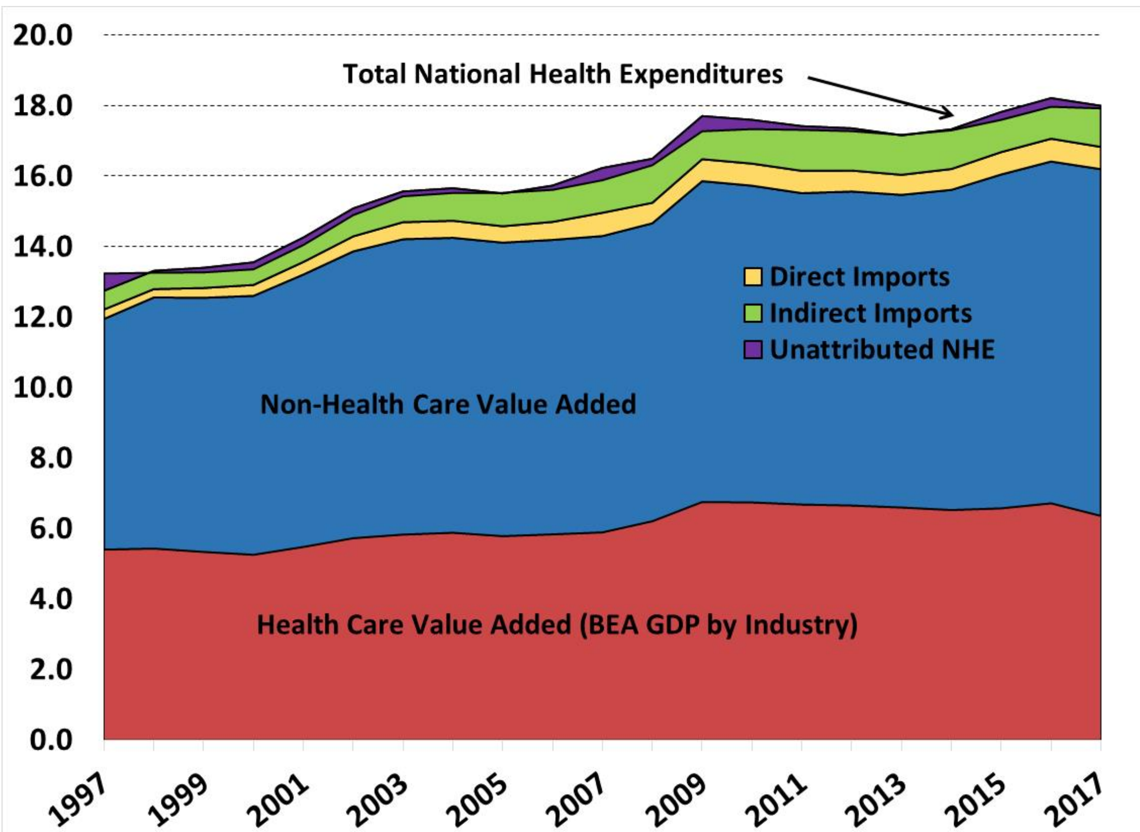
Table 5 showed that after solving for domestic total output demand requirements, the multiplier on domestic demand is 1.6. The annual 5.7 percent increase in direct output slightly outpaced the 5.6 percent annual increase in indirect output. Again, this mostly is due to increased import penetration, as direct imports increased at a rate of 8.6 percent per year. At $227 billion in 2017, indirect imports are larger than direct health care imports of $123 billion. Value added is calculated by multiplying the industry total output requirements by the observed industry value added to output ratios for each year. The total value added rose from 12.5 percent of GDP in 1998 to reach 16.3 percent in 2017 (Table 8).

Table 11. Demand and Supply Side Comparison and Reconciliation

	Levels (billions of dollars)			Percent change		Share of NHE		
	1998	2012	2017	1998-2012	1998-2017	1998	2012	2017
Gross Domestic Product	9,063	16,197	19,485	4.2	4.1			
National health expenditures (NHE)	1,201	2,798	3,492	6.2	5.8	100.0	100.0	100.0
NHE share of GDP	13.3	17.3	17.9					
Direct demand imports	21	97	123	11.4	9.7	1.8	3.4	3.5
Direct demand domestic production	1,180	2,702	3,369	6.1	5.7	98.2	96.6	96.5
Value added	1,138	2,521	3,156	5.8	5.5	94.7	90.1	90.4
Ambulatory care, hospitals, nursing homes	492	1,077	1,239	5.8	5.0	41.0	38.5	35.5
Other industries	646	1,443	1,917	5.9	5.9	53.8	51.6	54.9
Value added leaked due to imports	47	194	227	10.6	8.6	3.9	6.9	6.5
Unattributed value added	-5	-13	-14			-0.4	-0.5	-0.4

Source: Inforum LIFT Model Calculations with BEA IO and NIPA Data

Figure 4. Supply Reconciliation



Theoretically, total health care demand (NHE) is equal to the sum of direct and indirect imports plus the domestic value added generated in satisfying final demand. Table 11 and Figure 5 indicate that domestic value added attributable to health care production accounted was 94.7 percent of NHE in 1998 and 90.4 percent in 2017. Direct imports added 1.8 percent in 1998 and 3.5 percent in 2017, and indirect imports ("value added leaked due to imports") were 3.9 percent of NHE in 1998 and 6.5 percent in 2017. In this analysis, the unattributed value is a measure of inaccuracies of the process. Much of this error is due to simplifying assumptions, such as the assumption that the import share for goods and services are constant across categories of intermediate and final demand. The discrepancy is small, with values of -0.4 percent of NHE in both 1998 and 2017, and -0.5 percent in 2012.

6 Comments and Discussion

The National Health Expenditures (NHE) Accounts are widely circulated measures of health spending. The ratio of health care to GDP coming from those accounts is well-known, and often mentioned in the press. The most recent publication of the NHE Accounts shows total health care spending at about $3.5 trillion in 2017, or about 17.9 percent of GDP. However, when looking at the share of health care industries in total value added and employment, the percentage is much lower (6.4 percent), which is perceived as a puzzle by some commentators. However, this puzzle results from a failure to recognize that the value added and employment in the health care industries is only part of the resources necessary to produce health care. The value added and employment required in many supplying industries provides much of the missing link. In this paper, we have pursued the measurement of required resources on the supply side, and attempted a reconciliation of supply and demand for health care.

The methodology presented in this paper shows how to reconcile the main part of the discrepancy between demand and supply measures of the health care share. A small discrepancy remains, which can be explained as a slight mis-measurement of the value added and employment displaced by imported requirements.

The methods presented here make use of a time series of input-output tables in the Inforum LIFT model, which is based on the detailed benchmark tables and annual input-output tables produced by the Bureau of Economic Analysis. We have first translated National Health Expenditures into final demand by commodity, and determined the amount satisfied by domestic production and the amount supplied through imports. Next, we have used the input-output calculation to determine the many layers of indirect expenditures made on supplier industries, and of suppliers to suppliers. In addition to the industries normally considered as health care, we find substantial direct production of manufacturing, insurance, wholesale and retail trade, non-health care services and government. Indirect production is even more broadly spread, drawing production from almost all manufacturing industries, as well as additional trade, transportation and services industries. Some industries, such as pharmaceuticals, are purchased directly to supply health care, as well as indirectly, by physicians offices, hospitals, and other health care sectors.

As a result of including indirect production in the accounting, we find that health care uses 16.3 percent of total value added (GDP) in 2017. In addition, domestic health care demand required about 1.8 percent of GDP in direct and indirect imports in that year. The unattributed amount remaining is -0.1 percent of GDP. In other words, this exercise matches the 17.9% of GDP observed on the demand side[9].

Our next steps will be to better understand the shifts in value added and employment between industries supplying to health care that we observe in the historical period. In our research on this question thus far, we can divide the sources of this change into 3 elements:

1. Changes in labor productivity and value added to output ratios.
2. Changes in the share of imports.
3. Changes in the structure of interindustry purchases (input-output relationships).

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[9] These figures don't appear to add exactly, due to rounding error.

For both value added and employment, we have been analyzing the decomposition of the total effects into these three components of change.

Another interesting topic is the question of the average labor compensation per hour in health care related employment. This is directly related to the average compensation in each supplying industry, as well as the mix of industries in health care associated employment. The fact that health care related value added is 16.3 percent of total value added, and that health care associated employment is 19.6 percent of total employment implies that value added per employee in the health supplying sectors is lower than average. This is an area where an understanding of the occupational mix of the health care supplying industries would be useful.

Finally we seek to extend this analysis by relating the supply side of health care to the 10-year NHE projections. The calculations underlying this analysis have now been built into the LIFT model, which was run in historical simulation mode to generate the data for the tables in this paper. We will run LIFT in a forecast, which is based on and consistent with the latest NHE projections. Projected changes in labor productivity, value added to output, and import shares in the LIFT forecast will contribute to this forward looking picture of the supply side.

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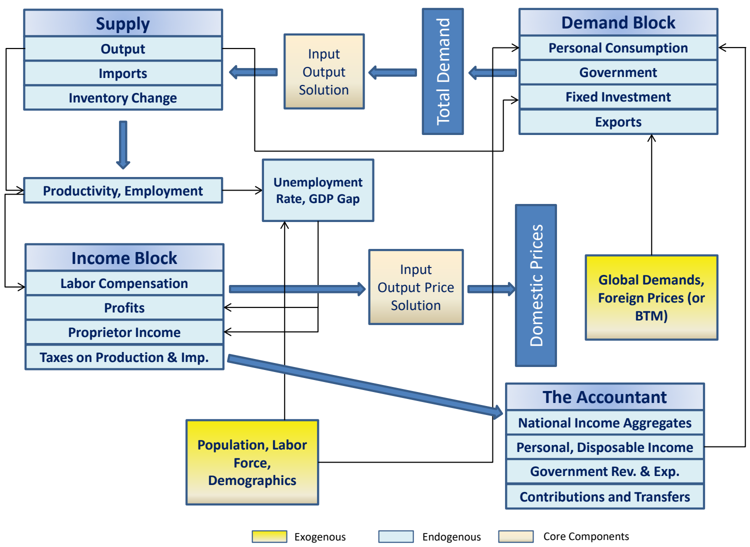
Appendix A: The LIFT Model

The LIFT model can be generally characterized as an Input-Output (IO) Econometric model. The core of the model consists of the multisectoral quantity and price relationships. Detailed variables are aggregated to obtain the aggregate macroeconomic product and income versions of GDP. Figure A-1 below shows a simple schematic diagram of the model.

Figure A-1. Summary Diagram of the LIFT Model



Macroeconomic properties of the model are very important, but it is useful and realistic to model behavior at the industry level. For example, investments are made in individual firms in response to market conditions in the industries in which those firms produce and compete. Aggregate investment is simply the sum of these industry investment purchases. Decisions to hire and fire workers are made jointly using investment decisions and an outlook for product demand in each industry. The net result of these hiring and firing decisions across all industries determines total employment and the unemployment rate. In the real world economy, pricing decisions are made at the detailed product level. Modeling price changes at the commodity level certainly captures the price structure of the economy better than an aggregate price equation. Prices and incomes are forced into consistency through the fundamental input-output identity and the aggregate price level is determined as current price GDP divided by constant price GDP.

Econometric equations are estimated for imports, and inventory change by commodity; personal consumption by category; and equipment and structures investment by industry. Consumption and investment bridge matrices are used to translate the consumption by category and investment by industry to the commodity level. Exports, government, consumption, and investment are calculated in the Demand Block before doing the IO solution. The solution used to solve the quantity IO system jointly determines domestic output, imports, and inventory change. Input-output coefficients are projected to change over time using a logistic curve.

Employment and hours worked are typically estimated as productivity functions, linking hours to industry output; and average hours worked equations, linking employment to hours. In the Income Block, wage equations by industry are used to obtain labor compensation. Other components of value added, such as profits, depreciation, and proprietors' income, may also be estimated depending on the data availability in any given country. Some countries have only compensation, gross operating surplus, and indirect taxes comprising total value added.

Value added is used in the IO price solution to obtain prices by commodity or by industry, depending on the type of IO table available. Some prices may be set exogenously, in which case several value added components need to be revised to maintain consistency. Alternatively, the modeling approach can focus on estimating price regressions directly, then adjusting value added to be consistent with price. The income side of the model is calculated in nominal terms only, though several variables may be deflated by the GDP deflator or average consumption deflator to obtain the "real" versions of those variables.

The macro accounts include most of the tables used in the National Income and Product Accounts (NIPA). The model also includes population by demographic category; labor force and participation rates; financial variables including monetary aggregates and interest rates; and full detail on transfers, contributions, and taxes in the government accounts. Government expenditures by detailed category are specified exogenously in real terms and converted to nominal values using a price deflator.

Prices calculated in the price-income side of the model are used as variables in the personal consumption, equipment and structures investment, and export/import equations. The result of the expenditure side calculation implies a certain level of GDP and of total employment (and unemployment rate) as well as sectoral outputs. All these variables may play a role in the wages and profits (or surplus) equations, so that tightness or slack in the economy affects the growth of value added and prices.

The model solves annually and a typical forecast interval is from 10 to 35 years, but it can be run to 2100 or longer. LIFT is dynamic, in that many of the equations include lagged effects or relations using first differences. Although the model is "bottom-up" in that detailed data is used to form the macro-aggregates, they may be controlled from the top down if necessary, to force consistency with another macro model forecast, or with *a priori* assumptions.