Preliminary Economic Analysis for OSHA's Proposed Crystalline Silica Rule: Industry and Macroeconomic Impacts

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I. Background

Exposure to crystalline silica is one of the oldest and most common occupational hazards. OSHA is endeavoring to update its existing standard and is planning to issue a proposed rule. The scope of the rulemaking will cover the general industry, construction, and maritime sectors. To meet its requirements under Executive Order 12866 and the Regulatory Flexibility Act, OSHA must develop a preliminary economic analysis (PEA) for the proposed crystalline silica standard. To meet the requirements of the OSH Act, the Agency must include in the PEA demonstration of the economic and technological feasibility of the standard. OSHA already has developed a PEA and a preamble summary of the PEA, and both have been submitted to OMB as part of the silica proposal package.

OSHA asked Inforum[1] to estimate the industry and aggregate employment impacts on the U.S. economy of the cost of OSHA's proposed silica rule using the LIFT (Long-term Interindustry Forecasting Tool) model of the U.S. economy.[2] Using industry-by-industry compliance cost estimates provided by OSHA, Inforum employed the LIFT model of the U.S. economy to compute the industry-level and macroeconomic impacts expected to follow implementation of the proposed crystalline silica standard. The general methodology was to embed the compliance costs into the industry price functions of the LIFT model, solve the equations of the model with the additional costs included in the calculations, and then compare the simulation to a baseline scenario which did not include the additional costs. Enforcement of the rule was assumed to start in 2014 and results were calculated over a ten-year horizon, that is, through 2023.

The net effects of the various silica rule compliance costs, measured across industries and across time, are products of several mechanisms that can work in different directions. The initial impact is to force affected industries to purchase equipment, supplies, and services to implement the new regulations. They also might need to divert workers towards compliance activities, thereby reducing overall labor productivity for the industry.[3] Firms respond to the cost increases by raising commodity prices for the goods they produce, but this leads to reduced demand for their products and leaves them more vulnerable to foreign competition. The net impact on employment for affected industries is ambiguous since the fall in demand means that fewer workers are needed, but decreased labor productivity means that more workers are needed for each unit produced.

Full assessment requires recognition of the linkages among the industries that comprise the economy. One industry's purchases are another industry's production. In this case, new demand for ventilation and other equipment, energy, and professional services raises production and, most likely, employment in the supplying industries. This effect might be particularly noticeable during recessionary periods when the rule induces industry to spend substantially more than it might otherwise have spent. On the other hand, during a full-employment economy or a capital shortage, the costs of the rule simply might crowd out other expenditures or investments.

[1] Inforum stands for the INterindustry FORecasting at the University of Maryland. The Interindustry Economic Research Fund, Inc. (IERF) handles contracts and subscriptions; a substantial portion of its receipts are donated to the University of Maryland college Park where the research is accomplished. Please visit our website at: www.inforum.umd.edu.

[2] A description of the LIFT model is provided in Appendix A.

[3] Labor productivity measured in the Lift model does not include the improved productivity of healthier workers or, in general, the health benefits arising from OSHA's silica rule.

Indeed, industries not facing new regulatory requirements and those working to help other firms to conform to new standards also will be affected if compliance requirements significantly raise general input and capital costs. For example, the silica rule will increase costs in material sectors such as ceramics, ferrous metals, and nonferrous metals. In turn, costs can then rise for all of the industries that consume these materials in production, which include most of the construction and manufacturing sectors, and demand for the goods and services that they produce will fall. Consumers also are harmed to the extent that the rule affects the purchase prices of consumption goods and services and residential construction. Suppliers of these materials and producers of consumer goods thus may be helped or harmed by new regulations, whether or not they themselves have to comply with the new silica requirements, to the extent that demand for their products ultimately is helped or harmed by the new regulations.

In order to measure the net economic costs of the silica rule, one needs a framework to account for all of these direct and indirect impacts. Also, the impacts of any given regulatory rule depend on the cost burden in proportion to the size of the individual industries and relative to the economy as a whole. While some regulatory rules can be material at the level of individual activities, their impact may not be noticeable within the larger sector or in the context of a $15 trillion economy.

The LIFT model is particularly suited for this type of analysis because industry detail on production costs, demand, supply, and employment are embedded within a model of the overall macroeconomy. Reducing silica exposure to workers involves extra and varying intermediate, capital, and labor costs, and such costs vary greatly by industry and through time. LIFT provides an accounting framework for each of these cost categories and contains mark-up equations that consistently compute the net effect on producer prices for 87 industries. Moreover, different types of costs have different impacts within the total economy. Larger intermediate and capital purchases imply enhancement of activity and employment in providing sectors such as machinery and professional services. Larger labor requirements generally mean lower productivity in the industry directly affected, with corresponding reductions to profitability and wage rates.

LIFT incorporates the cost and price impacts within the framework of a dynamic, general equilibrium model. Demand and supply responses to increased costs for any particular industry are a composite of econometrically estimated product-level demand functions for final consumption, capital investment, exports and imports. Finally, the LIFT model provides solutions for each year of a specified time frame so that assumed regulatory policies and their impacts can vary through time. Additional details are provided Appendix A.

This paper provides a report of the methodology and results of this exercise. The second section describes the compliance cost data provided by OSHA and the third section shows how these data are employed in simulations using the LIFT model. The fourth section describes the results.

II. Cost-Data by Industry and Across Time

OSHA contractor ERG provided silica-rule compliance cost data for 10 segments of the construction sector plus construction activity by state and local governments, and for 118 industrial sectors. The costs were specified in 2009 dollars and covered a 10 year horizon, beginning with the implementation of the rule. These costs were benchmarked to the production and employment conditions at the peak of the last business cycle in 2006, a peak that was particularly prominent for the construction sector. The data covered the eight cost types and were classified as intermediate, capital, and direct labor costs as indicated in the cost summary provided in Table 1. Industry effects reported there are concentrated, with almost 80 percent of additional costs borne by the construction industry.

In order to integrate the compliance costs within the LIFT model framework, we first established a mapping between the OSHA NAICS-based industries and the LIFT production sectors as shown in Table 2. All of the construction segments map to the construction sector within LIFT. OSHA industrial sectors correspond to LIFT production sectors for manufacturing and some service sectors. The correspondence is used as described below.

Several transformations of the cost data were necessary:

1. Index the costs by the annual level of employment relative to the employment level of 2006 (because OSHA cost estimates are based on 2006 employment levels). OSHA supplied the level of 2006 employment for each 6-digit NAICS sector for 2006. We extended these numbers through 2010 using growth rates from the most granular data available from the BLS Employment, Hours, and Earnings (EHE) data base for total employment for each 6-digit industry. Those figures then were extended through 2024 using the baseline employment projection for the corresponding LIFT sector as defined in Table 2. Given a full historical and forecasted profile for employment of each OSHA industry, we extend the current dollar level of costs by those employment trajectories assuming a constant real cost per employee.

2. Convert 2009 dollar costs to nominal figures using the LIFT baseline GDP deflator.

3. Aggregate the nominal costs from the OSHA industry level to the LIFT production sectors as defined in Table 2. The incremental compliance costs (derived in the previous two steps by indexing costs by annual employment levels and converting 2009 dollar costs to nominal dollars) are directly added to the corresponding aggregate LIFT industry cost function by category (electricity, services, capital, labor, etc.). In the alternative simulation, these incremental costs will boost the LIFT aggregate sector price calculated by the model, compared to the baseline, in proportion to their magnitude within the sector.
4.

The nominal dollar shocks for LIFT sectors are shown in Table 3. Because of the cost adjustments described above (due to changes in employment over time and the use of nominal dollars in the model), the costs reported in Table 3 are not the same as ERG provided in Table 1. The total shock is displayed in proportion to the nominal gross output figure of the baseline projection. In no case is the cost shock more than 0.1 percent of total gross output.

III. Incorporating the Costs Shocks into the LIFT Model

The Long-term Interindustry Forecasting Tool (LIFT) is a unique, 97-sector dynamic general equilibrium representation of the U.S. national economy. It combines an interindustry input-output (I-O) formulation with extensive use of regression analysis to employ a "bottom-up" approach to modeling the economy. 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.

Despite its industry basis, LIFT is a full macroeconomic model, with more than 800 variables determined consistently with the underlying industry detail. This macroeconomic "superstructure" contains key functions for household savings, interest rates, exchange rates, unemployment, taxes, government spending, and current account balances. Like dynamic macroeconometric models, this structure is configured to make LIFT exhibit "Keynesian" demand-driven properties over the short-run but neoclassical growth characteristics over the longer term. Especially in an economy with

substantial slack, monetary and fiscal policies significantly affect the level of output in the short-to-intermediate term. Over the long term, however, supply forces – available labor, capital, and technology – will determine the level of aggregate output, and the I-O structure at the model's core, together with labor productivity and investment equations, tie industry output to the factors of production and technological development.

Industry costs enter the LIFT model through the fundamental input-output price identity:

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

where p is the vector of 87 domestic commodity prices, v is the vector of value added per unit of commodity output, and A is the input-output coefficient matrix. Commodity prices thus are the sum of costs of purchased intermediate goods and services plus value added per unit of output. This identity ensures that costs, 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.

In general, the larger the compliance costs per unit of output, the larger the increase in unit price. However, industry supply responses occur primarily through cost-markup equations which determine how much of supply cost shocks are passed through to prices. In other words, some industries may tend to absorb at least some of the cost increases, at least for a time.

Moreover, the impact of cost increases on the demand for any given product depends on the price elasticities of demand that are endogenous and inherent to the LIFT model. For any given sector, the response of output to price is a composite of several econometric relationships, including product level final demand functions for consumption, investment, exports, and imports. Each of these functions would have its own price elasticity.

For example, the silica rule will increase the domestic production price of non-metallic mineral products (in the stone, clay, and glass sector). The increase in domestic costs means that the domestic sector will be less competitive internationally. All other things being equal, compared to the baseline, exports will be smaller by the percentage change in the relative export price times the price elasticity of the non-metal product export equation. Imports will increase according to the price elasticity in the import equation. Moreover, non-metal products purchased directly through consumption and capital formation would fall depending on the price sensitivity for the relevant consumer and investment products. The net change in demand for domestically produced non-metal products is the sum of all of these effects.

To analyze the silica rule, each compliance cost shock must be linked to some portion of the price function for each commodity, and the shock then will raise prices relative to the baseline scenario. Three types of adjustments are made to the model depending on whether the cost affects capital, intermediate purchases, or labor. These adjustments are explained in detail below and summarized by Table 4.

The table also indicates the LIFT production sector that supplies the products or services associated with the specific cost. For example, expenditures on personal protective equipment (masks, ventilators, etc.) are sourced from LIFT sector 58, Miscellaneous Manufacturing.

Capital Costs

For each affected industry, we model the costs of ventilation and other equipment as increases in real capital expenditures from General industrial equipment, which is represented as sector 39 in the LIFT model. (Constant-dollar expenditure levels are calculated by deflating the nominal costs figures of Table 3 by the baseline purchasers' price of such equipment.) When they occur, therefore, these expenditures will enhance production and imports associated with the manufacturing and distribution of industrial equipment. Subsequently, for the affected industries the compliance costs increase capital consumption for production of each affected commodity, thereby pushing up unit value added and ultimately prices.

Intermediate Costs

Intermediate cost shocks for purchases of personal protection equipment, energy, industrial hygienists and laboratory services, and medical services enter through the *A* matrix. For each affected commodity, we divide the real compliance costs (which are the nominal levels of Table 3 deflated by baseline producer price levels) by the baseline gross output, and we then add the resulting ratio to the corresponding baseline intermediate requirements coefficient. In other words, new regulations force firms to buy greater quantities of materials and services to produce the same levels of output, and so commodity prices tend to climb. This is portrayed in the model as increases in the *A* matrix coefficients relative to the baseline. Once again, however, an increase in costs for one industry is an increase in demand for other industries' production and/or imports, and so the net effects on each industry are not immediately obvious.

Labor Costs

The effects of compliance on labor costs within industries primarily depend on the amount of extra labor required for the production process in order to satisfy the rule. Activities include setting up equipment, monitoring the production environment, maintenance, and clean-up, as well as extra time devoted to exposure monitoring and medical surveillance. We model these extra activities by dividing the labor compliance costs by the average baseline industry wage per hour to obtain the additional hours required to produce each unit of output. We then calculate the detrimental effects on labor productivity, relative to baseline labor requirements. The increase in labor requirements results in a boost to unit value added in the price equation.

IV. LIFT Model Simulation Results

The simulation analysis began with the specification of a baseline scenario. This projection, summarized in Table 5, reflects an economy recovering very slowly from the deep recession of 2008 to 2009. The tepid Gross Domestic Product (GDP) growth of 2011 continues through 2012 before recovery accelerates in 2013 and 2014. Growth is 3.0 percent per year in 2015 and 2016 before settling to an average growth rate of about 2.4 percent per year through the forecast horizon. The economy reaches full employment around 2019 when the unemployment rate reaches 4.9 percent.

Given this baseline projection, the exogenous shocks to production costs across sectors are imposed via "add factors" for capital investment, intermediate input (A matrix) coefficients, and labor productivity. The summary macroeconomic results from the alternative simulation are displayed in Table 6. Gross output impacts by industry are shown in Table 7, and employment effect by industry in Table 8. In 2014, the initial year for the new policies, real GDP falls by $260 million in 2005 dollars, or 0.002 percent compared to the baseline level. This impact reaches -0.005 percent by 2017 and then recedes thereafter as the economy adjusts to higher relative costs in some industries by expanding activity in others. Across the ten year horizon, the cumulative real GDP impact is a little over $6.0

billion in 2005 dollars ($6.6 billion in 2009 dollars).

For 2014, the total net employment effects are positive with an increase of 5,830 jobs (0.004 percent of total employment). In subsequent years the net job difference is less than 2000, sometime positive and sometimes negative. The model solution for employment tends to oscillate around zero. Compared to the baseline, employment is up for three years, down for three, and then up a bit for three more. This oscillation results from the net stimulus in the initial periods being offset by mild crowding out in subsequent years. Such oscillation is typical for a model which, for most shocks, is designed to return to the baseline level of aggregate employment over the long run. Across ten years, the cumulative employment impact is a gain of 8,625 job-years.[4] The positive net employment impact is due mostly to additional jobs created in the construction industry. Cumulative employment in other sectors declines slightly.

Results for gross outputs by industry, producer prices by commodity, and employment by industry are provided in the workbook accompanying this report. The figures show that in no individual sector does the difference for output, prices, or employment exceed 0.1 percent of the baseline level in absolute terms (positive or negative). In other words, the principal conclusion of this exercise is that the silica rule leaves a negligible footprint on the economy because, as we saw in the previous section, the compliance costs are very small in proportion to gross output and costs, even for the most affected sectors such as construction and non-metallic mineral products.

[4] A "job-year" is the term of art utilized in dynamic analysis. It provides a means to compare the level of employment in the alternative simulation with those of the baseline. Measurement in job-years allows the accumulation of effects across years, and this cumulative measure shows that even temporary employment increases are beneficial. Still, it does not fully capture the degree of change within labor markets. Job-churn across years means that some jobs created (or destroyed) in previous years may not be the same as those created (or destroyed) in subsequent years, and industry-level employment patterns might change dramatically even if net long-run impacts on aggregate employment are small.

V. Comparison to the American Chemistry Council Study

The American Chemistry Council (ACC) contracted with Environomics, Inc. and the URS Corporation to use the IMPLAN input-output model to calculate the macroeconomic impact of the proposed silica rule using their independent estimates of compliance costs.[5] The report provided annualized compliance costs estimates across several sectors which were, in general, much larger than the OSHA estimated costs. The analysis assumed that for each sector a dollar of annualized cost increases, the sector would lead to 20 cents of direct revenue loss for the sector, presumably because of price increases. Such revenue losses were specified for several detailed sectors and expressed in 2009 dollars since that is the base year of the IMPLAN model utilized.

The revenue losses were placed into the IMPLAN model as reductions in final demand, which then used the standard static input-output identity of the model to yield the direct, indirect, and induced losses of output across sectors. Under the assumption of invariable industry relationships between output and employment and output and value added, aggregate employment and income effects for the total economy were computed.

The study reported that the proposed silica rule would result in a loss of $3.1 billion in GDP each year that the rule is in effect. If the rule had been in effect in 2009, a year in which the economy was in the trough of recession, this impact would have been 0.022 percent of GDP. Unfortunately, this figure appears to be erroneous. While the paper displays the fall of "output/GDP" at $3.089 billion per year, it also shows that the fall in total value added is $1.525 billion. Since GDP is the sum of value added in the economy, it appears that this figure should be the actual GDP impact estimated by the model.[6] A reduction of $1.5 billion would have been 0.011 percent of the recession-reduced GDP in 2009, or half of the reported impact.

Moreover, the report finds that the economy would lose 17,354 jobs each year the rule is in effect. If the rule had been introduced in 2009, this would have been equal to a loss of 0.012 percent of employment. The report goes on to claim:

> "Over a 10-year period, this would amount to a loss of more than 170,000 jobs and more than $30 billion of economic output."

What accounts for the difference between LIFT simulations and the ACC's estimates? There are several factors at play:

- Most important, the ACC's estimate starts with compliance costs that are 5 to 8 times larger than the OSHA estimates employed here ($5.5 billion vs. an average of $650 million, both in 2009 dollars). Moreover, the ACC assumes that the same peak cost estimates are imposed each year, where the OSHA cost estimates vary over the 10 year time period, with peak costs occurring in the first year.

[5] Environomics, Inc. and URS Corporation, "Estimated Costs and Adverse Economic Impacts of a Potential New OSHA Occupational Exposure Standard for Crystalline Silica With a PEL of 50 ug/m^3 and Ancillary Requirements," Draft Final Report For the American Chemistry Council Crystalline Silica Panel, July 2011.

[6] In an input-output framework such as IMPLAN, figures for "output" usually correspond to gross output or total revenue by sector. When gross output is added across sectors there is substantial double counting of intermediate input purchases. Value added, on the other hand, is the labor, capital, and indirect tax income generated in each sector. It corresponds to total revenue minus intermediate costs of goods and service inputs and, therefore, avoids double-counting.

- The ACC's application of the IMPLAN model did not account for the increase in demand for capital equipment and intermediate goods and services needed to comply with the proposed silica rule. Thus, the employment and income boosting impacts of these expenditures are not captured in their analysis.

- In computing revenue loss by industry, the report claims to use a price elasticity of demand of -1.5 and a price elasticity of supply of 1.0 to compute the revenue impacts for all regulated industries. However, it is not clear that they produce any connection between compliance costs and a price impact by commodity, so it is unclear how or if such price elasticities are used. Instead, they use an apparently arbitrary ratio of revenue loss to compliance cost of 1 to 5 across all sectors.

- In contrast, the methodology used in this report uses an explicit price function where annual compliance costs by industry change commodity prices in proportion to their share of total annual gross costs. In turn, price changes affect production and employment through a dynamic general equilibrium framework. Demand and supply price elasticities in the LIFT model are composites of several sets of empirically estimated functions for final demand, exports, imports, and price mark-ups. Furthermore, the parameters of these functions vary by type of product according to the econometric estimation.

- The IMPLAN model is static and cannot compute employment and output impacts over time, and it cannot show how the economy evolves to cope with changes in costs. In order to extrapolate over ten years, the authors simply multiply the first year effects by 10. The results are implausible for a dynamic economy as the full static one-year impact is unlikely to be the average impact over the course of several years. At least theoretically, the economy contains powerful forces pushing it towards full employment equilibrium. Therefore, most changes to output and employment due to cost or demand shocks tend to be neutralized through time. That is, most impacts, negative or positive, will approach zero over the long term.

- Indeed, the LIFT model produces dynamic results that vary from year to year, which is consistent with fluctuations in the state of the economy and with short and long term expenditure effects. It shows how the employment is reallocated among industries and how the economy eventually will return to the baseline, or potential, level of employment.

While the IMPLAN study places the regulatory analysis within the context of the overall economy, it does not take full advantage of the framework. For instance, given data for gross output in the base year it is possible to compute the industry price effect so that the revenue shocks can be judged relative to a price elasticity of demand. Instead, the study employs an entirely arbitrary construct of a 5 to 1 compliance cost to revenue loss. More important, any reputable impact analysis must provide the magnitude of effects relative to the size of the industry or economy under study (e.g., jobs lost as a percent of total employment). The absence of such figures from the ACC report is inexplicable. Finally, the authors' apparent misidentification of GDP effects and IMPLAN's inability to model the long-term properties of economy severely undermines the study's conclusion of long term cost to the economy.

Table 1: Summary Silica Rule Costs Provided by ERG
Millions of 2009$

	Construction										
		Year 1	2	3	4	5	6	7	8	9	10
Capital Costs											
	Ventilation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Other	151.5	151.5	151.5	151.5	151.5	151.5	151.5	151.5	151.5	151.5
Intermediate Costs											
	Personal Protect Equip	15.5	10.9	15.5	10.9	15.5	10.9	15.5	10.9	15.5	10.9
	Energy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Laboratory Costs	42.3	14.9	14.9	14.9	14.9	14.9	14.9	14.9	14.9	14.9
	Industrial Hygienists	46.6	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5
	Medical Costs	133.5	27.5	27.5	127.6	37.8	37.8	63.2	43.0	43.0	55.8
Labor Costs											
	Set-up, monitoring, etc.	346.6	234.6	234.6	265.0	237.7	237.7	245.5	239.3	239.3	243.2
Total compliance costs		736.0	455.9	460.5	586.3	474.0	469.3	507.2	476.1	480.8	492.8
	Industry										
		Year 1	2	3	4	5	6	7	8	9	10
Capital Costs											
	Ventilation	117.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Other	39.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8
Intermediate Costs											
	Personal Protect Equip	2.9	2.5	2.9	2.5	2.9	2.5	2.9	2.5	2.9	2.5
	Energy	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1
	Laboratory Costs	14.3	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2
	Industrial Hygienists	20.9	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8
	Medical Costs	5.8	1.0	1.0	3.4	1.5	1.4	2.6	1.7	1.7	2.3
Labor Costs											
	Set-up, monitoring, etc.	69.8	59.5	59.9	60.0	60.0	60.0	60.2	60.0	60.0	60.2
Total compliance costs		292.1	122.0	122.7	124.9	123.3	122.9	124.7	123.2	123.5	123.9
Total economy-wide cost		**1028.1**	**577.8**	**583.2**	**711.2**	**597.3**	**592.2**	**631.9**	**599.3**	**604.3**	**616.7**

Table 2: Correspondence Between OSHA Silica Sectors and LIFT Model Sectors

OSHA Sector	LIFT Sector	NAICS Code		Title
Construction Sectors				
CST - 1	7-8	236100		Residential Building Construction
2	7-8	236200		Nonresidential Building Construction
3	7-8	237100		Utility System Construction
4	7-8	237200		Land Subdivision
5	7-8	237300		Highway, Street, and Bridge Construction
6	7-8	237900		Other Heavy and Civil Engineering Construction
7	7-8	238100		Foundation, Structure, and Building Exterior Contractors
8	7-8	238200		Building Equipment Contractors
9	7-8	238300		Building Finishing Contractors
10	7-8	238900		Other Specialty Trade Contractors
11	7-8	999000		State and Local Governments
Industrial Sectors				
IND - 3	23	325510		Paint and coating manufacturing
1	24	324121		Asphalt paving mixture and block manufacturing
2	24	324122		Asphalt shingle and roofing materials
109	30	337215		Showcase, partition, shelving, and locker manufacturing
4	31	327111		Vitreous china plumbing fixtures & bathroom access mfg
5	31	327112		Vitreous china, fine earthenware, & other pottery mfg
6	31	327113		Porcelain electrical supply mfg
7	31	327121		Brick and structural clay mfg
8	31	327122		Ceramic wall and floor tile mfg
9	31	327123		Other structural clay product mfg
10	31	327124		Clay refractory manufacturing
11	31	327125		Nonclay refractory manufacturing
12	31	327211		Flat glass manufacturing
13	31	327212		Other pressed and blown glass and glassware mfg
14	31	327213		Glass container manufacturing
15	31	327320		Ready-mixed concrete manufacturing
16	31	327331		Concrete block and brick mfg
17	31	327332		Concrete pipe mfg
18	31	327390		Other concrete product mfg
19	31	327991		Cut stone and stone product manufacturing
20	31	327992		Ground or treated mineral and earth manufacturing
21	31	327993		Mineral wool manufacturing
22	31	327999		All other misc. nonmetallic mineral product mfg

Table 2 (contd): Correspondence Between OSHA Silica Sectors and LIFT Model Sectors

OSHA Sector	LIFT Sector	NAICS Code	Title
23	32	331111	Iron and steel mills
24	32	331112	Electrometallurgical ferroalloy product mfg
25	32	331210	Iron, steel pipe and tube mfg from purchased steel
26	32	331221	Rolled steel shape manufacturing
27	32	331222	Steel wire drawing
31	32	331511	Iron foundries
32	32	331512	Steel investment foundries
33	32	331513	Steel foundries (except investment)
37	32	332111	Iron and steel forging
28	33	331314	Secondary smelting and alloying of aluminum
29	33	331423	Secondary smelting, refining, and alloying of copper
30	33	331492	Secondary processing of nonferrous metal (exc cu & al)
34	33	331524	Aluminum foundries (except die-casting)
35	33	331525	Copper foundries (except die-casting)
36	33	331528	Other nonferrous foundries (except die-casting)
38	33	332112	Nonferrous forging
39	34	332115	Crown and closure manufacturing
40	34	332116	Metal stamping
41	34	332117	Powder metallurgy part manufacturing
42	34	332211	Cutlery and flatware (except precious) mfg
43	34	332212	Hand and edge tool manufacturing
44	34	332213	Saw blade and handsaw manufacturing
45	34	332214	Kitchen utensil, pot, and pan manufacturing
46	34	332323	Ornamental and architectural metal work
47	34	332439	Other metal container manufacturing
48	34	332510	Hardware manufacturing
49	34	332611	Spring (heavy gauge) manufacturing
50	34	332612	Spring (light gauge) manufacturing
51	34	332618	Other fabricated wire product manufacturing
52	34	332710	Machine shops
53	34	332812	Metal coating and allied services
54	34	332911	Industrial valve manufacturing
55	34	332912	Fluid power valve and hose fitting manufacturing
56	34	332913	Plumbing fixture fitting and trim manufacturing
57	34	332919	Other metal valve and pipe fitting manufacturing
58	34	332991	Ball and roller bearing manufacturing
59	34	332996	Fabricated pipe and pipe fitting manufacturing
60	34	332997	Industrial pattern manufacturing
61	34	332998	Enameled iron and metal sanitary ware mfg
62	34	332999	All other miscellaneous fabricated metal product mfg
66	34	333414	Heating equipment (except warm air furnaces) mfg

Table 2 (contd): Correspondence Between OSHA Silica Sectors and LIFT Model Sectors

OSHA Sector	LIFT Sector	NAICS Code		Title
67	37	333511		Industrial mold manufacturing
68	37	333512		Machine tool (metal cutting types) manufacturing
69	37	333513		Machine tool (metal forming types) manufacturing
70	37	333514		Special die and tool, die set, jig, and fixture mfg
71	37	333515		Cutting tool and machine tool accessory mfg
72	37	333516		Rolling mill machinery and equipment mfg
73	37	333518		Other metalworking machinery manufacturing
78	37	333991		Power-driven handtool manufacturing
79	37	333992		Welding and soldering equipment mfg
63	39	333319		Other commercial & service industry machinery mfg
64	39	333411		Air purification equipment manufacturing
65	39	333412		Industrial and commercial fan and blower mfg
74	39	333612		Speed changer, industrial high-speed drive, and gear mfg
75	39	333613		Mechanical power transmission equipment mfg
76	39	333911		Pump and pumping equipment manufacturing
77	39	333912		Air and gas compressor manufacturing
80	39	333993		Packaging machinery manufacturing
81	39	333994		Industrial process furnace and oven mfg
82	39	333995		Fluid power cylinder and actuator mfg
83	39	333996		Fluid power pump and motor manufacturing
84	39	333997		Scale and balance (except laboratory) mfg
85	39	333999		All other miscellaneous general purpose machinery mfg
87	44	335211		Electric housewares and household fans
88	44	335221		Household cooking appliance manufacturing
89	44	335222		Household refrigerator and home freezer mfg
90	44	335224		Household laundry equipment manufacturing
91	44	335228		Other major household appliance mfg
92	49	336111		Automobile manufacturing
93	49	336112		Light truck and utility vehicle mfg
94	49	336120		Heavy duty truck manufacturing
95	49	336211		Motor vehicle body manufacturing
96	49	336212		Truck trailer manufacturing
98	50	336311		Carburetor, piston, piston ring, and valve mfg
99	50	336312		Gasoline engine and engine parts mfg
100	50	336322		Other MV electrical and electronic equipment mfg
101	50	336330		MV steering & suspension components (exc spring) mfg
102	50	336340		Motor vehicle brake system manufacturing
103	50	336350		Motor vehicle transmission and power train parts mfg
104	50	336370		Motor vehicle metal stamping
105	50	336399		All other motor vehicle parts manufacturing

Table 2 (contd): Correspondence Between OSHA Silica Sectors and LIFT Model Sectors

OSHA Sector	LIFT Sector	NAICS Code		Title
106	52	336611		Ship building and repair
107	52	336612		Boat building
97	53	336213		Motor home manufacturing
108	53	336992		Military armored vehicle, tank, and component mfg
110	55	339114		Dental equipment and supplies manufacturing
86	57	334518		Watch, clock, and part manufacturing
112	58	339911		Jewelry (except costume) manufacturing
113	58	339913		Jewelers' materials and lapidary work mfg
114	58	339914		Costume jewelry and novelty manufacturing
115	58	339950		Sign manufacturing
117	59	482110		Rail transportation
116	69	423840		Industrial supplies, wholesalers
118	84	621210		Dental offices
111	85	339116		Dental laboratories

Table 3: Silica Rule Compliance Costs by LIFT Sector, 2014-2023
(Millions of current dollars)

7-8	**Construction**										
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Capital Costs											
	Ventilation Equipment	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Other	138.522	151.473	163.135	173.861	185.454	197.412	208.890	215.931	221.229	227.384
Intermediate Costs											
	Personal Protect Equip	14.205	10.882	16.729	12.490	19.018	14.182	21.421	15.512	22.687	16.335
	Energy										
	Laboratory Costs	38.620	14.874	16.019	17.072	18.211	19.385	20.512	21.203	21.723	22.328
	Industrial Hygienists	42.585	16.482	17.751	18.918	20.180	21.481	22.730	23.496	24.072	24.742
	Medical Costs	122.014	27.484	29.600	146.340	46.250	49.232	87.171	61.248	62.750	83.753
Labor Costs											
	Set-up, monitoring, etc.	316.788	234.465	252.517	303.987	290.929	309.686	338.357	340.988	349.354	364.928
Total Compliance Costs		672.735	455.659	495.751	672.669	580.041	611.378	699.080	678.379	701.816	739.469
Gross Output		1,112,730	1,198,969	1,282,196	1,361,507	1,448,338	1,538,178	1,630,489	1,699,900	1,766,260	1,840,805
Costs as % of output		0.060	0.038	0.039	0.049	0.040	0.040	0.043	0.040	0.040	0.040
23	**Other chemical manufacturing**										
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Capital Costs											
	Ventilation Equipment	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Other	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Intermediate Costs											
	Personal Protect Equip	0.009	0.008	0.010	0.009	0.011	0.010	0.012	0.011	0.013	0.011
	Energy	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Laboratory Costs	0.032	0.024	0.025	0.026	0.027	0.028	0.029	0.030	0.031	0.032
	Industrial Hygienists	0.047	0.035	0.036	0.037	0.039	0.040	0.042	0.044	0.045	0.046
	Medical Costs	0.015	0.003	0.003	0.010	0.004	0.001	0.001	0.001	0.001	0.001
Labor Costs											
	Set-up, monitoring, etc.	0.132	0.053	0.056	0.058	0.061	0.063	0.066	0.069	0.071	0.074
Total Compliance Costs		0.235	0.122	0.129	0.140	0.141	0.142	0.150	0.154	0.160	0.165
Gross Output		403,710	430,814	455,553	482,615	514,812	545,066	576,550	607,477	641,950	678,512
Costs as % of output		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
24	**Petroleum refining**										
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Capital Costs											
	Ventilation Equipment	1.307	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Other	1.371	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Intermediate Costs											
	Personal Protect Equip	0.038	0.032	0.037	0.032	0.037	0.032	0.036	0.032	0.037	0.031
	Energy	0.226	0.225	0.223	0.221	0.220	0.219	0.218	0.219	0.220	0.219
	Laboratory Costs	0.258	0.182	0.181	0.179	0.178	0.178	0.177	0.178	0.178	0.177
	Industrial Hygienists	0.410	0.289	0.287	0.285	0.283	0.282	0.281	0.282	0.282	0.281
	Medical Costs	0.060	0.010	0.010	0.034	0.015	0.000	0.000	0.000	0.000	0.000
Labor Costs											
	Set-up, monitoring, etc.	1.654	1.428	1.423	1.412	1.405	1.400	1.397	1.401	1.402	1.399
Total Compliance Costs		5.323	2.167	2.161	2.164	2.138	2.111	2.109	2.112	2.118	2.108
Gross Output		855,733	919,846	984,223	1,047,478	1,114,135	1,177,452	1,239,256	1,306,649	1,377,737	1,445,047
Costs as % of output		0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 3 (contd): Silica Rule Compliance Costs by LIFT Sector, 2014-2023 (Millions of current dollars)

30	**Furniture**										
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Capital Costs											
	Ventilation Equipment	0.295	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Other	0.036	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Intermediate Costs											
	Personal Protect Equip	0.004	0.003	0.004	0.004	0.005	0.004	0.005	0.004	0.005	0.005
	Energy	0.052	0.054	0.057	0.059	0.062	0.064	0.067	0.069	0.071	0.074
	Laboratory Costs	0.019	0.014	0.015	0.016	0.016	0.017	0.018	0.018	0.019	0.019
	Industrial Hygienists	0.027	0.020	0.021	0.022	0.023	0.024	0.025	0.026	0.027	0.028
	Medical Costs	0	0	0	0	0	0	0	0	0	0
Labor Costs											
	Set-up, monitoring, etc.	0.183	0.180	0.189	0.197	0.205	0.213	0.223	0.231	0.238	0.247
Total Compliance Costs		0.622	0.274	0.287	0.301	0.312	0.467	0.608	0.531	0.547	0.634
Gross Output		87,838	94,252	100,812	106,933	113,846	120,778	128,351	134,378	140,446	148,012
Costs as % of output		0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
31	**Stone, clay, glass**										
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Capital Costs											
	Ventilation Equipment	39.409	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Other	14.192	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Intermediate Costs											
	Personal Protect Equip	1.400	1.263	1.513	1.355	1.625	1.457	1.746	1.560	1.848	1.633
	Energy	6.965	7.277	7.528	7.804	8.084	8.393	8.685	8.987	9.189	9.402
	Laboratory Costs	6.637	4.920	5.090	5.277	5.466	5.674	5.872	6.076	6.213	6.357
	Industrial Hygienists	8.960	6.643	6.872	7.124	7.379	7.661	7.928	8.204	8.388	8.583
	Medical Costs	2.222	0.407	0.421	1.465	0.669	0.695	1.297	0.866	0.886	1.221
Labor Costs											
	Set-up, monitoring, etc.	36.019	33.236	34.577	35.885	37.182	38.602	40.083	41.364	42.296	43.348
Total Compliance Costs		116	54	56	59	60	62	66	67	69	71
Gross Output		118,104	125,894	133,490	140,627	148,981	156,853	164,852	171,388	178,447	186,550
Costs as % of output		0.098	0.043	0.042	0.042	0.041	0.040	0.040	0.039	0.039	0.038
32	**Primary ferrous metals**										
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Capital Costs											
	Ventilation Equipment	27.211	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Other	3.323	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Intermediate Costs											
	Personal Protect Equip	0.348	0.297	0.342	0.299	0.351	0.309	0.364	0.320	0.373	0.325
	Energy	4.753	4.693	4.666	4.722	4.790	4.884	4.961	5.051	5.093	5.130
	Laboratory Costs	1.492	1.050	1.043	1.056	1.071	1.092	1.109	1.130	1.139	1.147
	Industrial Hygienists	2.498	1.758	1.747	1.768	1.794	1.829	1.858	1.891	1.907	1.921
	Medical Costs	0.553	0.096	0.095	0.323	0.145	0.123	0.224	0.148	0.149	0.202
Labor Costs											
	Set-up, monitoring, etc.	8.139	7.014	7.017	7.107	7.214	7.355	7.498	7.613	7.676	7.746
Total Compliance Costs		48	15	15	15	15	16	16	16	16	16
Gross Output		126,803	135,032	144,818	153,915	165,242	176,314	187,475	197,484	207,663	218,700
Costs as % of output		0.038	0.011	0.010	0.010	0.009	0.009	0.009	0.008	0.008	0.008

Table 3 (contd): Silica Rule Compliance Costs by LIFT Sector, 2014-2023 (Millions of current dollars)

33 Primary nonferrous metals										
	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Capital Costs										
Ventilation Equipment	12.403	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other	1.509	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Intermediate Costs										
Personal Protect Equip	0.158	0.145	0.181	0.165	0.202	0.184	0.224	0.204	0.247	0.222
Energy	2.166	2.306	2.479	2.623	2.768	2.922	3.070	3.240	3.383	3.527
Laboratory Costs	0.768	0.580	0.623	0.659	0.696	0.735	0.772	0.815	0.851	0.887
Industrial Hygienists	1.137	0.858	0.923	0.976	1.030	1.088	1.143	1.206	1.259	1.313
Medical Costs	0.251	0.047	0.050	0.179	0.083	0.153	0.289	0.197	0.206	0.289
Labor Costs										
Set-up, monitoring, etc.	3.312	3.026	3.276	3.470	3.664	3.868	4.082	4.294	4.482	4.683
Total Compliance Costs	21.705	6.961	7.531	8.072	8.444	8.949	9.580	9.956	10.428	10.922
Gross Output	115,912	125,917	138,454	148,623	160,709	172,589	184,756	195,519	206,556	218,873
Costs as % of output	0.019	0.006	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005

34 Metal products										
	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Capital Costs										
Ventilation Equipment	9.736	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other	0.493	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Intermediate Costs										
Personal Protect Equip	0.091	0.082	0.098	0.088	0.106	0.096	0.115	0.103	0.123	0.109
Energy	2.112	2.195	2.275	2.368	2.469	2.571	2.673	2.767	2.847	2.931
Laboratory Costs	0.485	0.357	0.370	0.385	0.401	0.418	0.435	0.450	0.463	0.477
Industrial Hygienists	0.646	0.476	0.493	0.513	0.535	0.557	0.579	0.600	0.617	0.635
Medical Costs	0.144	0.026	0.027	0.095	0.044	0.044	0.082	0.055	0.056	0.078
Labor Costs										
Set-up, monitoring, etc.	2.703	2.485	2.589	2.697	2.812	2.928	3.054	3.154	3.245	3.346
Total Compliance Costs	16.410	5.621	5.853	6.147	6.368	6.613	6.938	7.130	7.351	7.577
Gross Output	375,025	398,517	422,717	445,421	471,481	496,930	523,726	545,915	569,807	596,000
Costs as % of output	0.004	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

37 Metalworking machinery										
	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Capital Costs										
Ventilation Equipment	1.134	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other	0.139	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Intermediate Costs										
Personal Protect Equip	0.015	0.013	0.016	0.014	0.018	0.016	0.020	0.018	0.022	0.019
Energy	0.198	0.207	0.216	0.229	0.241	0.255	0.269	0.282	0.293	0.303
Laboratory Costs	0.085	0.063	0.066	0.070	0.073	0.078	0.082	0.086	0.089	0.092
Industrial Hygienists	0.107	0.079	0.083	0.087	0.092	0.097	0.102	0.108	0.112	0.116
Medical Costs	0.023	0.004	0.004	0.016	0.007	0.008	0.016	0.011	0.011	0.016
Labor Costs										
Set-up, monitoring, etc.	0.329	0.296	0.312	0.330	0.348	0.368	0.390	0.408	0.424	0.439
Total Compliance Costs	2.029	0.662	0.697	0.745	0.778	0.821	0.878	0.913	0.951	0.985
Gross Output	50,834	54,419	58,287	62,387	66,600	71,477	76,826	82,039	86,498	90,581
Costs as % of output	0.004	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Table 3 (contd): Silica Rule Compliance Costs by LIFT Sector, 2014-2023 (Millions of current dollars)

39	General & miscellaneous industrial machinery										
		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Capital Costs											
	Ventilation Equipment	1.327	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Other	0.162	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Intermediate Costs											
	Personal Protect Equip	0.017	0.015	0.019	0.017	0.020	0.018	0.022	0.020	0.024	0.022
	Energy	0.232	0.244	0.255	0.267	0.278	0.290	0.303	0.317	0.329	0.341
	Laboratory Costs	0.078	0.059	0.061	0.064	0.067	0.070	0.073	0.076	0.079	0.082
	Industrial Hygienists	0.123	0.092	0.096	0.100	0.105	0.109	0.114	0.120	0.124	0.128
	Medical Costs	0.027	0.005	0.005	0.018	0.008	0.011	0.020	0.014	0.014	0.020
Labor Costs											
	Set-up, monitoring, etc.	0.406	0.372	0.393	0.411	0.428	0.447	0.468	0.489	0.507	0.526
Total Compliance Costs		2.372	0.787	0.829	0.877	0.907	0.946	1.000	1.036	1.078	1.119
Gross Output		107,081	112,939	118,840	124,838	131,210	138,119	145,587	153,247	160,399	167,398
Costs as % of output		0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
44	**Household appliances**										
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Capital Costs											
	Ventilation Equipment	0.185	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Other	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Intermediate Costs											
	Personal Protect Equip	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	Energy	0.046	0.046	0.047	0.048	0.048	0.049	0.049	0.050	0.051	0.051
	Laboratory Costs	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004
	Industrial Hygienists	0.009	0.006	0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.007
	Medical Costs	0.002	0.000	0.000	0.001	0.001	0.002	0.003	0.002	0.002	0.003
Labor Costs											
	Set-up, monitoring, etc.	0.072	0.069	0.070	0.071	0.072	0.073	0.074	0.075	0.075	0.076
Total Compliance Costs		0.319	0.126	0.128	0.131	0.132	0.135	0.138	0.139	0.140	0.141
Gross Output		20,962	21,607	22,178	22,878	23,607	24,344	25,147	25,910	26,699	27,502
Costs as % of output		0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
49	**Motor vehicles**										
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Capital Costs											
	Ventilation Equipment	1.459	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Other	0.173	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Intermediate Costs											
	Personal Protect Equip	0.018	0.017	0.021	0.019	0.023	0.021	0.026	0.024	0.029	0.026
	Energy	0.258	0.275	0.293	0.310	0.327	0.345	0.364	0.383	0.398	0.415
	Laboratory Costs	0.070	0.054	0.058	0.061	0.064	0.068	0.072	0.075	0.078	0.082
	Industrial Hygienists	0.136	0.104	0.111	0.117	0.124	0.131	0.138	0.145	0.151	0.157
	Medical Costs	0.029	0.005	0.006	0.021	0.010	0.008	0.015	0.010	0.011	0.015
Labor Costs											
	Set-up, monitoring, etc.	0.240	0.198	0.213	0.226	0.239	0.252	0.268	0.280	0.291	0.304
Total Compliance Costs		2.384	0.654	0.701	0.753	0.787	0.825	0.882	0.917	0.958	0.998
Gross Output		373,077	411,200	443,845	476,749	513,256	550,101	591,830	627,021	664,027	705,528
Costs as % of output		0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 3 (contd): Silica Rule Compliance Costs by LIFT Sector, 2014-2023
(Millions of current dollars)

50	**Motor vehicle parts**										
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Capital Costs											
	Ventilation Equipment	1.821	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Other	0.223	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Intermediate Costs											
	Personal Protect Equip	0.023	0.020	0.023	0.019	0.022	0.019	0.022	0.019	0.022	0.018
	Energy	0.318	0.313	0.309	0.306	0.304	0.302	0.300	0.298	0.294	0.291
	Laboratory Costs	0.095	0.067	0.066	0.065	0.065	0.065	0.064	0.064	0.063	0.062
	Industrial Hygienists	0.169	0.119	0.117	0.116	0.116	0.115	0.114	0.113	0.112	0.110
	Medical Costs	0.037	0.006	0.006	0.021	0.009	0.006	0.010	0.007	0.007	0.009
Labor Costs											
	Set-up, monitoring, etc.	0.376	0.302	0.301	0.299	0.297	0.295	0.295	0.291	0.287	0.284
Total Compliance Costs		3.061	0.827	0.822	0.827	0.813	0.801	0.805	0.792	0.784	0.774
Gross Output		164,851	178,903	189,217	200,181	211,830	223,766	236,707	247,199	257,710	269,777
Costs as % of output		0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
52	**Ships, boats**										
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Capital Costs											
	Ventilation Equipment	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Other	11.737	12.267	12.775	13.255	13.788	14.265	14.783	15.202	15.640	16.206
Intermediate Costs											
	Personal Protect Equip	0.062	0.065	0.067	0.070	0.073	0.075	0.078	0.080	0.083	0.086
	Energy	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Laboratory Costs	0.264	0.192	0.200	0.208	0.216	0.223	0.231	0.238	0.245	0.254
	Industrial Hygienists	0.466	0.340	0.354	0.367	0.382	0.395	0.409	0.421	0.433	0.449
	Medical Costs	1.139	0.209	0.217	0.757	0.347	0.008	0.015	0.010	0.010	0.015
Labor Costs											
	Set-up, monitoring, etc.	0.605	0.281	0.292	0.419	0.340	0.352	0.430	0.389	0.400	0.450
Total Compliance Costs		14.273	13.353	13.906	15.076	15.146	15.318	15.947	16.340	16.811	17.459
Gross Output		30,153	31,468	32,756	33,974	35,383	36,579	37,962	38,823	40,021	41,618
Costs as % of output		0.047	0.042	0.042	0.044	0.043	0.042	0.042	0.042	0.042	0.042
53	**Other transportation equipment**										
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Capital Costs											
	Ventilation Equipment	0.112	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Other	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Intermediate Costs											
	Personal Protect Equip	0.001	0.001	0.002	0.001	0.002	0.001	0.002	0.002	0.002	0.002
	Energy	0.020	0.020	0.021	0.022	0.022	0.023	0.024	0.025	0.025	0.026
	Laboratory Costs	0.006	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005
	Industrial Hygienists	0.010	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.010	0.010
	Medical Costs	0.002	0.000	0.000	0.001	0.001	0.174	0.323	0.215	0.221	0.305
Labor Costs											
	Set-up, monitoring, etc.	0.186	0.190	0.197	0.203	0.209	0.215	0.222	0.229	0.235	0.241
Total Compliance Costs		0.350	0.224	0.232	0.240	0.247	0.428	0.586	0.484	0.498	0.589
Gross Output		53,032	56,438	58,967	61,621	64,319	67,135	70,291	73,115	75,978	79,155
Costs as % of output		0.001	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001

Table 3 (contd): Silica Rule Compliance Costs by LIFT Sector, 2014-2023
(Millions of current dollars)

55	Medical instruments and supplies										
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Capital Costs											
	Ventilation Equipment	0.606	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Other	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Intermediate Costs											
	Personal Protect Equip	0.007	0.006	0.008	0.007	0.008	0.007	0.008	0.007	0.008	0.007
	Energy	0.105	0.108	0.111	0.114	0.115	0.116	0.117	0.118	0.118	0.119
	Laboratory Costs	0.025	0.018	0.019	0.019	0.019	0.019	0.020	0.020	0.020	0.020
	Industrial Hygienists	0.036	0.027	0.027	0.028	0.028	0.028	0.029	0.029	0.029	0.029
	Medical Costs	0.011	0.002	0.002	0.007	0.003	0.000	0.000	0.000	0.000	0.000
Labor Costs											
	Set-up, monitoring, etc.	0.043	0.026	0.028	0.029	0.029	0.029	0.030	0.030	0.030	0.030
Total Compliance Costs		0.833	0.187	0.195	0.203	0.202	0.200	0.203	0.204	0.206	0.206
Gross Output		129,024	137,538	146,897	154,778	161,727	168,795	176,174	183,581	191,070	199,117
Costs as % of output		0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
57	**Other instruments**										
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Capital Costs											
	Ventilation Equipment	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Other	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Intermediate Costs											
	Personal Protect Equip	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Energy	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
	Laboratory Costs	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	Industrial Hygienists	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	Medical Costs	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Labor Costs											
	Set-up, monitoring, etc.	0.026	0.027	0.029	0.030	0.031	0.033	0.034	0.036	0.037	0.038
Total Compliance Costs		0.045	0.031	0.033	0.035	0.036	0.038	0.040	0.041	0.043	0.044
Gross Output		148,315	162,489	178,629	193,874	210,358	226,599	242,537	259,159	276,321	294,804
Costs as % of output		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
58	**Miscellaneous manufacturing**										
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Capital Costs											
	Ventilation Equipment	1.544	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Other	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Intermediate Costs											
	Personal Protect Equip	0.126	0.115	0.142	0.130	0.161	0.148	0.182	0.166	0.201	0.182
	Energy	0.311	0.330	0.350	0.372	0.397	0.422	0.449	0.476	0.497	0.521
	Laboratory Costs	0.691	0.520	0.552	0.587	0.626	0.667	0.709	0.751	0.785	0.822
	Industrial Hygienists	0.898	0.676	0.717	0.763	0.814	0.866	0.921	0.976	1.020	1.068
	Medical Costs	0.200	0.037	0.039	0.141	0.066	0.081	0.155	0.106	0.111	0.156
Labor Costs											
	Set-up, monitoring, etc.	1.176	0.797	0.864	0.923	0.985	1.049	1.129	1.185	1.238	1.304
Total Compliance Costs		4.950	2.475	2.664	2.916	3.049	3.232	3.544	3.661	3.852	4.053
Gross Output		92,303	98,218	104,747	111,428	119,199	126,864	134,998	140,814	147,527	155,726
Costs as % of output		0.005	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003

Table 3 (contd): Silica Rule Compliance Costs by LIFT Sector, 2014-2023
(Millions of current dollars)

59	**Railroads**										
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Capital Costs											
	Ventilation Equipment	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Other	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Intermediate Costs											
	Personal Protect Equip	0.151	0.135	0.161	0.143	0.171	0.152	0.181	0.160	0.189	0.167
	Energy	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Laboratory Costs	0.707	0.528	0.545	0.561	0.578	0.594	0.611	0.625	0.639	0.655
	Industrial Hygienists	1.508	1.127	1.163	1.197	1.234	1.269	1.303	1.333	1.364	1.397
	Medical Costs	0.240	0.043	0.045	0.155	0.070	0.002	0.004	0.003	0.003	0.004
Labor Costs											
	Set-up, monitoring, etc.	1.319	0.745	0.790	0.814	0.842	0.866	0.902	0.913	0.934	0.963
Total Compliance Costs		3.925	2.578	2.704	2.870	2.896	2.883	3.001	3.033	3.129	3.187
Gross Output		79,276	83,304	87,228	91,025	95,587	99,529	103,621	107,456	112,283	117,457
Costs as % of output		0.005	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
69	**Wholesale trade**										
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Capital Costs											
	Ventilation Equipment	0.196	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Other	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Intermediate Costs											
	Personal Protect Equip	0.004	0.004	0.005	0.004	0.005	0.005	0.006	0.005	0.006	0.005
	Energy	0.034	0.035	0.037	0.038	0.039	0.041	0.042	0.044	0.045	0.047
	Laboratory Costs	0.043	0.031	0.033	0.034	0.035	0.036	0.038	0.039	0.040	0.042
	Industrial Hygienists	0.044	0.032	0.034	0.035	0.036	0.038	0.039	0.040	0.042	0.043
	Medical Costs	0.007	0.001	0.001	0.005	0.002	0.007	0.013	0.009	0.009	0.012
Labor Costs											
	Set-up, monitoring, etc.	0.113	0.099	0.104	0.108	0.112	0.116	0.121	0.125	0.129	0.133
Total Compliance Costs		0.444	0.204	0.213	0.223	0.230	0.242	0.258	0.261	0.270	0.282
Gross Output		1,441,484	1,526,321	1,616,321	1,704,911	1,802,808	1,899,249	2,002,348	2,095,509	2,201,823	2,313,865
Costs as % of output		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
84	**Physicians**										
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Capital Costs											
	Ventilation Equipment	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Other	0.121	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Intermediate Costs											
	Personal Protect Equip	0.007	0.007	0.008	0.008	0.009	0.008	0.010	0.009	0.011	0.010
	Energy	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Laboratory Costs	0.177	0.133	0.142	0.149	0.157	0.165	0.173	0.181	0.189	0.198
	Industrial Hygienists	0.182	0.136	0.146	0.153	0.161	0.169	0.178	0.185	0.194	0.203
	Medical Costs	0.012	0.002	0.002	0.008	0.004	0.002	0.005	0.003	0.003	0.004
Labor Costs											
	Set-up, monitoring, etc.	0.365	0.135	0.146	0.154	0.162	0.170	0.179	0.186	0.195	0.205
Total Compliance Costs		0.864	0.413	0.444	0.472	0.493	0.516	0.545	0.564	0.591	0.620
Gross Output		706,754	764,570	829,076	885,631	945,162	1,007,002	1,069,738	1,127,746	1,193,628	1,269,948
Costs as % of output		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 3 (contd): Silica Rule Compliance Costs by LIFT Sector, 2014-2023
(Millions of current dollars)

85	Other medical services										
		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Capital Costs											
	Ventilation Equipment	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Other	0.479	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Intermediate Costs											
	Personal Protect Equip	0.029	0.027	0.034	0.031	0.037	0.034	0.041	0.037	0.044	0.040
	Energy	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Laboratory Costs	0.480	0.368	0.397	0.418	0.438	0.460	0.475	0.499	0.517	0.539
	Industrial Hygienists	0.703	0.538	0.581	0.611	0.641	0.673	0.695	0.730	0.757	0.788
	Medical Costs	0.046	0.009	0.009	0.033	0.015	0.003	0.005	0.003	0.003	0.005
Labor Costs											
	Set-up, monitoring, etc.	1.334	0.470	0.511	0.538	0.565	0.594	0.616	0.644	0.668	0.698
Total Compliance Costs		3.071	1.412	1.532	1.631	1.697	1.763	1.832	1.913	1.989	2.068
Gross Output		347,522	385,428	424,761	457,253	491,005	526,671	555,565	595,588	631,151	672,365
Costs as % of output		0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total Compliance Costs		920.074	563.390	607.724	790.679	700.630	735.882	829.749	811.770	838.878	880.415
Gross Domestic Product		17,727,492	18,758,355	19,819,793	20,860,250	21,989,504	23,114,516	24,285,219	25,385,695	26,570,561	27,869,816
Costs as % of GDP		0.005	0.003	0.003	0.004	0.003	0.003	0.003	0.003	0.003	0.003

Table 4: Embedding Silica Rule Compliance Costs into LIFT Commodity Price Equations

Compliance Cost Type		LIFT Supply Sector
Capital Costs		
Ventilation equipment		39 General industrial machinery
Other capital equipment		
Raises commodity prices by increasing capital consumption (unit value added).		
Intermediate Purchases		
Personal Protective Equipment	58	Miscellaneous Manufacturing
Industrial Hygienists	77	Professional Services
Laboratory Costs	77	Professional Services
Energy Costs	66	Electrical Utilities
Medical Costs	85	Other Medical Services
Raises commodity prices by increasing real intermediate requirements (A matrix).		
Direct Labor Costs		Own-industry labor cost
Raises commodity prices by increasing labor compensation (unit value added).		

Table 5: LIFT Model - OSHA Baseline Summary

(First line is magnitude, second line is percentage change)													
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
REAL GDP by FINAL DEMAND CATEGORY (Billions of chained 2005 dollars)													
Gross Domestic Product	13485	13817	14337	14798	15241	15696	16109	16567	16985	17419	17722	18078	18507
percent change	1.8	2.5	3.8	3.2	3.0	3.0	2.6	2.8	2.5	2.6	1.7	2.0	2.4
PRICE INDICATOR, 2005=100													
GDP Deflator	112.4	114.6	116.8	119.8	123.1	126.3	129.5	132.7	136.1	139.4	143.2	147.0	150.6
	1.0	2.0	1.9	2.5	2.7	2.6	2.6	2.5	2.5	2.4	2.7	2.6	2.5
EMPLOYMENT, PRODUCTIVITY, and INCOME													
Employment (thousands)	142633	143967	147023	150016	152588	155002	156909	159145	161000	162792	163483	164226	165612
percent change	0.3	0.9	2.1	2.0	1.7	1.6	1.2	1.4	1.2	1.1	0.4	0.5	0.8
Unemployment Rate	9.0	8.5	7.4	6.6	6.1	5.6	5.3	4.9	4.6	4.5	4.6	4.8	4.8
Labor Productivity (05$/hr)	52.7	53.4	54.2	54.8	55.5	56.2	57.0	57.7	58.5	59.3	60.0	61.0	61.9
percent change	1.5	1.4	1.6	1.1	1.2	1.3	1.3	1.4	1.3	1.4	1.3	1.5	1.5
Real Personal Inc, bil 05$	11687	11836	12370	12834	13209	13641	14052	14495	14910	15332	15618	15952	16355
percent change	2.4	1.3	4.5	3.7	2.9	3.3	3.0	3.2	2.9	2.8	1.9	2.1	2.5

Table 6: Silica Rule Simulation Results Relative to Baseline Forecast
Macroeconomic Summary

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Real Gross Domestic Product (Billions of chained 2005 dollars)										
Baseline	**14,798**	**15,241**	**15,696**	**16,109**	**16,567**	**16,985**	**17,419**	**17,722**	**18,078**	**18,507**
Percent Difference	**-0.002**	**-0.003**	**-0.003**	**-0.005**	**-0.004**	**-0.004**	**-0.004**	**-0.004**	**-0.003**	**-0.003**
Difference in bill 05$	**-0.260**	**-0.478**	**-0.482**	**-0.754**	**-0.715**	**-0.707**	**-0.760**	**-0.658**	**-0.609**	**-0.592**
Cumulative		**-0.737**	**-1.220**	**-1.974**	**-2.688**	**-3.396**	**-4.155**	**-4.813**	**-5.423**	**-6.015**
GDP Expenditures (Percent difference from base)										
Personal Consumption	-0.002	-0.004	-0.002	-0.004	-0.004	-0.003	-0.004	-0.003	-0.003	-0.003
Nonresidential Structures	-0.004	0.000	-0.009	-0.016	-0.015	-0.016	-0.014	-0.012	-0.011	-0.010
Equipment Investment	0.015	0.012	0.009	0.012	0.016	0.018	0.021	0.023	0.026	0.028
Residential Investment	-0.003	-0.027	-0.023	-0.037	-0.038	-0.036	-0.036	-0.036	-0.034	-0.033
Exports	-0.001	-0.003	-0.004	-0.005	-0.005	-0.006	-0.006	-0.006	-0.006	-0.006
Imports	0.007	0.001	0.002	0.001	0.003	0.004	0.005	0.006	0.007	0.008
Government	-0.002	-0.002	-0.002	-0.003	-0.002	-0.002	-0.003	-0.002	-0.003	-0.003
Price Indicators (Percent difference from base)										
GDP Deflator	0.005	0.006	0.008	0.010	0.011	0.012	0.012	0.013	0.013	0.014
PCE Deflator	0.003	0.005	0.007	0.009	0.010	0.011	0.011	0.011	0.012	0.012
Employment (Millions of jobs)										
Total baseline	**150.0**	**152.6**	**155.0**	**156.9**	**159.1**	**161.0**	**162.8**	**163.5**	**164.2**	**165.6**
Percent difference	**0.004**	**0.000**	**0.001**	**0.000**	**-0.001**	**0.000**	**0.000**	**0.000**	**0.001**	**0.001**
Difference in thousands	**5.83**	**0.63**	**0.81**	**-0.28**	**-1.03**	**-0.63**	**-0.31**	**0.38**	**1.31**	**1.92**
Cumulative		**6.453**	**7.266**	**6.984**	**5.953**	**5.328**	**5.016**	**5.391**	**6.703**	**8.625**
Construction employment										
Total baseline	7.9	8.4	8.8	9.1	9.5	9.9	10.2	10.3	10.2	10.3
Percent difference	0.056	0.032	0.028	0.024	0.018	0.018	0.020	0.020	0.021	0.022
Difference in thousands	4.43	2.67	2.44	2.22	1.74	1.82	2.05	2.05	2.16	2.27

Table 7: Silica Rule Simulation Results Relative to Baseline Forecast
Gross Output by Producing Sector, Percentage Difference from Baseline

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
1 Agriculture,forestry,fish	-0.001	-0.002	-0.001	-0.003	-0.003	-0.003	-0.003	-0.003	-0.002	-0.002
Mining	0.000	-0.001	-0.001	-0.002	-0.001	-0.001	-0.002	-0.001	-0.001	-0.001
2 Metal mining	0.000	-0.001	-0.001	-0.002	-0.001	-0.001	-0.001	0.000	0.000	0.000
3 Coal mining	0.002	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.001
4 Natural gas extraction	0.000	-0.001	0.000	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
5 Crude petroleum	0.000	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
6 Non-metallic mining	-0.002	-0.007	-0.007	-0.010	-0.009	-0.009	-0.009	-0.009	-0.009	-0.008
Construction	-0.003	-0.007	-0.009	-0.014	-0.014	-0.014	-0.014	-0.013	-0.013	-0.012
7 New construction	-0.005	-0.009	-0.013	-0.022	-0.023	-0.023	-0.022	-0.021	-0.020	-0.019
8 Maint & repair construct	-0.001	-0.005	-0.005	-0.008	-0.007	-0.007	-0.008	-0.007	-0.007	-0.007
Non-Durables	-0.001	-0.002	-0.001	-0.002	-0.002	-0.002	-0.002	-0.002	-0.001	-0.001
9 Meat products	-0.001	-0.001	0.000	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
10 Dairy products	-0.001	-0.001	0.000	0.000	0.000	0.000	-0.001	0.000	0.000	0.000
11 Canned & frozen foods	0.000	0.000	0.002	0.002	0.001	0.002	0.001	0.002	0.002	0.002
12 Bakery and grain products	-0.001	-0.001	0.000	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
13 Alcoholic beverages	-0.001	-0.002	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
14 Other food products	0.000	-0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.001
15 Tobacco products	0.000	0.001	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003
16 Textiles and knitting	-0.004	-0.011	-0.007	-0.014	-0.012	-0.012	-0.012	-0.011	-0.010	-0.009
17 Apparel	-0.008	-0.015	-0.009	-0.017	-0.013	-0.013	-0.014	-0.011	-0.010	-0.009
18 Paper	0.000	-0.004	-0.002	-0.004	-0.004	-0.003	-0.003	-0.003	-0.002	-0.002
19 Printing & publishing	-0.001	-0.005	-0.004	-0.006	-0.005	-0.005	-0.005	-0.004	-0.003	-0.003
20 Ag. fertilizers & chemicals	-0.001	-0.002	-0.002	-0.003	-0.003	-0.004	-0.004	-0.004	-0.004	-0.004
21 Plastics & synthetics	0.000	-0.002	-0.002	-0.003	-0.003	-0.003	-0.003	-0.002	-0.002	-0.002
22 Drugs	0.001	0.000	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002
23 Other chemicals	0.000	-0.002	-0.002	-0.003	-0.003	-0.003	-0.003	-0.003	-0.002	-0.002
24 Petroleum refining	0.000	-0.002	-0.001	-0.002	-0.002	-0.001	-0.002	-0.001	-0.001	-0.001
25 Fuel oil	0.000	-0.002	-0.001	-0.002	-0.002	-0.001	-0.001	-0.001	-0.001	0.000
26 Rubber products	0.000	-0.003	-0.002	-0.003	-0.003	-0.003	-0.003	-0.002	-0.002	-0.001
27 Misc. plastics products	-0.001	-0.004	-0.004	-0.005	-0.004	-0.004	-0.003	-0.003	-0.002	-0.001
28 Shoes & leather	-0.006	-0.009	-0.003	-0.010	-0.009	-0.010	-0.011	-0.009	-0.008	-0.008
Durable materials & produc	0.000	-0.005	-0.005	-0.007	-0.006	-0.005	-0.004	-0.003	-0.002	-0.002
29 Lumber	0.003	-0.011	-0.006	-0.011	-0.012	-0.010	-0.011	-0.010	-0.009	-0.009
30 Furniture	-0.003	-0.005	-0.005	-0.005	-0.003	-0.002	-0.001	0.001	0.002	0.003
31 Stone, clay & glass	-0.006	-0.014	-0.014	-0.017	-0.017	-0.016	-0.016	-0.015	-0.014	-0.013
32 Primary ferrous metals	0.003	-0.004	-0.004	-0.004	-0.002	-0.001	0.000	0.001	0.002	0.003
33 Primary nonferrous metals	0.001	-0.001	-0.001	-0.001	-0.001	0.000	0.000	0.000	0.001	0.001
34 Metal products	-0.001	-0.003	-0.003	-0.004	-0.003	-0.002	-0.002	0.000	0.001	0.001
Non-Electrical Machinery	0.023	0.012	0.011	0.012	0.014	0.016	0.018	0.020	0.021	0.022
35 Engines and turbines	0.000	-0.001	-0.001	-0.001	0.000	0.001	0.001	0.002	0.002	0.003
36 Ag., Construct eqpt.	0.003	0.005	0.006	0.010	0.014	0.017	0.022	0.025	0.029	0.033
37 Metalworking machinery	0.018	0.003	0.002	0.002	0.005	0.008	0.010	0.011	0.013	0.014
38 Special industry machinery	0.007	-0.003	-0.006	-0.006	-0.005	-0.003	-0.002	-0.001	-0.001	0.000
39 General industrial eq.	0.112	0.057	0.061	0.061	0.063	0.064	0.064	0.063	0.062	0.062
40 Computers	-0.001	0.003	-0.003	-0.003	0.002	0.003	0.004	0.006	0.007	0.008
41 Office equipment	-0.002	-0.002	-0.006	-0.003	-0.002	-0.001	0.000	0.001	0.002	0.003
42 Service industry machinery	-0.002	-0.004	-0.006	-0.006	-0.004	-0.003	-0.003	-0.001	0.000	0.001

Table 7 (contd): Silica Rule Simulation Results Relative to Baseline Forecast
Gross Output by Producing Sector, Percentage Difference from Baseline

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Non-Electrical Machinery	0.023	0.012	0.011	0.012	0.014	0.016	0.018	0.020	0.021	0.022
35 Engines and turbines	0.000	-0.001	-0.001	-0.001	0.000	0.001	0.001	0.002	0.002	0.003
36 Ag., Construct eqpt.	0.003	0.005	0.006	0.010	0.014	0.017	0.022	0.025	0.029	0.033
37 Metalworking machinery	0.018	0.003	0.002	0.002	0.005	0.008	0.010	0.011	0.013	0.014
38 Special industry machinery	0.007	-0.003	-0.006	-0.006	-0.005	-0.003	-0.002	-0.001	-0.001	0.000
39 General industrial eq.	0.112	0.057	0.061	0.061	0.063	0.064	0.064	0.063	0.062	0.062
40 Computers	-0.001	0.003	-0.003	-0.003	0.002	0.003	0.004	0.006	0.007	0.008
41 Office equipment	-0.002	-0.002	-0.006	-0.003	-0.002	-0.001	0.000	0.001	0.002	0.003
42 Service industry machinery	-0.002	-0.004	-0.006	-0.006	-0.004	-0.003	-0.003	-0.001	0.000	0.001
Electrical Machinery	0.000	-0.001	-0.002	-0.003	-0.002	-0.001	-0.001	0.000	0.000	0.000
43 Elec. indl. apparatus,dist. eq.	0.004	0.000	0.000	0.000	0.002	0.003	0.004	0.005	0.007	0.008
44 Household appliances	-0.001	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.003
45 Elec. lighting & wiring eqpt.	-0.001	-0.002	-0.003	-0.004	-0.004	-0.003	-0.004	-0.003	-0.003	-0.003
46 TV, DVD, radios,etc.	-0.006	-0.013	-0.016	-0.022	-0.023	-0.025	-0.027	-0.027	-0.027	-0.027
47 Communications equipment	0.000	-0.001	-0.001	-0.001	-0.002	-0.002	-0.002	-0.002	-0.003	-0.003
48 Electronic components	-0.001	-0.001	-0.002	-0.002	-0.001	0.000	0.000	0.001	0.001	0.002
Transportation Equipment	-0.002	-0.002	-0.002	-0.002	0.000	0.001	0.002	0.004	0.005	0.006
49 Motor vehicles	-0.002	-0.002	0.001	0.001	0.006	0.009	0.012	0.016	0.019	0.021
50 Motor vehicle parts	-0.003	-0.005	-0.005	-0.005	-0.003	-0.001	0.000	0.002	0.004	0.005
51 Aerospace	0.000	-0.001	-0.002	-0.003	-0.004	-0.004	-0.004	-0.005	-0.005	-0.005
52 Ships & boats	-0.004	-0.007	-0.006	-0.008	-0.007	-0.007	-0.007	-0.005	-0.004	-0.004
53 Other transport equipment	-0.002	-0.004	-0.004	-0.005	-0.005	-0.005	-0.005	-0.005	-0.004	-0.004
Instruments & misc mfg	0.001	-0.002	-0.001	-0.002	-0.001	-0.001	-0.001	-0.001	0.000	0.000
54 Search & navigation equip	-0.001	-0.001	-0.003	-0.002	-0.003	-0.002	-0.002	-0.002	-0.002	-0.002
55 Medical instr & supplies	-0.001	-0.001	-0.002	-0.002	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003
56 Ophthalmic goods	0.000	-0.004	-0.006	-0.008	-0.008	-0.009	-0.010	-0.010	-0.011	-0.011
57 Other instruments	0.000	-0.001	-0.001	-0.001	0.000	0.001	0.001	0.002	0.003	0.003
58 Misc manufacturing	0.009	-0.004	0.002	-0.002	0.000	-0.003	0.000	-0.003	0.001	-0.001
Transportation	0.000	-0.003	-0.002	-0.003	-0.003	-0.002	-0.002	-0.001	-0.001	-0.001
59 Railroads	0.000	-0.002	-0.002	-0.003	-0.002	-0.002	-0.002	-0.001	0.000	0.000
60 Trucking, Hwy passenger	0.000	-0.003	-0.002	-0.003	-0.002	-0.002	-0.002	-0.001	0.000	0.000
61 Water transport	0.001	-0.003	-0.002	-0.004	-0.003	-0.002	-0.002	-0.001	-0.001	0.000
62 Air transport	0.000	-0.003	-0.002	-0.003	-0.003	-0.003	-0.003	-0.002	-0.002	-0.002
63 Pipeline	0.000	-0.002	-0.002	-0.003	-0.002	-0.002	-0.003	-0.002	-0.002	-0.002
64 Transportation services	0.001	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.001	-0.001	-0.001
Utilities	0.000	-0.002	-0.003	-0.004	-0.003	-0.003	-0.003	-0.002	-0.002	-0.002
65 Communications services	-0.002	-0.003	-0.006	-0.006	-0.005	-0.005	-0.005	-0.004	-0.004	-0.005
66 Electric utilities	0.004	0.001	0.002	0.000	0.000	0.000	0.000	0.001	0.001	0.001
67 Gas utilities	0.000	-0.001	0.000	-0.002	-0.002	-0.002	-0.002	-0.002	-0.001	-0.001
68 Water and sanitary services	0.000	-0.001	0.000	-0.002	-0.001	-0.001	-0.001	-0.001	-0.001	0.000

Table 7 (contd): Silica Rule Simulation Results Relative to Baseline Forecast
Gross Output by Producing Sector, Percentage Difference from Baseline

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Trade	-0.001	-0.004	-0.003	-0.004	-0.004	-0.003	-0.003	-0.002	-0.002	-0.001
69 Wholesale trade	0.000	-0.002	-0.002	-0.002	-0.002	-0.001	-0.001	0.000	0.001	0.002
70 Retail trade	-0.003	-0.008	-0.005	-0.008	-0.007	-0.007	-0.007	-0.006	-0.005	-0.005
71 Restaurants and bars	-0.001	-0.002	-0.001	-0.002	-0.002	-0.001	-0.002	-0.001	-0.001	-0.001
Finance, Insur & Real Est	-0.002	-0.004	-0.003	-0.005	-0.005	-0.005	-0.005	-0.004	-0.004	-0.004
72 Finance & insurance	-0.002	-0.003	-0.002	-0.004	-0.003	-0.003	-0.004	-0.003	-0.003	-0.003
73 Real estate and royalties	0.000	-0.004	-0.004	-0.006	-0.006	-0.006	-0.007	-0.006	-0.006	-0.005
74 Owner-occupied housing	-0.003	-0.005	-0.003	-0.005	-0.004	-0.004	-0.005	-0.004	-0.004	-0.004
Services	0.004	0.000	-0.001	0.000	-0.001	-0.001	0.000	0.000	0.000	0.001
75 Hotels	0.000	-0.002	-0.002	-0.003	-0.002	-0.002	-0.002	-0.002	-0.001	-0.001
76 Personal services	-0.001	-0.003	-0.002	-0.003	-0.003	-0.002	-0.003	-0.002	-0.001	-0.001
77 Professional services	0.020	0.005	0.005	0.012	0.005	0.006	0.008	0.007	0.008	0.009
78 Computer & data process	0.000	0.000	-0.002	-0.003	-0.001	-0.001	-0.001	0.000	0.000	0.000
79 Advertising	-0.001	-0.003	-0.002	-0.004	-0.003	-0.003	-0.003	-0.002	-0.002	-0.001
80 Other business services	0.001	-0.003	-0.002	-0.003	-0.003	-0.003	-0.003	-0.002	-0.001	-0.001
81 Automobile services	-0.001	-0.005	-0.003	-0.004	-0.003	-0.003	-0.003	-0.001	0.000	0.000
82 Movies and amusements	-0.003	-0.004	-0.004	-0.006	-0.006	-0.006	-0.007	-0.006	-0.006	-0.006
83 Private hospitals	0.001	0.000	0.000	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	0.000
84 Physicians	0.001	0.001	0.000	-0.001	-0.001	-0.001	-0.001	-0.001	0.000	0.000
85 Oth med. srv. & dentists	0.001	0.000	0.000	-0.002	-0.002	-0.002	-0.002	-0.001	-0.001	-0.001
86 Nursing homes	0.001	0.001	0.000	-0.001	0.000	0.000	0.000	0.000	0.000	0.000
87 Edu, social services, NPO	-0.001	-0.002	-0.002	-0.003	-0.004	-0.004	-0.004	-0.003	-0.002	-0.002
Miscellaneous										
88 Government enterprises	0.000	-0.002	-0.001	-0.002	-0.002	-0.002	-0.002	-0.001	-0.001	0.000
93 Government industry	-0.005	-0.004	-0.006	-0.007	-0.005	-0.006	-0.006	-0.006	-0.006	-0.006
94 Domestic servants	-0.005	-0.010	-0.005	-0.011	-0.010	-0.010	-0.012	-0.010	-0.008	-0.008

Table 8: Silica Rule Simulation Results Relative to Baseline Forecast
Employment by Producing Sector, Percentage Difference from Baseline

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
1 Agriculture,forestry,fish	-0.016	-0.061	-0.049	-0.075	-0.089	-0.089	-0.096	-0.094	-0.084	-0.083
Mining	0.000	-0.009	-0.009	-0.015	-0.014	-0.013	-0.014	-0.013	-0.011	-0.011
2 Metal mining	0.000	0.000	-0.001	-0.001	-0.001	-0.001	0.000	0.000	0.000	0.000
3 Coal mining	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001
5 Petroleum & natural gas	-0.001	-0.004	-0.003	-0.005	-0.005	-0.004	-0.005	-0.004	-0.004	-0.003
6 Non-metallic mining	-0.002	-0.006	-0.006	-0.008	-0.009	-0.008	-0.009	-0.009	-0.008	-0.008
7-8. Construction	4.429	2.673	2.439	2.225	1.743	1.823	2.053	2.049	2.158	2.271
Non-Durables	-0.024	-0.127	-0.121	-0.156	-0.171	-0.157	-0.163	-0.143	-0.109	-0.090
9 Meat products	-0.003	-0.004	-0.001	-0.003	-0.005	-0.005	-0.007	-0.007	-0.007	-0.007
10 Dairy products	0.000	-0.001	-0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11 Canned & frozen foods	0.000	0.000	0.002	0.003	0.003	0.003	0.003	0.003	0.004	0.004
12 Bakery and grain products	-0.001	-0.002	-0.002	-0.001	-0.002	-0.002	-0.003	-0.003	-0.003	-0.002
13 Alcoholic beverages	-0.001	-0.003	-0.003	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002
14 Other food products	0.000	-0.001	0.000	0.002	0.001	0.001	0.001	0.001	0.001	0.002
15 Tobacco products	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16 Textiles and knitting	-0.006	-0.016	-0.013	-0.021	-0.021	-0.020	-0.021	-0.019	-0.016	-0.015
17 Apparel	-0.006	-0.019	-0.019	-0.020	-0.025	-0.022	-0.022	-0.021	-0.017	-0.015
18 Paper	-0.001	-0.008	-0.012	-0.013	-0.016	-0.015	-0.014	-0.014	-0.011	-0.009
19 Printing & publishing	-0.011	-0.060	-0.046	-0.071	-0.069	-0.065	-0.068	-0.055	-0.041	-0.035
20 Ag fertilizers & chemicals	0.000	0.000	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
21 Plastics & synthetics	0.000	-0.001	-0.002	-0.002	-0.003	-0.003	-0.003	-0.002	-0.002	-0.002
22 Drugs	0.002	0.002	0.003	0.004	0.005	0.006	0.006	0.006	0.007	0.008
23 Other chemicals	0.000	-0.005	-0.008	-0.009	-0.012	-0.012	-0.012	-0.012	-0.010	-0.009
24 Petroleum refining	0.007	0.005	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.003
26 Rubber products	0.000	-0.002	-0.003	-0.004	-0.005	-0.004	-0.004	-0.004	-0.003	-0.002
27 Plastic products	-0.002	-0.011	-0.017	-0.019	-0.021	-0.018	-0.016	-0.013	-0.008	-0.005
28 Shoes & leather	-0.001	-0.002	-0.002	-0.002	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003
Durable Materials & Products	0.516	0.343	0.276	0.246	0.233	0.260	0.280	0.305	0.332	0.352
29 Lumber	0.009	-0.030	-0.048	-0.055	-0.069	-0.066	-0.065	-0.064	-0.061	-0.059
30 Furniture	-0.007	-0.015	-0.017	-0.019	-0.013	-0.007	-0.004	0.004	0.012	0.017
31 Stone, clay & glass	0.364	0.293	0.271	0.263	0.255	0.258	0.259	0.261	0.261	0.260
32 Primary ferrous metals	0.072	0.049	0.036	0.036	0.033	0.034	0.035	0.035	0.035	0.036
33 Primary nonferrous metals	0.052	0.044	0.040	0.043	0.041	0.044	0.046	0.047	0.049	0.051
34 Metal products	0.026	0.001	-0.007	-0.021	-0.013	-0.002	0.008	0.023	0.035	0.047
Non-Electrical Machinery	0.330	0.375	0.268	0.295	0.333	0.380	0.419	0.451	0.477	0.503
35 Engines and turbines	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001
36 Ag., Construct eqpt.	0.010	0.019	0.022	0.038	0.052	0.069	0.087	0.103	0.120	0.136
37 Metalworking machinery	0.046	0.019	0.011	0.010	0.016	0.027	0.034	0.039	0.044	0.050
38 Special industry machinery	0.008	-0.001	-0.007	-0.006	-0.006	-0.004	-0.003	-0.002	-0.002	-0.001
39 General industrial machinery	0.270	0.338	0.259	0.272	0.280	0.291	0.299	0.304	0.302	0.302
40 Computers	-0.002	0.006	-0.006	-0.005	0.003	0.005	0.007	0.010	0.012	0.013
41 Office equipment	0.000	-0.001	-0.001	-0.002	-0.001	-0.001	0.000	0.000	0.000	0.001
42 Service industry machinery	-0.002	-0.005	-0.009	-0.012	-0.010	-0.008	-0.006	-0.004	-0.001	0.001

Table 8 (contd): Silica Rule Simulation Results Relative to Baseline Forecast Employment by Producing Sector, Percentage Difference from Baseline

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Electrical Machinery	-0.001	-0.007	-0.020	-0.022	-0.015	-0.011	-0.007	-0.001	0.004	0.008
43 Elec. indust. app. & dist. eq.	0.003	0.002	0.000	0.000	0.001	0.003	0.005	0.006	0.008	0.009
44 Household appliances	0.001	0.000	0.000	0.000	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
45 Elec. lighting & wiring equip	-0.001	-0.003	-0.004	-0.005	-0.006	-0.005	-0.005	-0.005	-0.005	-0.004
46 TV, DVD, radios,etc.	-0.001	-0.002	-0.003	-0.004	-0.005	-0.005	-0.005	-0.005	-0.004	-0.004
47 Communication equipment	0.000	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
48 Electronic components	-0.003	-0.003	-0.011	-0.012	-0.005	-0.002	0.000	0.004	0.007	0.009
Transportation Equipment	0.000	-0.027	-0.028	-0.026	-0.014	0.006	0.023	0.043	0.064	0.082
49 Motor vehicles	-0.003	-0.007	0.000	0.007	0.022	0.041	0.055	0.073	0.091	0.107
50 Motor vehicle parts	-0.001	-0.008	-0.009	-0.008	-0.006	-0.002	0.000	0.003	0.005	0.007
51 Aerospace	-0.001	-0.004	-0.011	-0.015	-0.019	-0.022	-0.024	-0.026	-0.027	-0.028
52 Ships & boats	0.005	-0.006	-0.005	-0.005	-0.006	-0.005	-0.004	-0.003	-0.001	0.000
53 Other transport equip	0.000	-0.003	-0.004	-0.006	-0.005	-0.005	-0.005	-0.005	-0.004	-0.004
Instruments	-0.002	-0.005	-0.012	-0.013	-0.012	-0.009	-0.006	-0.004	-0.001	0.002
54 Search & navigation equip	0.001	0.000	-0.003	-0.002	-0.004	-0.002	-0.002	-0.002	-0.002	-0.002
55 Medical instr & supplies	-0.001	-0.003	-0.004	-0.006	-0.007	-0.007	-0.007	-0.007	-0.007	-0.007
56 Ophthalmic goods	0.000	0.000	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
57 Other instruments	-0.001	-0.002	-0.004	-0.004	-0.001	0.002	0.004	0.007	0.010	0.012
58 Miscellaneous manufactur	0.035	0.008	0.008	0.006	0.008	0.002	0.007	0.004	0.011	0.009
Transportation	0.011	-0.118	-0.093	-0.153	-0.137	-0.124	-0.115	-0.076	-0.045	-0.022
59 Railroads	0.016	0.004	0.005	0.003	0.004	0.004	0.005	0.006	0.007	0.008
60 Trucking, Hwy passenger	-0.005	-0.075	-0.054	-0.088	-0.078	-0.066	-0.060	-0.035	-0.015	0.002
61 Water transport	0.003	-0.006	-0.007	-0.011	-0.009	-0.008	-0.008	-0.005	-0.003	-0.002
62 Air transport	-0.005	-0.036	-0.027	-0.046	-0.041	-0.040	-0.042	-0.032	-0.028	-0.026
63 Pipeline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
64 Transportation services	0.002	-0.005	-0.010	-0.011	-0.013	-0.013	-0.011	-0.009	-0.007	-0.005
Utilities	-0.011	-0.046	-0.069	-0.095	-0.080	-0.073	-0.072	-0.058	-0.058	-0.057
65 Communications services	-0.026	-0.045	-0.072	-0.087	-0.074	-0.068	-0.065	-0.057	-0.058	-0.060
66 Electric utilities	0.015	0.005	0.006	0.000	0.002	0.002	0.002	0.005	0.005	0.006
67 Gas utilities	0.000	-0.001	-0.001	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.001
68 Water and sanitary services	-0.001	-0.005	-0.002	-0.006	-0.005	-0.005	-0.006	-0.004	-0.003	-0.002
Trade	-0.656	-1.680	-1.102	-1.730	-1.566	-1.434	-1.516	-1.188	-0.910	-0.781
69 Wholesale trade	-0.006	-0.153	-0.141	-0.195	-0.131	-0.081	-0.043	0.024	0.091	0.138
70 Retail trade	-0.531	-1.297	-0.863	-1.350	-1.264	-1.191	-1.275	-1.070	-0.910	-0.852
71 Restaurants and bars	-0.119	-0.230	-0.096	-0.187	-0.173	-0.157	-0.197	-0.139	-0.090	-0.067
Finance, Insur & Real Est	-0.112	-0.305	-0.239	-0.380	-0.367	-0.360	-0.395	-0.342	-0.303	-0.293
72 Finance & insurance	-0.104	-0.228	-0.160	-0.255	-0.236	-0.230	-0.258	-0.215	-0.187	-0.181
73 Real estate and royalties	-0.009	-0.077	-0.079	-0.125	-0.131	-0.130	-0.136	-0.127	-0.116	-0.112

Table 8 (contd): Silica Rule Simulation Results Relative to Baseline Forecast Employment by Producing Sector, Percentage Difference from Baseline

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Services	1.340	-0.395	-0.441	-0.406	-0.879	-0.832	-0.707	-0.563	-0.207	0.039
75 Hotels	-0.002	-0.046	-0.033	-0.054	-0.052	-0.048	-0.051	-0.038	-0.028	-0.022
76 Pers. & repair serv, exc. auto	-0.018	-0.059	-0.035	-0.068	-0.059	-0.056	-0.064	-0.044	-0.034	-0.028
77 Professional services	1.269	0.316	0.314	0.818	0.341	0.374	0.556	0.479	0.510	0.616
78 Computer & data processing	0.000	0.002	-0.054	-0.068	-0.035	-0.033	-0.027	-0.010	-0.001	0.007
79 Advertising	-0.002	-0.009	-0.007	-0.010	-0.009	-0.008	-0.008	-0.006	-0.005	-0.004
80 Other business services	0.117	-0.225	-0.193	-0.277	-0.304	-0.279	-0.266	-0.204	-0.145	-0.103
81 Automobile services	-0.014	-0.069	-0.044	-0.054	-0.050	-0.040	-0.041	-0.021	-0.004	0.006
82 Movies and amusements	-0.046	-0.105	-0.121	-0.151	-0.171	-0.175	-0.191	-0.194	-0.188	-0.189
83 Private hospitals	0.035	-0.003	-0.019	-0.068	-0.055	-0.058	-0.069	-0.051	-0.033	-0.018
84 Physicians	0.029	0.018	0.005	-0.016	-0.014	-0.019	-0.024	-0.015	-0.006	0.002
85 Oth medical serv & dentists	0.092	0.021	-0.017	-0.082	-0.077	-0.083	-0.099	-0.074	-0.046	-0.026
86 Nursing homes	0.027	0.015	0.008	-0.015	-0.007	-0.009	-0.014	-0.004	0.007	0.015
87 Education, social services	-0.145	-0.251	-0.243	-0.360	-0.392	-0.397	-0.409	-0.380	-0.236	-0.217
Civilian Government	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total Civilian jobs	**5.828**	**0.625**	**0.813**	**-0.281**	**-1.031**	**-0.625**	**-0.313**	**0.375**	**1.313**	**1.922**

Appendix A:
The LIFT Model of the U.S. Economy

Inforum has over 40 years of experience in the building and use of detailed industry and regional models. The Long-term Interindustry Forecasting Tool (LIFT) is a unique, 97-sector dynamic general equilibrium representation of the U.S. national economy. It 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 by distributing predetermined macroeconomic quantities among industries. For example, aggregate investment, total exports, and employment are not determined directly, but are computed as the sum of their parts: investment by industry, exports by commodity, and employment by industry. Indeed, LIFT contains full demand and supply accounting for 97 productive sectors. (See Table A-1 for LIFT sector titles.)

This bottom-up technique provides 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.

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 they 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 energy or environmental policies and the dynamics of the economy's adjustment process over time.

Despite its industry basis, LIFT is a general equilibrium model, using bottom-up accounting to determine macroeconomic quantities that are consistent with the underlying industry detail. It includes more than 800 macroeconomic variables that are consistent with the National Income and Product Accounts (NIPA) and other published data. 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 model, 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, supply forces -- available labor, capital, and technology -- will determine the level of output in the long term.

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, Korea, and the major European and North American 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, and government expenditures). 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, and construction by type) and where remaining variables represent consumption by product, 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).

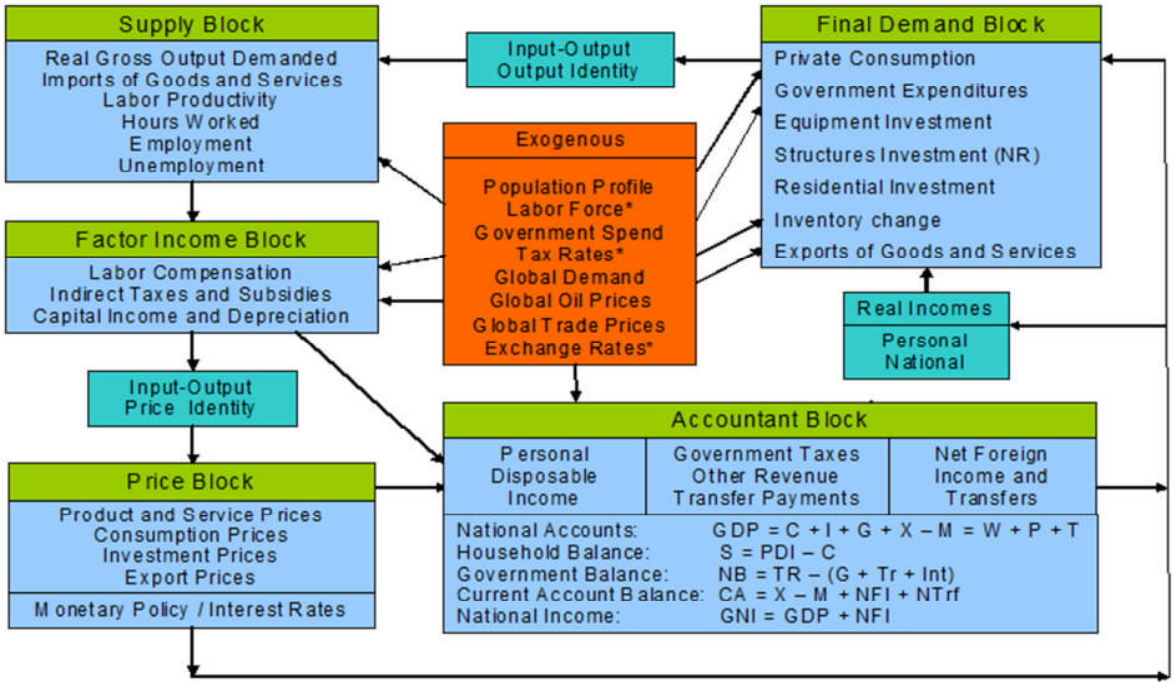
Commodity prices are determined in a similar fashion. In the factor income block, econometric behavioral equations predict each value-added component (including compensation, profits, interest, rent, and indirect taxes) by industry. Labor compensation depends on industry-specific wages which are determined by industry-specific factors as well as overall labor market 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.

Figure A-1: LIFT Schematic Diagram



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 building alternative simulations because it indicates the consistency between economic growth determined on the product side with the inflation and income components. The model allows us to examine how alternative microeconomic conditions or policies will affect other aspects of the economy.

As a result of this dynamic and bottom-up framework, LIFT uniquely is suited to explore many important economic relationships among industries and their implications for the economy as a whole. 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 operation 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 sponsors and in conducting 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, to share ideas, and to pursue development of models that reflect the world around us and that prove useful to our research sponsors and partners around the world.

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