NIST Advanced Manufacturing Series
NIST AMS 100-83

The Manufacturing Cost Guide

Version 2.0 Primer

Douglas Thomas
David Webb

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August 2026

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Howard Lutnick, Secretary

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Abstract

This primer provides an overview for using the Manufacturing Cost Guide 2.0: (https://www.nist.gov/services-resources/software/manufacturing-cost-guide) by explaining how to use the tool and providing documentation on how the estimates are calculated. This tool executes economic input-output analysis to examine industry supply chains. It provides estimates of value added and measures of various externalities throughout a selected industry's supply chain and answers questions about how industries supply each other and where in the supply chain externalities occur. The estimates are made at the industry level using the North American Industry Classification System (NAICS). The tool facilitates examining upstream supply chains and to a limited extent downstream supply chains. Although this is based on a static model, it allows flexibility in examining different industries and magnitudes of an industry (e.g., total industry output vs. a portion thereof).

Results are provided for multiple years; thus, a user could compare supply chains between years. Results can also be calculated at varying levels of granularity. For instance, a user might be interested in the supply chain for all of manufacturing or they might be interested in a subsector of manufacturing such as automobile parts. The tool facilitates both levels of granularity. The results of the tool can aid governments, planners, and practitioners in rapidly and cost-effectively understanding potential outcomes of policy decisions, infrastructure projects, efficiency improvements, and supply chain disruptions.

Keywords

Manufacturing, primer, manufacturing cost guide, supply chain, input-output

intended to be used in any situation where a failure could cause risk of injury or damage to property. The software developed by NIST employees is not subject to copyright protection within the United States.

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Acknowledgments

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1. Introduction

Many public research organizations and other change agents seek to improve efficiency in the manufacturing industry. The Manufacturing Cost Guide (MCG) 2.0 estimates the inputs from various industries required to produce selected industry outputs. The tool aids in mapping the flow of goods and services throughout an economy and can be used to answer questions such as:

- What amount of value added from the steel industry is needed for automobile production?
- What externalities are associated with plastic resin manufacturing?
- What industries supply semiconductor manufacturing and what value do they contribute?
- What is the impact of a supply chain disruption in metal ore mining on automotive manufacturing?
- How have input needs changed over time for automobile production?

MCG 2.0 estimates value added (i.e., an industry's contribution to gross domestic product or GDP) and measures of 22 externalities (e.g., acidification potential or energy use).

This tool executes economic input-output analysis. This approach is used to model interdependencies between industries, mapping the flow of goods and services through an economy. A user can select an industry and estimate the value added and/or the externalities associated with the industry and its supply chain. The results reveal values by industry, provided at three levels of granularity. MCG 2.0 improves upon MCG 1.0 [1] by updating data, adopting a more rigorous methodology for estimating supply chain statistics, providing multiple years of analysis at the detailed level, including more externality metrics, and analyzing the impact of supply chain disruption on downstream industries.

1.1. Scope

MCG 2.0 provides calculations for the U.S. economy for the most recent data available at the time of development. The detailed data is for 2012 and 2017 while aggregated data is for 2012 and 2023. This primer provides an overview of how to use the tool and provides documentation on how the estimates are calculated.

1.2. Approach

The approaches used here follow those of traditional economic input-output (I-O) analysis. The MCG tool makes the results of such analyses more accessible to non-experts and those who aim to make rapid supply chain estimates. I-O Analysis is viewed as an economic modeling

technique used to understand how different sectors of an economy are interconnected. It examines how the output of one industry serves as an input for another, creating a network of economic relationships. By organizing these relationships into a structured table, the model shows how changes in demand in one sector—such as increased consumer spending or government investment—affect production, income, and employment in other sectors. Frequently, I-O analysis is used by analysts to estimate the direct and indirect effects of economic activities, making it useful for policy evaluation, regional planning, and impact assessment. The intended application here is for understanding the inputs needed for production in order to better target costs to improve industry level efficiency as well as improve supply chain resilience. The methods for estimating the values are presented in Appendix A.1.

1.3. Data

The economic data utilized in this tool includes the Bureau of Economic Analysis' (BEA) input output data, including:

- Use Table After Redefinitions [2]
- Total Requirements Table After Redefinitions [2]
- Import Matrix After Redefinitions [2]

For externalities, the data was drawn from the USEEIO v2.0.1-411 data set [3]. It is a U.S. extended input-output model dataset that includes sector disaggregation data, model component matrices, result matrices, and supporting metadata. It is designed to represent current U.S. economic and externality relationships across all 50 states and is used to estimate externalities associated with goods and services at a macro-scale. The tool also utilizes weights from the default weights from NIST's Building for Environmental and Economic Sustainability (BEES software) tool [4].

1.4. Application

Many efficiency or productivity analyses focus on direct inputs (e.g., labor, energy, and materials) within an establishment; however, prominent costs, losses, inefficiencies, and externalities can occur at different points in a supply chain, including the supply chains of other goods. Analyses focused on individual establishments can obscure these types of costs/losses.

The MCG tool addresses this limitation for change agents (i.e., those who aim to advance innovation and industrial competitiveness such as governments, trade organizations, universities, and think tanks) and manufacturers by identifying where these costs originate and propagate. Further, it can reveal where the industries are in the supply chain that drive both the highest costs and externalities, guiding stakeholders to where efficiency and productivity investments might have the greatest impact.

2. Using the MCG 2.0 Tool

MCG 2.0 is embedded in a Microsoft Excel file that can be downloaded from the National Institute of Standards and Technology website: https://www.nist.gov/services-resources/software/manufacturing-cost-guide. The tool requires Microsoft Excel to be installed with the optimal version being Microsoft Excel version 2508 Build 16.0.19127.20532, as this is the version that was used during the tool's creation. Some familiarity with Microsoft Excel is recommended but not required to use this tool.

The opening screen is shown in Figure 2.1. To get started with examining manufacturing costs, click the "Let's Get Started" button (if shown, you will have to click the 'Enable Content' button at the top of the Excel screen to enable macros). This takes the user to the next tab, which is the "Analysis Type" tab. Note that tabs are the worksheet tabs used in Microsoft Excel and are located near the bottom of the Excel window.

The tool guides the user through a series of tabs to narrow the scope of the analysis. A map of these tabs is provided in Figure 2.2. The first tab is the "Introduction" tab. The next tab is the "Analysis Type" followed by the "Analysis Level" tab and "Select Industries" tab. Depending on whether the user opts to examine externalities, there is a "Weighting" tab to prioritize externality impact categories followed by a "Review Inputs" tab. Finally, the results are presented in one or two tabs depending on user selections.

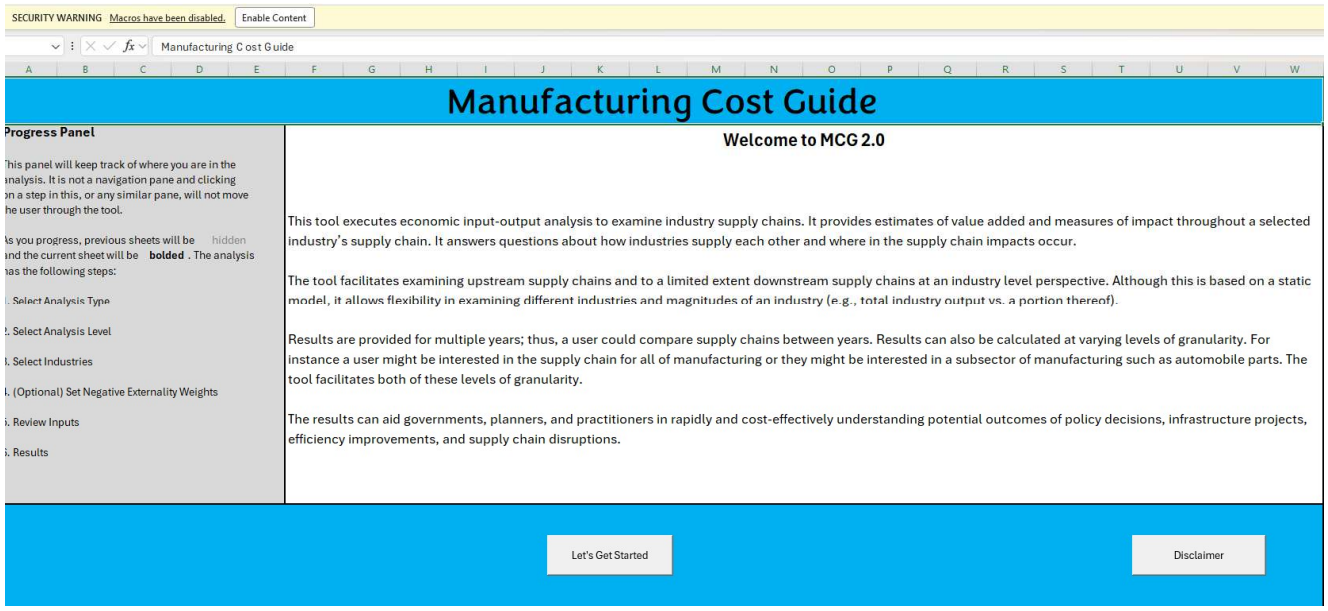


Figure 2.1: Opening Screen of The Manufacturing Cost Guide

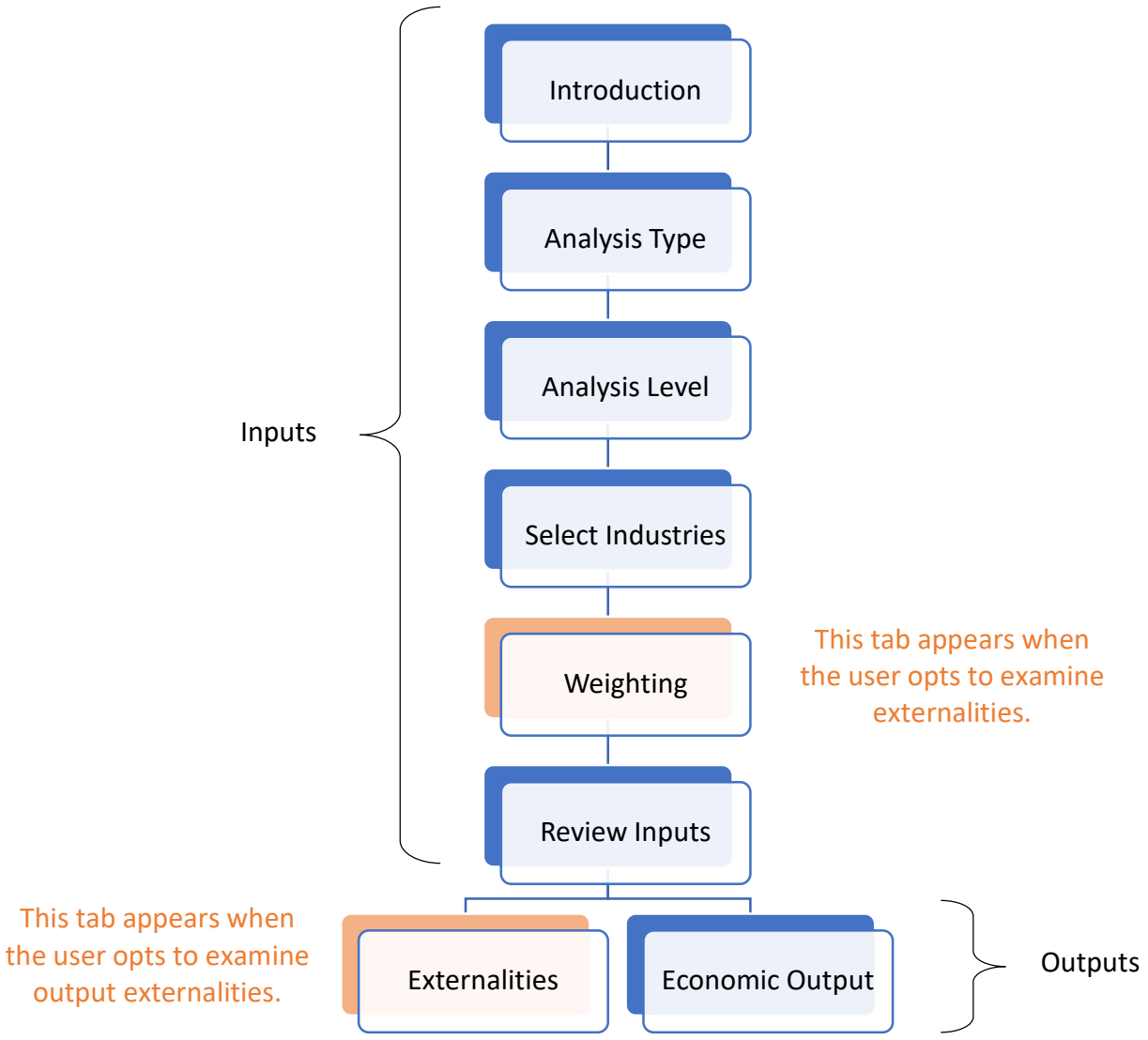


Figure 2.2: Workflow Map of Manufacturing Cost Guide Tabs

The "Analysis" tab presents two sets of options, as seen in Figure 2.3. The first option is to select from a set of three radio buttons indicating whether the user wants to examine one of the following:

- Total Industry Output – The user selects one or more industries, and the results represent, by industry, the total output, value added, and/or externalities associated with the user selected industries (both for goods and services).
- User Defined Industry Output - The user selects one or more industries along with a dollar value for each industry. The results represent the output, value added, and/or externalities associated with the dollar value and industry combinations.
- Downstream Analysis – The user selects a combination of industries and a dollar value, typically representing a disruption. The first industry would be the industry that is

unable to deliver the total needed goods/services. The second industry is the one that does not receive the goods/services. The user selected dollar value represents the level of disruption or the amount that goes undelivered. The results represent the direct and indirect losses that might occur downstream as a result of the disruption.

The second option on the page is a check box indicating whether to include externalities, which includes the items listed in Table 2.1.

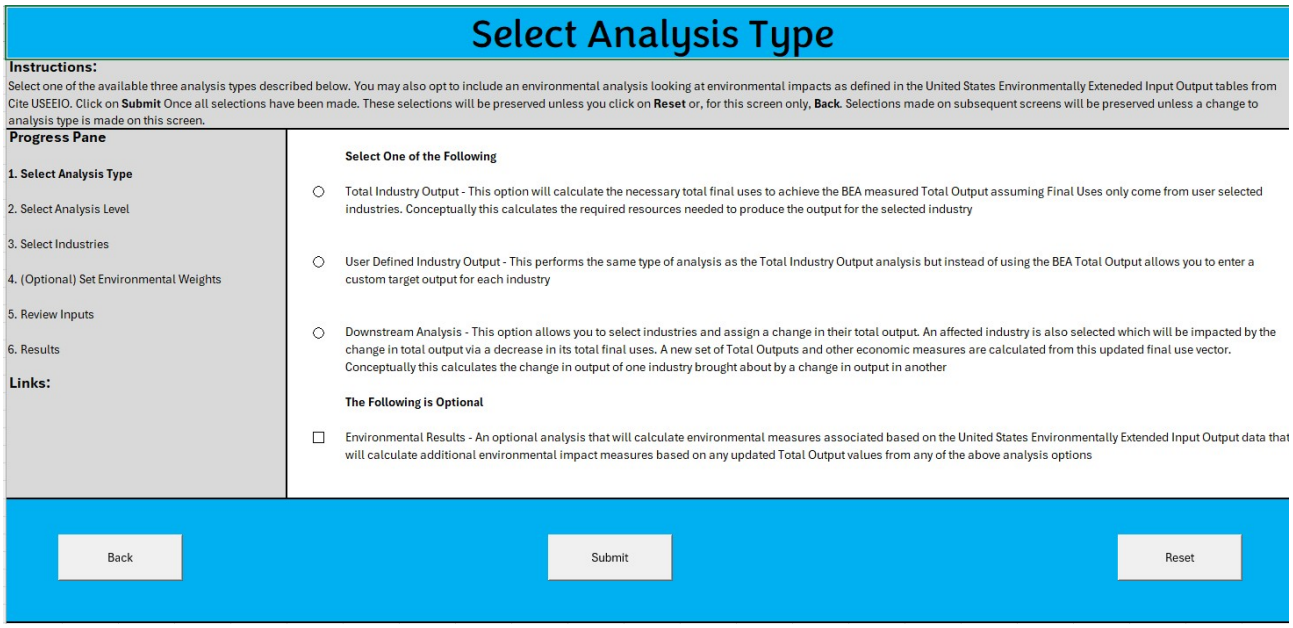


Figure 2.3: "Analysis Type" Tab

Once the user clicks “Submit,” the next tab is the “Analysis Level” tab where there are three options. The first is a set of radio buttons to select the level of granularity for the analysis:

- Total Industry Aggregation - The analysis will use a broad-level of aggregation for U.S. economic activity consisting of 15 total industry categories.
- Sector Aggregation - The analysis will use a mid-level of aggregation for U.S. economic activity consisting of 71 total industry categories.
- Subsector Aggregation - The analysis will use a detailed-level of aggregation for U.S. economic activity consisting of 402 total industry categories.

If the user wishes to examine broader industry activity, they should choose the *Total Industry Aggregation* or the *Sector Aggregation.* If they prefer to examine detailed industries they should choose the *Subsector Aggregation.* All models encompass the entirety of the U.S. economy, but they vary in their granularity.

The other two options on this tab are to select the year for the data analysis. Note that the different levels of aggregation are available for different years. The most recent data available at the detailed-level aggregation is for 2017 while that for the other two levels of aggregation

are estimated for 2023. This option can be helpful for understanding how much the data changes over time.

Table 2.1: Externalities

Externalities
Acidification Potential (kg SO_2 eq)
Commercial Construction and Demolition Debris (kg)
Commercial Municipal Solid Waste (kg)
Commercial RCRA Hazardous Waste (kg)
Energy Use (MJ)
Eutrophication Potential (kg N eq)
Freshwater Ecotoxicity Potential (CTU_e)
Freshwater Withdrawals (kg)
Greenhouse Gases (kg CO_2 eq)
Hazardous Air Pollutants (kg)
Human Health - Cancer (CTU_h)
Human Health - Noncancer (CTUh)
Human Health - Respiratory Effects (kg $PM_{2.5}$ eq)
Human Health Toxicity (CTU_h)
Jobs Supported (jobs)
Land Use (m^2-yr)
Minerals and Metals Use (kg)
Nonrenewable Energy Use (MJ)
Ozone Depletion (kg CFC-11 eq)
Pesticides (kg)
Renewable Energy Use (MJ)
Smog Formation Potential (kg O_3 eq)

The next tab that appears after clicking “Submit” is where the user selects the industries to be analyzed (see Figure 2.4) where the results will represent the inputs needed to produce the output from the industry selected. Multiple industries can be selected; however, as more industries are selected there is an increase in the potential for the tool to be unable to estimate the results, as there is a system of equations being solved (see Appendix A.1). Selecting many industries may result in no valid solution being found. To address this issue, the “Analysis Level” tab provides options for varying levels of aggregation, so that the user can select a single broad level rather than many detailed level industries and avoid the risk that there is not a clear result. If the user selected “User Defined Industry Output” in the “Analysis Type” tab, there will be a column labeled “Enter Dollar Amount” where the user indicates the dollar amount of an industry to examine. The default value is the observed value of final demand. The results will show the amount needed from each industry to produce that amount of final demand the user indicates on this tab. The total industry output shows the total effect of the industries selected. The industries are organized by the North American Industry Classification System or NAICS.

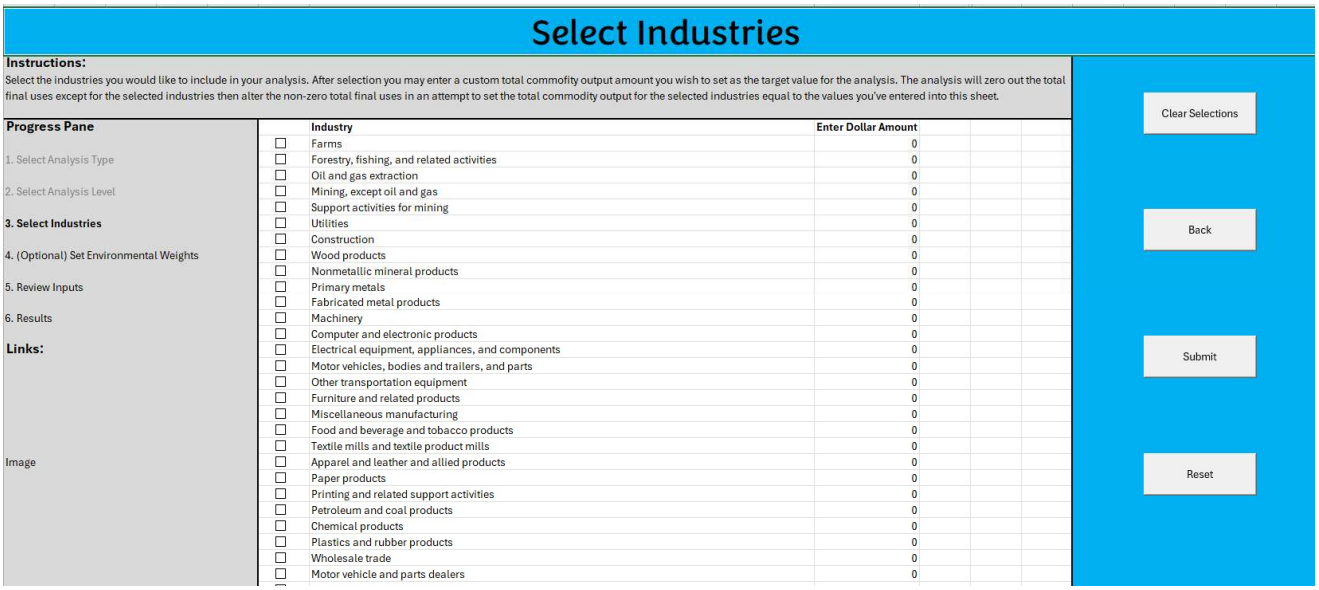


Figure 2.4: "Select Industries" Tab for "User Defined Industry Output" Analysis

If the user selected "Downstream" analysis on the "Analysis Type" tab, when they click submit the "Select Industries" tab will have a column labeled "Enter Dollar Amount" and one to select "Affected Industry." The user selects the industry that is providing supplies to another industry. Then, the user indicates the amount of supply that they want to examine. Then they indicate the industry that is affected. This can be viewed as examining a disruption:

- The industry selected is the supplier being affected, the dollar amount is the amount that fails to reach the customer, and
- The "affected industry" is the customer that does not receive goods/services.

The results represent the amount of goods/services that could not be produced as a result of the shortage along with the supply chain affects of the lost production of goods/services. Note that this represents a shortage immediately when those goods or services are needed for the production of goods and/or services and do not account for buffers that are created by inventories.

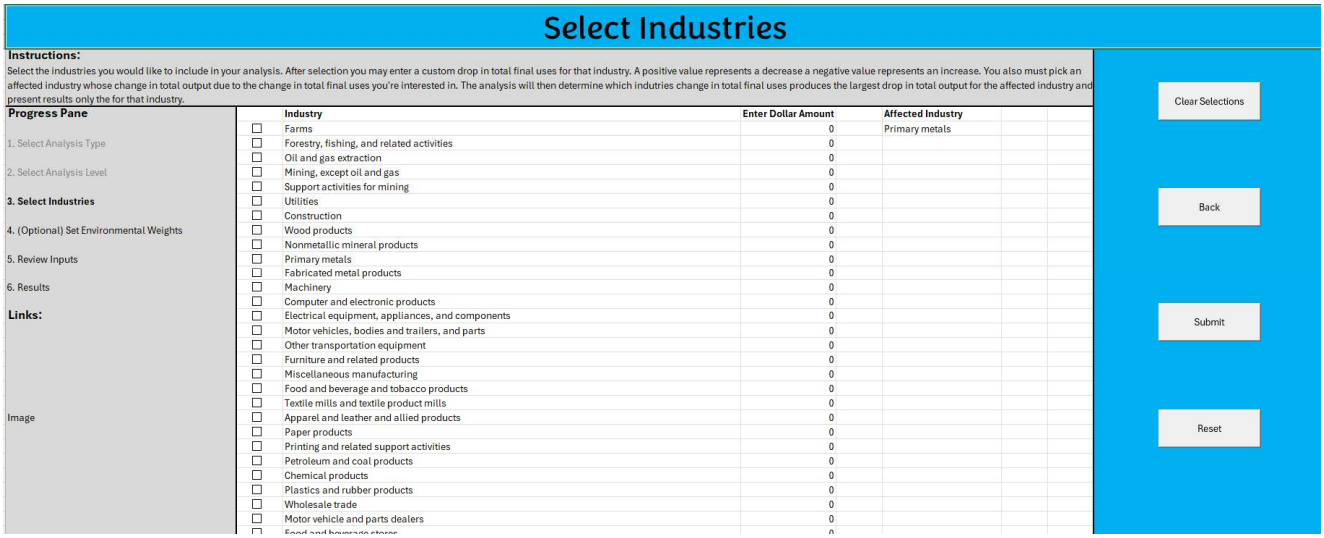


Figure 2.5: "Select Industries" Tab for "Downstream" Analysis

If the user opted to examine externalities, the next tab will be the "Weighting" tab, where the user selects weights for each externality. The results will include both the associated amounts of each externality along with a weighted total for all 22 externalities. The default weights are from NIST's Building for Environmental and Economic Sustainability (BEES software) [5]. Note that the BEES tool does not have all of the same metrics; thus, for those metrics that are not in BEES are zero for the default value. The weights must sum to one.

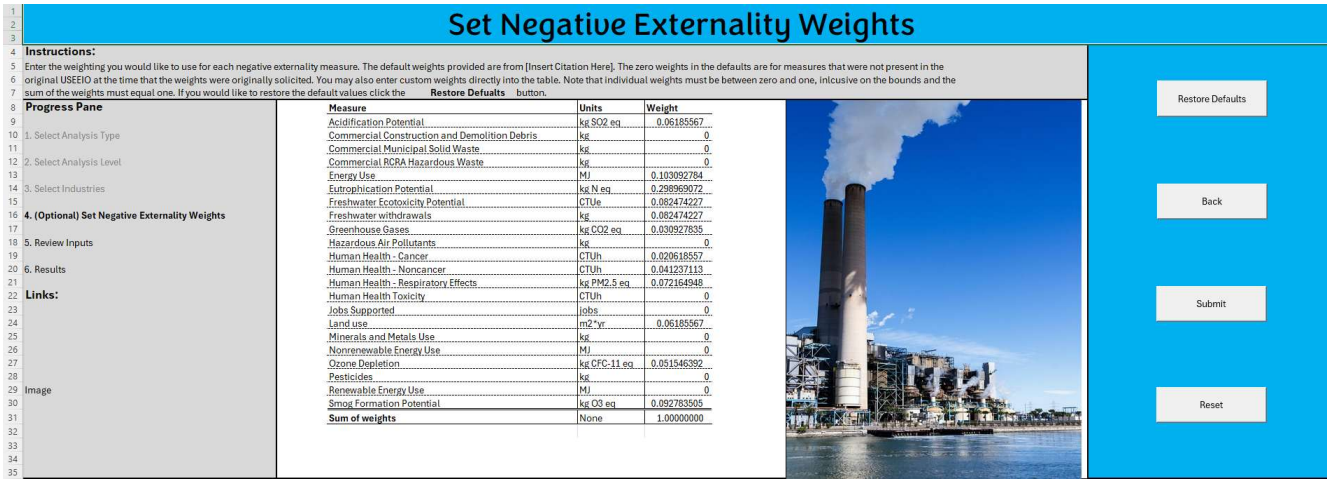
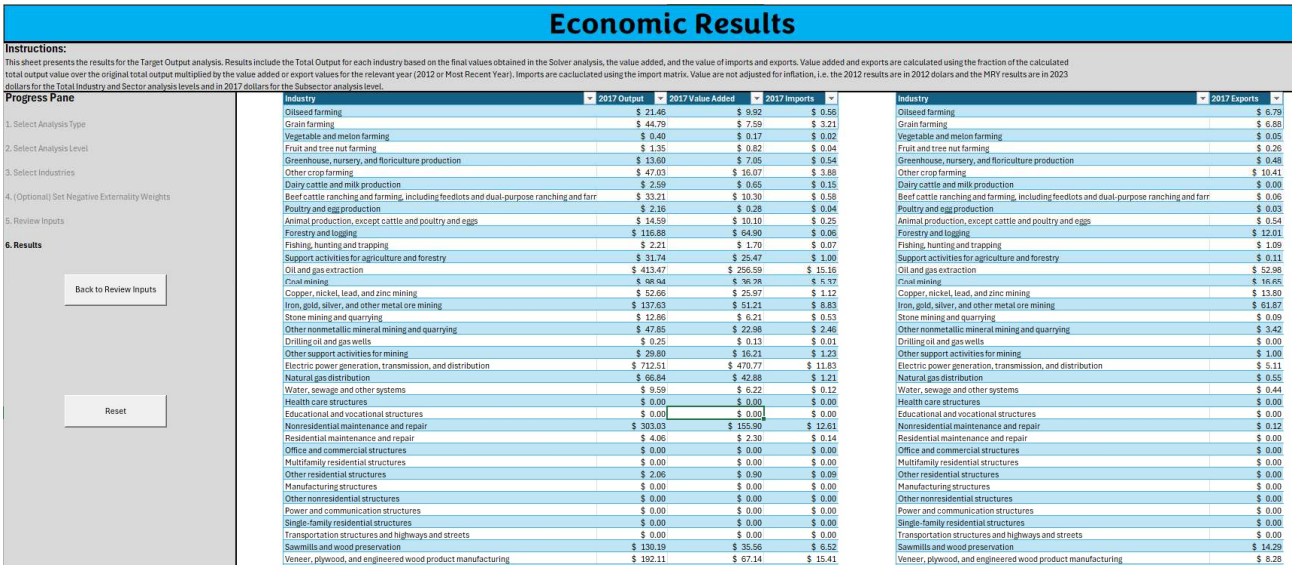


Figure 2.6: "Weighting" Tab

If the user did not opt to examine externalities the next tab is the "Review Inputs" tab. This tab is also the next tab after clicking submit on the "Weighting" tab. On the "Review Inputs" tab the

user can examine all the selections before running the tool. Once the user clicks the "Run" button, the tool will estimate the results, which may take a few moments. An example of the "Economic Results" tab is shown in Figure 2.7, which is for the "Subsector Aggregation" and shows 2017 output, value added, and imports associated with the industry selected, which was automobile manufacturing. When the user selects additional data such as the 2012 data option and/or the externalities data, they are added as additional columns into the table, as shown in Figure 2.8.



Economic Results

Instructions:

This sheet presents the results for the Target Output analysis. Results include the Total Output for each industry based on the final values obtained in the Solver analysis, the value added, and the value of imports and exports. Value added and exports are calculated using the fraction of the calculated total output value over the original total output multiplied by the value added or export values for the relevant year (2012 or Most Recent Year). Imports are caclucliated using the import matrix. Value are not adjusted for inflation, i.e. the 2012 results are in 2012 dolars and the MRY results are in 2023 dollars for the Total Industry and Sector analysis levels and in 2017 dollars for the Subsector analysis level.

Progress Pane

1. Select Analysis Type
2. Select Analysis Level
3. Select Industries
4. (Optional) Set Negative Externality Weights
5. Review Inputs
6. **Results**

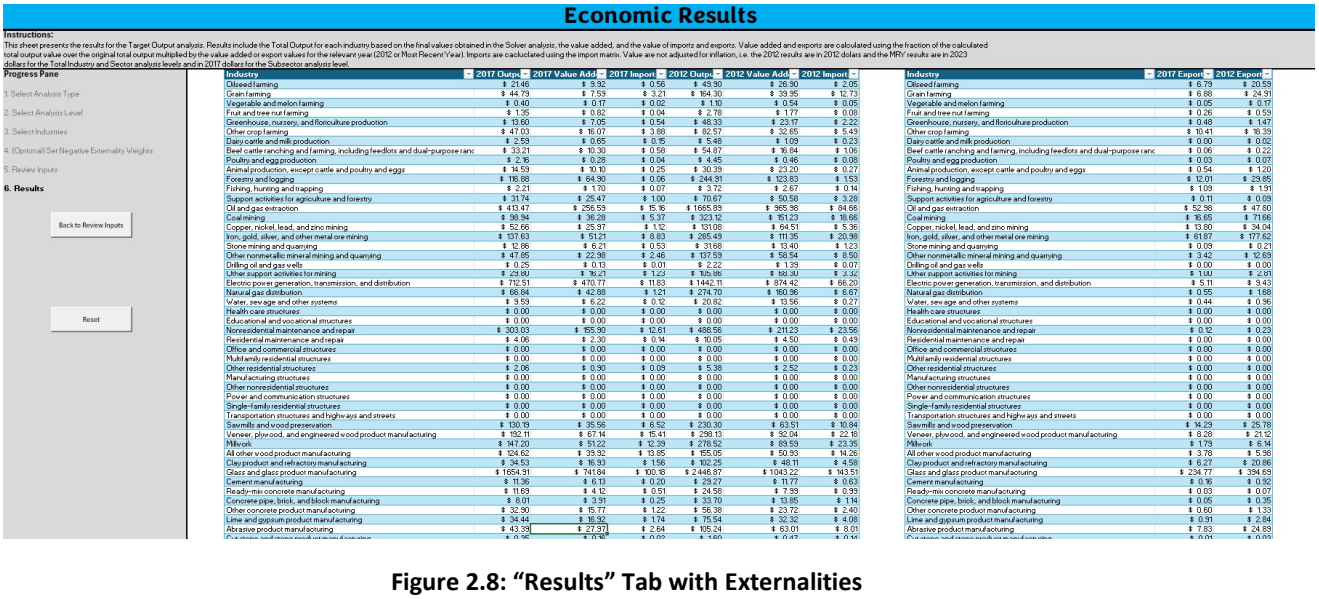
Back to Review Inputs

Reset

Industry	2017 Output	2017 Value Added	2017 Imports
Oilseed farming	$ 21.46	$ 9.92	$ 0.56
Grain farming	$ 44.79	$ 7.59	$ 3.21
Vegetable and melon farming	$ 0.40	$ 0.17	$ 0.02
Fruit and tree nut farming	$ 1.35	$ 0.82	$ 0.04
Greenhouse, nursery, and floriculture production	$ 13.60	$ 7.05	$ 0.54
Other crop farming	$ 47.03	$ 16.07	$ 3.88
Dairy cattle and milk production	$ 2.59	$ 0.65	$ 0.15
Beef cattle ranching and farming, including feedlots and dual-purpose ranching and farr	$ 33.21	$ 10.30	$ 0.58
Poultry and egg production	$ 2.16	$ 0.28	$ 0.04
Animal production, except cattle and poultry and eggs	$ 14.59	$ 10.10	$ 0.25
Forestry and logging	$ 116.88	$ 64.90	$ 0.06
Fishing, hunting and trapping	$ 2.21	$ 1.70	$ 0.07
Support activities for agriculture and forestry	$ 31.74	$ 25.47	$ 1.00
Oil and gas extraction	$ 413.47	$ 256.59	$ 15.16
Coal mining	$ 98.94	$ 36.28	$ 5.37
Copper, nickel, lead, and zinc mining	$ 52.66	$ 25.97	$ 1.12
Iron, gold, silver, and other metal ore mining	$ 137.63	$ 51.21	$ 8.83
Stone mining and quarrying	$ 12.86	$ 6.21	$ 0.53
Other nonmetallic mineral mining and quarrying	$ 47.85	$ 22.98	$ 2.46
Drilling oil and gas wells	$ 0.25	$ 0.13	$ 0.01
Other support activities for mining	$ 29.80	$ 16.21	$ 1.23
Electric power generation, transmission, and distribution	$ 712.51	$ 470.77	$ 11.83
Natural gas distribution	$ 66.84	$ 42.88	$ 1.21
Water, sewage and other systems	$ 9.59	$ 6.22	$ 0.12
Health care structures	$ 0.00	$ 0.00	$ 0.00
Educational and vocational structures	$ 0.00	$ 0.00	$ 0.00
Nonresidential maintenance and repair	$ 303.03	$ 155.90	$ 12.61
Residential maintenance and repair	$ 4.06	$ 2.30	$ 0.14
Office and commercial structures	$ 0.00	$ 0.00	$ 0.00
Multifamily residential structures	$ 0.00	$ 0.00	$ 0.00
Other residential structures	$ 2.06	$ 0.90	$ 0.09
Manufacturing structures	$ 0.00	$ 0.00	$ 0.00
Other nonresidential structures	$ 0.00	$ 0.00	$ 0.00
Power and communication structures	$ 0.00	$ 0.00	$ 0.00
Single-family residential structures	$ 0.00	$ 0.00	$ 0.00
Transportation structures and highways and streets	$ 0.00	$ 0.00	$ 0.00
Sawmills and wood preservation	$ 130.19	$ 35.56	$ 6.52
Veneer, plywood, and engineered wood product manufacturing	$ 192.11	$ 67.14	$ 15.41

Industry	2017 Exports
Oilseed farming	$ 6.79
Grain farming	$ 6.88
Vegetable and melon farming	$ 0.05
Fruit and tree nut farming	$ 0.26
Greenhouse, nursery, and floriculture production	$ 0.48
Other crop farming	$ 10.41
Dairy cattle and milk production	$ 0.00
Beef cattle ranching and farming, including feedlots and dual-purpose ranching and farr	$ 0.06
Poultry and egg production	$ 0.03
Animal production, except cattle and poultry and eggs	$ 0.54
Forestry and logging	$ 12.01
Fishing, hunting and trapping	$ 1.09
Support activities for agriculture and forestry	$ 0.11
Oil and gas extraction	$ 52.98
Coal mining	$ 16.66
Copper, nickel, lead, and zinc mining	$ 13.80
Iron, gold, silver, and other metal ore mining	$ 61.87
Stone mining and quarrying	$ 0.09
Other nonmetallic mineral mining and quarrying	$ 3.42
Drilling oil and gas wells	$ 0.00
Other support activities for mining	$ 1.00
Electric power generation, transmission, and distribution	$ 5.11
Natural gas distribution	$ 0.55
Water, sewage and other systems	$ 0.44
Health care structures	$ 0.00
Educational and vocational structures	$ 0.00
Nonresidential maintenance and repair	$ 0.12
Residential maintenance and repair	$ 0.00
Office and commercial structures	$ 0.00
Multifamily residential structures	$ 0.00
Other residential structures	$ 0.00
Manufacturing structures	$ 0.00
Other nonresidential structures	$ 0.00
Power and communication structures	$ 0.00
Single-family residential structures	$ 0.00
Transportation structures and highways and streets	$ 0.00
Sawmills and wood preservation	$ 14.29
Veneer, plywood, and engineered wood product manufacturing	$ 8.28

Figure 2.7: "Results" Tab



Economic Results

Instructions:

This sheet presents the results for the Target Output analysis. Results include the Total Output for each industry based on the final values obtained in the Solver analysis, the value added, and the value of imports and exports. Value added and exports are calculated using the fraction of the calculated total output value over the original total output multiplied by the value added or export values for the relevant year (2012 or Most Recent Year). Imports are caclucliated using the import matrix. Value are not adjusted for inflation, i.e. the 2012 results are in 2012 dolars and the MRY results are in 2023 dollars for the Total Industry and Sector analysis levels and in 2017 dollars for the Subsector analysis level.

Progress Pane

1. Select Analysis Type
2. Select Analysis Level
3. Select Industries
4. (Optional) Set Negative Externality Weights
5. Review Inputs
6. **Results**

Back to Review Inputs

Reset

Industry	2017 Outpu	2017 Value Add	2017 Import	2012 Outpu	2012 Value Add	2012 Import
Oilseed farming	$ 21.46	$ 9.92	$ 0.56	$ 43.95	$ 26.50	$ 2.05
Grain farming	$ 44.79	$ 7.59	$ 3.21	$ 164.30	$ 39.95	$ 12.73
Vegetable and melon farming	$ 0.40	$ 0.17	$ 0.02	$ 1.10	$ 0.54	$ 0.05
Fruit and tree nut farming	$ 1.35	$ 0.82	$ 0.04	$ 2.76	$ 1.77	$ 0.09
Greenhouse, nursery, and floriculture production	$ 13.60	$ 7.05	$ 0.54	$ 48.33	$ 23.17	$ 2.22
Other crop farming	$ 47.03	$ 16.07	$ 3.88	$ 82.57	$ 32.65	$ 5.43
Dairy cattle and milk production	$ 2.59	$ 0.65	$ 0.15	$ 5.48	$ 1.69	$ 0.23
Beef cattle ranching and farming, including feedlots and dual-purpose ranc	$ 33.21	$ 10.30	$ 0.58	$ 54.87	$ 16.84	$ 1.06
Poultry and egg production	$ 2.16	$ 0.28	$ 0.04	$ 4.45	$ 0.46	$ 0.08
Animal production, except cattle and poultry and eggs	$ 14.59	$ 10.10	$ 0.25	$ 30.39	$ 23.20	$ 0.27
Forestry and logging	$ 116.88	$ 64.90	$ 0.06	$ 244.91	$ 123.83	$ 1.53
Fishing, hunting and trapping	$ 2.21	$ 1.70	$ 0.07	$ 3.72	$ 2.67	$ 0.14
Support activities for agriculture and forestry	$ 31.74	$ 25.47	$ 1.00	$ 70.67	$ 50.58	$ 3.28
Oil and gas extraction	$ 413.47	$ 256.59	$ 15.16	$ 1665.89	$ 365.36	$ 84.66
Coal mining	$ 98.94	$ 36.28	$ 5.37	$ 323.12	$ 151.23	$ 18.66
Copper, nickel, lead, and zinc mining	$ 52.66	$ 25.97	$ 1.12	$ 131.08	$ 64.51	$ 5.36
Iron, gold, silver, and other metal ore mining	$ 137.63	$ 51.21	$ 8.83	$ 285.43	$ 111.35	$ 20.98
Stone mining and quarrying	$ 12.86	$ 6.21	$ 0.53	$ 31.68	$ 13.40	$ 1.23
Other nonmetallic mineral mining and quarrying	$ 47.85	$ 22.98	$ 2.46	$ 137.53	$ 58.54	$ 8.50
Drilling oil and gas wells	$ 0.25	$ 0.13	$ 0.01	$ 2.22	$ 1.33	$ 0.07
Other support activities for mining	$ 29.80	$ 16.21	$ 1.23	$ 165.86	$ 88.30	$ 3.32
Electric power generation, transmission, and distribution	$ 712.51	$ 470.77	$ 11.83	$ 1442.11	$ 874.42	$ 66.20
Natural gas distribution	$ 66.84	$ 42.88	$ 1.21	$ 274.70	$ 160.96	$ 6.67
Water, sewage and other systems	$ 9.59	$ 6.22	$ 0.12	$ 20.82	$ 13.56	$ 0.27
Health care structures	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00
Educational and vocational structures	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00
Nonresidential maintenance and repair	$ 303.03	$ 155.90	$ 12.61	$ 488.56	$ 211.23	$ 23.56
Residential maintenance and repair	$ 4.06	$ 2.30	$ 0.14	$ 10.05	$ 4.50	$ 0.49
Office and commercial structures	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00
Multifamily residential structures	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00
Other residential structures	$ 2.06	$ 0.90	$ 0.09	$ 5.38	$ 2.52	$ 0.23
Manufacturing structures	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00
Other nonresidential structures	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00
Power and communication structures	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00
Single-family residential structures	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00
Transportation structures and highways and streets	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00
Sawmills and wood preservation	$ 130.19	$ 35.56	$ 6.52	$ 230.30	$ 63.51	$ 10.84
Veneer, plywood, and engineered wood product manufacturing	$ 192.11	$ 67.14	$ 15.41	$ 298.13	$ 92.04	$ 22.18
Millwork	$ 147.20	$ 51.22	$ 12.39	$ 278.52	$ 89.59	$ 23.35
All other wood product manufacturing	$ 124.62	$ 39.92	$ 13.65	$ 155.05	$ 50.93	$ 14.26
Clay product and refractory manufacturing	$ 34.53	$ 16.13	$ 1.56	$ 102.25	$ 48.11	$ 4.58
Glass and glass product manufacturing	$ 1654.31	$ 741.84	$ 100.18	$ 2446.87	$ 1043.22	$ 143.51
Cement manufacturing	$ 11.36	$ 6.13	$ 0.20	$ 29.27	$ 11.77	$ 0.63
Ready-mix concrete manufacturing	$ 11.69	$ 4.12	$ 0.51	$ 24.56	$ 7.89	$ 0.93
Concrete pipe, brick, and block manufacturing	$ 8.01	$ 3.91	$ 0.25	$ 33.70	$ 13.85	$ 1.14
Other concrete product manufacturing	$ 32.90	$ 15.77	$ 1.22	$ 56.38	$ 23.72	$ 2.40
Lime and gypsum product manufacturing	$ 34.44	$ 16.32	$ 1.74	$ 75.54	$ 32.32	$ 4.08
Abrasive product manufacturing	$ 43.39	$ 27.97	$ 2.64	$ 105.24	$ 63.01	$ 8.01

Industry	2017 Export	2012 Export
Oilseed farming	$ 6.79	$ 20.59
Grain farming	$ 6.88	$ 24.91
Vegetable and melon farming	$ 0.05	$ 0.17
Fruit and tree nut farming	$ 0.26	$ 0.53
Greenhouse, nursery, and floriculture production	$ 0.48	$ 1.47
Other crop farming	$ 10.41	$ 18.39
Dairy cattle and milk production	$ 0.00	$ 0.02
Beef cattle ranching and farming, including feedlots and dual-purpose ranc	$ 0.06	$ 0.22
Poultry and egg production	$ 0.03	$ 0.07
Animal production, except cattle and poultry and eggs	$ 0.54	$ 1.20
Forestry and logging	$ 12.01	$ 23.85
Fishing, hunting and trapping	$ 1.09	$ 1.91
Support activities for agriculture and forestry	$ 0.11	$ 0.09
Oil and gas extraction	$ 52.98	$ 47.80
Coal mining	$ 16.65	$ 71.66
Copper, nickel, lead, and zinc mining	$ 13.80	$ 34.04
Iron, gold, silver, and other metal ore mining	$ 61.87	$ 177.62
Stone mining and quarrying	$ 0.09	$ 0.21
Other nonmetallic mineral mining and quarrying	$ 3.42	$ 12.68
Drilling oil and gas wells	$ 0.00	$ 0.00
Other support activities for mining	$ 1.00	$ 2.91
Electric power generation, transmission, and distribution	$ 5.11	$ 9.43
Natural gas distribution	$ 0.55	$ 1.68
Water, sewage and other systems	$ 0.44	$ 0.96
Health care structures	$ 0.00	$ 0.00
Educational and vocational structures	$ 0.00	$ 0.00
Nonresidential maintenance and repair	$ 0.12	$ 0.23
Residential maintenance and repair	$ 0.00	$ 0.00
Office and commercial structures	$ 0.00	$ 0.00
Multifamily residential structures	$ 0.00	$ 0.00
Other residential structures	$ 0.00	$ 0.00
Manufacturing structures	$ 0.00	$ 0.00
Other nonresidential structures	$ 0.00	$ 0.00
Power and communication structures	$ 0.00	$ 0.00
Single-family residential structures	$ 0.00	$ 0.00
Transportation structures and highways and streets	$ 0.00	$ 0.00
Sawmills and wood preservation	$ 14.29	$ 25.78
Veneer, plywood, and engineered wood product manufacturing	$ 8.28	$ 21.12
Millwork	$ 1.79	$ 6.14
All other wood product manufacturing	$ 3.78	$ 5.98
Clay product and refractory manufacturing	$ 6.27	$ 20.86
Glass and glass product manufacturing	$ 234.77	$ 394.69
Cement manufacturing	$ 0.16	$ 0.92
Ready-mix concrete manufacturing	$ 0.03	$ 0.07
Concrete pipe, brick, and block manufacturing	$ 0.05	$ 0.35
Other concrete product manufacturing	$ 0.60	$ 1.33
Lime and gypsum product manufacturing	$ 0.91	$ 2.84
Abrasive product manufacturing	$ 7.83	$ 24.89

Figure 2.8: "Results" Tab with Externalities

3. Case Study: Plastics

This section presents an analysis of the plastics manufacturing industry demonstrating MCG 2.0. Note that the true number of significant figures for the results are not strictly known because total model uncertainty is not fully characterized. Dollar results are rounded to the nearest whole number while externalities are shown at three significant figures. Plastics manufacturing sectors by 6-digit NAICS codes are provided in Table 3.1. There are 14 NAICS codes for plastics manufacturing, which are aggregated into 10 for MCG 2.0. Two of the NAICS codes are relevant to producing resin or synthetic rubber while the remaining codes use these materials to produce products. This case study includes an analysis of output, value added, and externalities. A comparison of the 2012 and 2017 analyses were made to see if there were substantial relative changes. It also simulates a $100 shortage of *Rubber and Plastics Hoses and Belting* for Automobile Manufacturing. Note that this is conceptual in that it is a $100 of materials not available at the time of production. In a real-world scenario, $100 of materials would likely be available through inventory buffers.

To analyze the output, value added, and externalities associated with plastics and its supply chain, the following selections in the tool were made:

- Analysis Type
    - “Total Industry Output” selected
    - “Negative Externality Results” selected
- Analysis Level
    - “Subsector Aggregation” selected
    - “2012 BEA Data” selected
    - “Most Recent Year Data” selected
- Industries
    - The industries selected include those in Table 3.1
- Externality Weights
    - The default weights were used.

To simulate a $100 shortage of *Rubber and plastics Hoses and Belting* for Automobile Manufacturing, the following selections in the tool were made:

- Analysis Type
    - “Downstream Analysis” selected
- Analysis Level
    - “Subsector Aggregation” selected
    - “Most Recent Year Data” selected
- Industries

- Industry: The industries selected include those in Table 3.1
- Affected Industry: Automobile Manufacturing

The result of the value added and output analysis are shown in Table 3.2, which includes the top 25 supply chain industries, including the plastics industries themselves, by value added. Output and value added are two different metrics where output is similar to revenue and value added is output less items purchased from other establishments. The results from the tool show what output or value added is needed from each industry to produce plastics (i.e., the industries we selected in Table 3.1. It includes the value that the plastics industries contribute as well. The largest non-plastics industry (i.e., plastic industries are those in Table 3.1) is Other Nondurable Goods Merchant Wholesalers. As shown in Table 3.2, Nondurable Goods Merchant Wholesalers contributes $17 108 million in output or $9 939 in value added to the plastics manufacturing industries. Electric power generation, transmission, and distribution is among the top 10. An examination of the rankings of the supply chain for plastics manufacturing industries shows a Spearman correlation coefficient of 0.9808, which is high;

Table 3.1: NAICS Codes for Plastics Manufacturing

BEA 2017 NAICS code	2017 NAICS code	Meaning of NAICS code
325211	325211	Plastics material and resin manufacturing
3252AO (includes 325220)	325212	Synthetic rubber manufacturing (32522: Artificial and Synthetic Fibers and Filaments Manufacturing)
326110	326111	Plastics bag and pouch manufacturing
	326112	Plastics packaging film and sheet (including laminated) manufacturing
	326113	Unlaminated plastics film and sheet (except packaging) manufacturing
326120	326121	Unlaminated plastics profile shape manufacturing
	326122	Plastics pipe and pipe fitting manufacturing
326130	326130	Laminated plastics plate, sheet (except packaging), and shape manufacturing
326140	326140	Polystyrene foam product manufacturing
326150	326150	Urethane and other foam product (except polystyrene) manufacturing
326160	326160	Plastics bottle manufacturing
326190	326191	Plastics plumbing fixture manufacturing
	326199	All other plastics product manufacturing
326220	326220	Rubber and plastics hoses and belting manufacturing

Table 3.2: Plastic and Synthetic Rubber (Top 25 by Value Added), $million 2017

Industry	2017 Output	2017 Value Added	2017 Imports
Other plastics product manufacturing	98 121	31 879	8 476
Plastics material and resin manufacturing	87 378	21 439	9 500
Plastics packaging materials and unlaminated film and sheet manufacturing	38 144	10 505	3 899
Other nondurable goods merchant wholesalers	17 108	9 939	255
Petrochemical manufacturing	22 127	9 083	1 954
Oil and gas extraction	13 600	8 440	499
Other basic organic chemical manufacturing	31 574	8 208	2 231
Plastics pipe, pipe fitting, and unlaminated profile shape manufacturing	18 396	6 239	1 714
Management of companies and enterprises	9 294	5 974	167
Electric power generation, transmission, and distribution	8 456	5 587	140
Synthetic rubber and artificial and synthetic fibers and filaments manufacturing	14 703	4 829	1 165
Plastics bottle manufacturing	11 018	3 242	1 365
Other real estate	7 859	3 216	117
Truck transportation	6 731	3 185	126
Urethane and other foam product (except polystyrene) manufacturing	10 735	3 130	1 328
Monetary authorities and depository credit intermediation	4 619	3 072	51
Petroleum refineries	16 952	3 071	5 201
Polystyrene foam product manufacturing	9 761	2 631	972
Other basic inorganic chemical manufacturing	5 714	2 618	455
Drugs and druggists' sundries	5 026	2 303	431
Other durable goods merchant wholesalers	4 251	2 281	74
Warehousing and storage	4 340	2 218	99
Rail transportation	3 991	2 206	128
Employment services	3 298	2 124	43
Rubber and plastics hoses and belting manufacturing	5 184	1 952	1 126

however, plastic manufacturing industries are a narrowly defined and, likely, structurally stable set of industries. Plastic sub-industries likely share similar technologies, capital intensity, and downstream demand. Thus, changes in economic conditions might tend to affect them in parallel rather than reshuffling their relative positions. The externalities of plastics manufacturing is shown in Table 3.3. According to the weighted value of impacts, *Grain Farming, Other Basic Organic Chemical Manufacturing,* and *Other Crop Farming* are the top sources of externalities (not shown), likely due to agriculture being a supply chain contributor to producing plastics.

A $100 disruption or shortage in *Rubber and Plastics Hoses and Belting* manufacturing was simulated in the second analysis to examine its effect on *Automobile Manufacturing*. The results represent the effect of a shortage that is not buffered through inventory. The output in automobile manufacturing decreased by $23 230 (see Table 3.4), which is substantial given the small amount of the shortage. This means that for every $100 of *Rubber and Plastics Hoses and Belting* manufacturing downstream there is $23 230 in *Automobile Manufacturing* associated with it. The total decrease in all other manufacturing (not shown) was $41 618.

Table 3.3: Externalities of Plastics Manufacturing

Negative Externalities	Value
Acidification Potential (kg SO2 eq)	294
Commercial Construction and Demolition Debris (kg)	984
Commercial Municipal Solid Waste (kg)	2240
Commercial RCRA Hazardous Waste (kg)	5500
Energy Use (MJ)	2600000
Eutrophication Potential (kg N eq)	122
Freshwater Ecotoxicity Potential (CTUe)	106000
Freshwater Withdrawals (kg)	8410000
Greenhouse Gases (kg CO2 eq)	227000
Hazardous Air Pollutants (kg)	39.2
Human Health - Cancer (CTUh)	0.00003
Human Health - Noncancer (CTUh)	0.00134
Human Health - Respiratory Effects (kg PM2.5 eq)	79.9
Human Health Toxicity (CTUh)	0.0
Jobs Supported (jobs)	1.65
Land Use (m2-yr)	162000
Minerals and Metals Use (kg)	73200
Nonrenewable Energy Use (MJ)	2330000
Ozone Depletion (kg CFC-11 eq)	0.139
Pesticides (kg)	2.64
Renewable Energy Use (MJ)	274000
Smog Formation Potential (kg O3 eq)	4480

Table 3.4: Simulated Effect of a $100 Shortage in Rubber and Plastics Hoses and Belting for Automobile Manufacturing Industry (Top 20 Industries Affected), $2017

Industry	2017 Change in Output
Automobile manufacturing	-23 230
Motor vehicle seating and interior trim manufacturing	-3 262
Motor vehicle gasoline engine and engine parts manufacturing	-2 266
Motor vehicle and motor vehicle parts and supplies	-2 149
Motor vehicle metal stamping	-1 863
Other motor vehicle parts manufacturing	-1 468
Other engine equipment manufacturing	-1 192
Motor vehicle transmission and power train parts manufacturing	-1 169
Iron and steel mills and ferroalloy manufacturing	-1 064
Glass and glass product manufacturing	-1 027
Other durable goods merchant wholesalers	-967
Management of companies and enterprises	-905
Truck transportation	-787
Machinery, equipment, and supplies	-784
Motor vehicle steering, suspension component (except spring), and brake systems manufacturing	-773
Other real estate	-652
Other plastics product manufacturing	-564
Motor vehicle electrical and electronic equipment manufacturing	-546
Other nondurable goods merchant wholesalers	-462
Plastics material and resin manufacturing	-450
Electric power generation, transmission, and distribution	-442

The results of the analysis identify the primary sources of costs, externalities, and the effects of a shortage of materials for *Automobile Manufacturing*. The comparison between 2012 and 2017 data reveals that the relative rankings change very little for this set of industries, making them relevant even if they are dated.

4. Case Study: Downstream Impact of a Shortage of Metal ore Mining on Automobile Manufacturing

A second case study was evaluated to examine the downstream effects of a disruption in NAICS code 2122AO: Iron, gold, silver, and other metal ore mining on automobile manufacturing. This examination used the “Downstream Analysis” along with “Subsector Aggregation” using the BEA 2023 data. A $100 shortage in NAICS 2122AO is estimated for automobile manufacturing. The following selections in the tool were made:

- Analysis Type
    - “Downstream Analysis” selected
- Analysis Level
    - “Subsector Aggregation” selected
    - “Most Recent Year Data” selected
- Industries
    - Industry: “NAICS 2122AO Iron, gold, silver, and other metal ore mining”
    - Affected Industry: Automobile Manufacturing

The results demonstrate the effect of a shortage when it is not buffered by inventory. The total decrease in output was estimated as $75 926. The top 20 industries affected are listed in Table 4.1. Automobile manufacturing decreased by $27 198; thus, there is a substantial impact. Implicitly, for every $1 of production shortage for NAICS 2122AO, there is $272 in lost output for automobile manufacturing.

Table 4.1: Lost Output Due to $100 Production Shortage of NAICS 2122AO (Iron, gold, silver, and other metal ore mining) on the Automobile Manufacturing Industry (Top 20 Losses), $2017

Industry	2017 Change in Output
Automobile manufacturing	-27 198
Motor vehicle seating and interior trim manufacturing	-3 819
Motor vehicle gasoline engine and engine parts manufacturing	-2 653
Motor vehicle and motor vehicle parts and supplies	-2 517
Motor vehicle metal stamping	-2 182
Other motor vehicle parts manufacturing	-1 718
Other engine equipment manufacturing	-1 396
Motor vehicle transmission and power train parts manufacturing	-1 368
Iron and steel mills and ferroalloy manufacturing	-1 246
Glass and glass product manufacturing	-1 202
Other durable goods merchant wholesalers	-1 132
Management of companies and enterprises	-1 060
Truck transportation	-922
Machinery, equipment, and supplies	-918
Motor vehicle steering, suspension component (except spring), and brake systems manufacturing	-905
Other real estate	-763
Other plastics product manufacturing	-660
Motor vehicle electrical and electronic equipment manufacturing	-639
Other nondurable goods merchant wholesalers	-540
Plastics material and resin manufacturing	-527

5. Case Study: The Manufacturing Industry Impact on the U.S. Economy

A third case study estimated the manufacturing industry's impact on the U.S. economy. This analysis used the "Total Industry Output" option with the "Total Industry Aggregation" option. The industry examined was the manufacturing industry, which is labeled as NAICS 31G. In the tool, the following options were selected:

- Analysis Type
  - "Total Industry Output" selected
- Analysis Level
  - "Total Industry Aggregation" selected
  - "Most Recent Year Data" selected
- Industries
  - Industry "31G Manufacturing" selected

The results represent the output or value added that each industry contributes to manufacturing, including the manufacturing industry itself. The total impact in terms of value added (i.e., GDP) for 2023 was $4.5 trillion, as seen in Table 5.1. The industry with the largest ties to manufacturing, outside of manufacturing itself, is the wholesale trade industry.

Table 5.1: The Manufacturing Industry's Impact on the U.S. Economy ($million 2023)

Industry	2023 Output	2023 Value Added
Manufacturing	6 905 203	2 597 480
Wholesale trade	619 320	356 548
Professional and business services	530 143	349 872
Mining	524 015	292 545
Finance, insurance, real estate, rental, and leasing	437 198	271 438
Agriculture, forestry, fishing, and hunting	438 946	193 699
Transportation and warehousing	305 726	164 189
Utilities	89 396	62 027
Information	104 135	60 500
Government	99 355	59 585
Construction	45 028	24 558
Other services, except government	37 751	23 705
Arts, entertainment, recreation, accommodation, and food services	37 763	21 067
Retail trade	30 100	18 968
Educational services, health care, and social assistance	1 441	898
TOTAL	10 205 522	4 497 078

6. Summary

This report presents an overview of MCG 2.0 and demonstrates its application through case studies. MCG 2.0 is an economic input–output analysis tool developed to examine industry supply chains and estimate value added, output, and externalities across industries classified by NAICS codes. The tool allows users to analyze upstream and, to a limited extent, downstream supply chain relationships at varying levels of industry granularity and across multiple years. These capabilities support rapid assessments of supply chain structures, including costs and externalities. It also facilitates examining the structural changes in supply chains over time, providing insight into the extent of data relevancy as it ages.

A case study applies MCG 2.0 to plastics manufacturing, which consists of 14 six-digit NAICS codes aggregated into 10 sectors within the tool. The analysis examines industry output, value added, and externalities, compares results between 2012 and 2017, and simulates a conceptual $100 shortage in Rubber and Plastics Hoses and Belting Manufacturing to assess downstream impacts on Automobile Manufacturing. A second case study was evaluated to examine the downstream effects of a disruption in NAICS code 2122AO: Iron, gold, silver, and other metal ore mining on automobile manufacturing. This examination used the “Downstream Analysis” along with “Subsector Aggregation” using the BEA 2023 data. A third case study estimated the manufacturing industry’s impact on the U.S. economy. This analysis used the “Total Industry Output” option with the “Total Industry Aggregation” option.

In conclusion, the Manufacturing Cost Guide 2.0 provides a practical and flexible framework for understanding complex industry supply chains, their economic contributions, and associated externalities. The case studies demonstrate the tool’s ability to identify key cost drivers, trace the sources of externalities and economic impacts, and quantify the potential downstream consequences of supply disruptions. Together, these results highlight the value of MCG 2.0 as a decision-support resource for decision makers, planners, and practitioners seeking to evaluate potential trade-offs, improve resilience, and make more informed decisions across manufacturing supply chains.

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Appendix A. Methods for Economic Input-Output Analysis

The basic equation for economic input-output analysis is the following:

Equation 1

$$X = (I - A)^{-1} * Y$$

Where

$(I - A)^{-1}$ = Total Requirements Matrix
$X =$ Vector of output required to produce final demand
$Y =$ Vector of final demand, as defined in the BEA Input-Output data
$I =$ Identity matrix
$A =$ Matrix of coefficients

The Bureau of Economic Analysis provides three tables that are used for the related calculations: total requirements matrix represented as $(I - A)^{-1}$, Use table which contains both the vector of final demand (Y) and the vector of output (X), and an import matrix that indicates intermediate imports for each industry. The MCG tool manipulates the vector of final demand (Y) to understand the effects on the vector of output (X). The data that is used for the calculations includes the following:

- Use Table After Redefinitions [2]
- Total Requirements Table After Redefinitions [2]
- Import Matrix After Redefinitions [2]

The methods below are consistent with those presented in Miller and Blair [6]. Concepts and methods regarding Bureau of Economic Analysis input output data can be found in Horowitz and Planting [4].

A.1. Total Industry Output

When the user selects “Total Industry Output” as the analysis type, the model estimates the full supply-chain effects associated with the observed output of the industries selected by the user. The analysis is based on the standard Leontief demand-driven framework.

First, a modified output vector is created in which the industries selected by the user are assigned their actual observed output levels, and all other industries are assigned a value of zero. This modified vector represents production occurring only in the selected industries, holding their observed output constant while excluding all other industries.

Next, the model then calculates the level of final demand required to support this constrained output structure:

Equation 2

$$X' = (I - A)^{-1} * Y'$$

Where

X' = Vector of observed output where unselected industries equal zero.

$Y' =$ is the vector of final demand that must be solved to reproduce X' with unselected industries equaling zero.

The estimated final demand Y' represents the direct final demand necessary to generate the observed production levels of the selected industries. This can require solving a system of equations, which is done using Excel's Solver function. The estimated final demand vector Y' is then used in the standard Leontief model in Equation 1 resulting in X''. The new X'' includes the original observed output levels for the selected industries (by construction) and the indirect output generated in other industries that supply inputs to those industries.

A.2. User Defined Industry Output

If the user selected "User Defined Industry Output," then the industry's they select and their corresponding values will replace corresponding values in the vector of final demand (Y). All unselected values are zero. A new vector of output (X) is then calculated:

Equation 3

$$X'' = (I - A)^{-1} * Y''$$

Where

X'' = Vector of output required to produce final demand where unselected industries equal zero.

$Y'' =$ Vector of final demand where unselected industries are zero.

A.3. Downstream Analysis

For the downstream analysis, the user indicates a source industry (s) and an affected industry (a) along with a value of impact (m). The results are first estimated by taking the value of impact (m) and dividing it by the corresponding value from the total requirements matrix for source industry (s) and the impacted industry (p).

Equation 4

$$q = \frac{m}{R_{a,s}}$$

The value q is then treated as a "User Defined Industry Output" value for the affected industry and utilized in Equation 3.

A.4. Value Added, Externalities, Imports, and Exports

To calculate value added and externalities, the proportion of output calculated above in the vector of output (X' or X'') is divided by the total output found in the original vector of output (X). For "Total Industry Output" analysis type the equation is the following:

Equation 5

$$P_i = \frac{X'_i}{X_i}$$

For the "User Defined Industry Output," X'_i is replaced with X''_i. To calculate value added, the value P_i is multiplied by total value added for industry i:

Equation 6

$$VA'_i = P_i * VA_i$$

Where

VA'_i = The estimated value added

VA_i = Original total value added from the Bureau of Economic Analysis

For externalities, a similar process is performed, except instead of total value added it is the total of a particular externality for the selected industry or industries:

Equation 7

$$NE'_{n,i} = P_i * NE_{n,i}$$

Where

$NE_{n,i}$ = The total of externality n for industry i, where n is 1 of the 22 externalities examined

$NE'_{n,i}$ = The estimated externality n for industry i, where n is 1 of the 22 externalities examined

For imports and exports a similar process is performed where $NE_{n,i}$ is replaced with the total imports or exports for the corresponding industry:

Equation 8

$$T'_{ie,i} = P_i * T_{ie,i}$$

Where

$T_{ie,i}$ = The total value of ie for industry i, where ie is either imports or exports

$T'_{ie,i}$ = The new estimated value of ie for industry i, where ie is either imports or exports

Exports are found in the Bureau of Economic Analysis Use table while imports are the sum of the columns for each industry in the Bureau of Economic Analysis Import Matrix.