Impact Factors: Methodological Standards for Applied Input-Output Analysis

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Abstract

Input-output economics, commonly referred to as economic impact analysis, is a common methodology to examine changes in local, regional, and national economies. Social Accounting Matrix (SAM) models are a more comprehensive form of input-output (I-O) models, though the term "I-O model" is frequently used to describe both. These models are used for a wide variety of purposes but are most often used for economic impact and economic contribution analysis. The field is brimming with studies by analysts with a loose understanding of the method to those following strict academic rigor. This paper outlines the best practices in conducting economic impact and contribution analysis to set standards for conducting these analyses. Using a thorough review of the literature and examining best practices from the field, a list of recommendations for conducting a robust economic impact and contribution analysis will be presented. It will include understanding model assumptions, analysis framing and methodology recommendations, and interpretation of results. This includes considerations when choosing a region of study, what type of event to examine, which values to include and exclude, using margins, when there is a need for a net analysis, how to accurately report results, and understanding reasonable multipliers.

1 Introduction & Brief History of Input-Output Analysis

I-O is a type of applied economic analysis that tracks the interdependence among various producing and consuming sectors of an economy. More particularly, it measures the relationship between a given set of demands for final goods and services and the inputs required to satisfy those demands. The economic activity of the whole country is visualized as if it were covered by one huge accounting system (Leontief, 1936).

The history of Input-Output analysis is most often linked to the Nobel Prize winning work of Wassily W. Leontief in 1973. This was his life's work stemming from his dissertation titled "Die Wirtschaft als Kreislauf" (The Economy as Circular Flow) in 1929 from Friedrich Wilhelm University (now Humboldt University of Berlin) in Germany (Bollard, 2020). He built his first Input-Output table of a 95 x 95 industry transaction matrix of the 1939 economy of the United States. Per the press release of The Royal Swedish Academy of Sciences, "Professor Leontief is the sole and unchallenged creator of the input-output technique" (The Royal Swedish Academy of Sciences, 1973).

Leonteif's work was built upon a long history of thought leadership on economic systems including William Petty (1623-1687), Richard Cantilllon (1697-1734), Francois Quesnay (1694-1774), Achille-Nicolas Isnard

(1749-1803), Robert Torrens (1780-1864), Karl Marx (1818-83), Vladimir Karpovich Dmitriev (1868-913), Ladislaus von Bortkiewicz (1868-1931), and Georg von Charasoff (1877- 1931) (Kurz and Salvadori, 2010; Kurz, 2011). History suggests that French Jesuit Father Maurice Potron (1872–1942) was the preeminent predecessor of Leontief, creating the idea of an input-output table twenty years prior (Abraham-Frois and Lendjel, 2006; Bjerkholt and Kurz, 2006; Bidard, 2014). Kurz (2011) argues that the seeds of input-output analysis can even be traced to ancient Mesopotamia and their "corn model" describing inputs and outputs required for production. Working at the same time as Leontief, Italian Pierre Sraffa (1898-1983) followed similar paths rooted in classical political economics and the physiocrats, although there is no proof the men knew each other (Kurz and Salvadori, 2006). Also working at the same time, Norwegian economist Ragnar Frisch (1895-1973) claimed that he was the inventor of input-output analysis, although he later utilized Leontief's work (Bjerkholt and Knell, 1956).

Returning to the hailed "father of I-O," Leontief (1986) stated that input-output analysis is "A method of systematically quantifying the mutual interrelationships among the various sectors of a complex economic system." Input-output modeling is an applied form of economic analysis that traces the interdependence of producing and consuming actors in an economy (Leontief, 1936). Input-output analysis is commonly used to estimate the impacts of "shocks" to an economy and to analyze their resulting ripple effects. I-O tables give a "comprehensive structural picture of a region's economy" and can measure changes within regions (Isard, 1953). Miller and Blair (2022), now in their third edition, state "the fundamental purpose of the input–output framework is to analyze the interdependence of industries in an economy." In its most basic form, an I-O model consists of a system of linear equations, each one of which describes the distribution of an industry's product or commodity throughout the economy.

Richard Stone (1913-1991) gave the field the concept of the social accounting matrix (SAM) (Rose and Miernyk, 1989). The full-detail SAM gives a complete picture of the flow of funds, both market and non-market, throughout the economy in a given year. Market flows occur between the suppliers of goods and services and the purchasers of those goods and services, including both industrial and institutional suppliers and purchasers, where institutions include households, governments, capital, inventory, and trade. Non-market flows occur between institutions and are often called inter-institutional transfers. In such transactions there is no well-defined market value being exchanged in return for the payment; for example, while taxes are used to fund government services, these government services do not have a market value since they are not purchased in a market setting. In a typical SAM, the columns represent payments or expenditures by the column entity (industry, commodity, or institution), while the rows represent a receipt of income by the row entity (industry, commodity, or institution).

Karen Polenske (1937-), a student of Leontief, created an operational multi-regional input-output (MRIO) based on the work of Isard's interregional input-output model (IRIO) and Japanese economists (Polenske, 1970, 1972; Rose and Miernyk, 1989). MRIO analysis makes it possible to track how an impact in one region affects the production and spending in another region. It allows the analyst to demonstrate how an impact in one region disperses into other regions and see how these effects in surrounding areas create additional effects in the initial region.

There are currently at least seven methods utilized across the globe (Kop Jansen and Ten Raa, 1990). These include the European System of Integrated Economic Accounts, Commodity Technology (utilized in Germany); the Stone method or by-product technology model (utilized in Japan); Industry technology model (utilized in United States); Mixed technology model; Lump-sum method; and the Transfer method (Kop Jansen and Ten Raa, 1990). I-O tables show the relationships between producers and consumers either through industry outputs (industry × industry tables) or product outputs (product × product tables).

Various frameworks can be used to present I-O accounts. Most U.S. models based on the Bureau of Economic Analysis (BEA) data utilize the make-use tables, while the United Nations, Organisation for Economic, Co-operation and Development (OECD), and most international countries utilize supply-use tables (Guo et al., 2002). The make table refers to the production of commodities by industries while the use table refers to the use of these commodities (Bureau of Economic Analysis, 2009). While the BEA's featured set of accounts have traditionally been prepared using a make-use approach, the supply-use approach has recently generated additional attention, in part due to its applicability in analyzing global value chains, and the BEA has begun to produce both make-use and supply-use tables (Young et al., 2015). These supply-use tables provide an integrated presentation of the total domestic supply of goods and services from both domestic and foreign producers and the use of this supply across the U.S. economy. According to the BEA, the U.S. supply-use framework is not only similar to the make-use framework, it is also fully consistent with that framework. The supply-use tables are not estimated or balanced independently of the make-use framework. Instead, the make-use framework serves as a starting point for the estimation process, with adjustments, additions, and other transformations introduced to translate these tables into the supply-use framework. The principal adjustments concern the valuation of imports and the accounting of taxes. For example, in the supply-use framework, there are import duties, which become positive imports of wholesale trade in the make use framework. Values in the supply-use framework are typically expressed in basic prices whereas values in the make-use framework are expressed in producer prices. One result of this is that in the supply-use framework, sales taxes are reported under the industry that purchased the commodity, whereas in the make-use framework, sales taxes are reported under the industry that remitted the taxes (e.g., wholesale and retail sectors). Because the supply-use framework uses basic prices, it has been used to examine price changes associated with policies such as carbon taxation (Kay and Jolley, 2023).

Despite a long history of solid economic theory and practical work, conventions on appropriate modeling have yet to be presented. In fact, the field simultaneously uses the terms input-output analysis, social accounting matrix analysis, interindustry analysis, and economic impact analysis. The remainder of this paper outlines a set of standards for designing, running, and interpreting minimally viable I-O analysis and other keys to success using this technique to investigate and analyze economic systems.

2 Model Assumptions

There are nine key assumptions to acknowledge before utilizing I-O models. While they may seem limiting, they form a transparent and understandable basis for the underlying framework of the model.

Constant Returns to Scale

The same quantity of inputs is needed per unit of output, regardless of the level of production (Adams and Stewart, 1956; Christ, 1955; Miller and Blair, 2022). In other words, if output increases by 10 percent, input requirements will also increase by 10 percent.

Fixed Input Structure / No Substitution Effects

There is no input substitution in the production of any one commodity (Adams and Stewart, 1956; Bess and Ambargis, 2011; Christ, 1955; Miller and Blair, 2022). This means that the same recipe of inputs will always be used to create the output unless changes to the production function are made by the analyst. An industry's production function represents the list and value of inputs (goods and services) required by the industry to produce its own product(s). In the SAM, the production functions are expressed in dollars, whereas in the calculation of multipliers, those dollar values are first converted to ratios representing each input expenditure per dollar of industry output.

Industry Homogeneity

I-O models typically assume that all firms within an industry are characterized by a common production process. If the production structure of the initially-affected firm is not consistent with the average relationships of the firms that make up the industry in the I-O accounts, then the impact of the change on the economy will differ from that implied by a regional multiplier (Bess and Ambargis, 2011).

No Supply Constraints

I-O analysis assumes there are no restrictions to inputs, raw materials, and employment (Christ, 1955). The assumption is that there are sufficient inputs to produce an unlimited amount of product. It is up to the user to decide whether this is a reasonable assumption for their study area and analysis, especially when dealing with large-scale impacts.

Constant Technology

An industry, and the production of commodities, uses the same technology to produce each of its products (Guo et al., 2002). In other words, an industry's production function is a weighted average of the inputs required to produce the primary product and each of the by-products, weighted by the output of each of the products. The technology assumption is used to convert make-use or supply-use tables into a symmetric input-output table.

Constant Byproduct Coefficients

As a requirement of the technology assumption, industry byproduct coefficients are constant. An industry will always produce the same mix of commodities regardless of the level of production. In other words, an industry will not increase the output of one product without proportionately increasing the output of all its other products.

Static Model

No price changes are built into I-O models and the underlying data and relationships are not affected by impact runs (Bess and Ambargis, 2011; Isard, 1951). I-O models do not account for general equilibrium effects such as offsetting gains or losses in other industries or geographies or the diversion of funds from other projects. The model assumes that consumer preferences, government policy, technology, and prices all remain constant.

Backward Linkages

Standard I-O analysis is backward-looking, in the sense that the ripple effects associated with an initial impact or activity are upstream effects; that is, they are supply chain impacts stemming from input purchases (and all the associated household spending). While SAMs can be used to calculate forward-linked multipliers, sometimes referred to as Ghosh multipliers, forward-linked analysis relies on the assumption that an increase in the availability of an input would spur the users of that input to increase their purchases of the input by way of increasing their own levels of production (Ghosh, 1958). For example, an economic impact analysis of biofuels production from woody biomass would measure the plant operation, logging, and forestry impacts,, but it would not capture the forward linkages associated with new fuel blending stations or gasoline retailers as a result of additional biofuels production (Lester et al., 2015).

Time Delineated

The length of time that it takes for the economy to settle at its new equilibrium after an initial change in economic activity is unclear because time is not explicitly included in regional I-O models. Some analysts assume the adjustment will be completed in one year because the flows in the underlying industry data are measured over the same length of time. However, the actual adjustment period varies and is dependent on the change in final demand and the related industry structure that is unique to each regional impact study (Bess and Ambargis, 2011).

3 Understanding Terminology

I-O models look at changes to industries or institutions. Where Industries represent groups of firms with similar inputs to production. They range from broad industries like "fruit farming" to very specific industries like "bowling centers." Institutions are entities that create final demand including: households, federal, state, and local government enterprises and administration, capital, inventory, and trade

One of the most popular terms surrounding I-O modeling is the multiplier. Again quoting Miller and Blair (2022), "The notion of multipliers rests upon the difference between the initial effect of an exogenous change and the total effects of that change." Multipliers are a measure of an industry's connection to the wider local economy by way of input purchases, payments of wages and taxes, and other transactions. It is a measure of total effects per direct effect within a region. Expressed as a ratio, a multiplier describes how for a given change in a particular industry, there will be a resultant change in the overall economy. Multipliers can be expressed in terms of industry output, employment, or value added (and any of the component parts of value added) and are unitless, given that the numerator and denominator are expressed in the same units of measure. For example, an employment multiplier of 2 would indicate that for every new job created by the exogenous shock, a total of two jobs (the first job plus one additional job) would be created or supported in the economy. When using different units of measure for the numerator versus the denominator, the term "response coefficient" is often used. For example, an analyst may be interested in the jobs supported by tourist spending in a region, which could be expressed as total employment per dollar of tourist spending. There are currently two commonly accepted types of multipliers: Type 1 and Type SAM. The Type 1 multiplier, used by Leontief due to limited access to complex computers, measures the direct and indirect effects, divided by the direct effect. The Type SAM multiplier, available far after the Type 1, includes the spending of households. It is calculated as the sum of the direct, indirect, and induced effects, divided by the direct effect.

There are three types of effects that sum to the total effect. The first is the direct effect, which is the initial change to an industry, commodity, or institution being analyzed. It is simply the value of the production that is applied to the I-O multipliers to quantify the wider effects throughout the economy. The indirect effect stems from the supply chain or business-to-business spending of the direct effect. The induced effect stems from the household spending supported by the employment in the direct and indirect effect.

These effects are represented through the resulting economic indicators, including employment, labor income, value added, output, and taxes. Generally speaking, employment represents either jobs or job years, and consists of both wage and salary employees as well as proprietors. Labor income consists of all payments to employees including wages, and benefits, as well as proprietor income. Value added, also referred to as the contribution to gross domestic product, is simply the difference between output and the spending on non-labor inputs. Output is the total value of industry production, which may or may not be equal to revenue, depending on the industry in question. In the case of farm sectors, on-farm consumption of production means that the value of production may actually be lower than sales. In the case of manufacturing sectors, net additions to inventory would yield values of production that are higher than sales values, whereas net subtractions from inventory would yield values of production that are lower than sales values. Taxes include various types, are paid by various industries and institutions, and are collected by various governing bodies. While value added has a specific tax-only category (taxes on production and imports, less subsidies in the U.S. models), all other components of value added also include taxes, including payroll taxes in the case of the employee compensation and proprietor income components of value added, and profit taxes in the case of the other property income component of value added.

Output is not analogous to GDP; therefore, output impacts should never be compared to the study area's GDP. Output double-counts relative to GDP in the sense that it includes the value of output of other industries since it includes expenditures on intermediate inputs; therefore, it is preferable to report value-added impacts more prominently than (or in place of) output impacts. Note that exact definitions of each of the indicators vary by model and the way data is organized in that country.

Many values reported are nested values. For example, labor income impacts are a component of value added impacts, and value added impacts are a component of output impacts. Similarly, tax impacts are a component of value added. To avoid double- or triple-counting or unintentionally misleading readers, it should be made clear that the impacts cannot be summed across indicators.

I-O tables consist entirely of monetary values; employment figures sit outside in satellite tables linked after the analysis to the results via ratios (e.g., employment per dollar of output). Other tables can also be linked to I-O including environmental and occupational data.

4 Utilizing I-O

4.1 Defining the Research Question

Before beginning an analysis using I-O, the purpose of the study and the research question to be investigated should be clearly defined. There are times when I-O is not the most straightforward approach when model data must be modified or another method should be considered. Examples of these include price changes, policy changes, socio-political impacts, feasibility analysis, cost-benefit analysis, net effects of innovation and transitions, opportunity costs, and forward linkages. For example, a computable general equilibrium (CGE) model is a better fit for examining changes in technology. As with any research, it is essential to outline what will be analyzed, generate hypotheses, and state the goals and objectives (Patten, 2005).

4.2 Region Selection

It is generally recommended that I-O analysis be used at the level of a functional economy as the lowest level of geographical detail. Consider a city without the remainder of the county or metropolitan statistical area; it really cannot function without the interconnectedness of the entire region. While a similar point could be made about any geography, including an entire country, which of course still relies on imports (albeit to a lesser degree), this issue is particularly pernicious at the zip code level. Furthermore, the smaller the geography, the fewer raw data points available, thereby making models at such small geographic levels even less ideal for use in impact analysis.

If one were to run a given impact in each of several regions separately, the sum of the results in each region will not yield the same results as running the total direct impact amount on an aggregated model of those regions, nor will it yield the same results as running an MRIO analysis with all those same regions. For example, if one were to run a one million output impact in a given industry in each of the 50 states plus Washington, D.C. and sum the results, that sum would be smaller than the values that would result from running a fifty-one million output impact in the same industry in a U.S. model. There are two reasons for this. The first is that the sum of the separate impacts does not account for impacts that each state has on other states due to commuting and trade in the U.S. Second, the national model is not a simple average of all the states, but rather represents a weighted average based on each state's proportion of that industry's activity.

To include indirect and induced impacts to surrounding, neighboring, or otherwise economically-connected regions, it is more advisable to use a multi-regional input-output (MRIO) approach than to combine multiple regions into an even larger study area. Linking other regions to the base region allows the base region to remain distinct, thereby yielding direct impacts that are grounded on the specific and unique economic profile of the base area, rather than on a weighted average that less well represents the place where the direct impacts occur. If using a more aggregate area, the event must be customized to reflect the direct effects that would occur in the smaller region.

4.3 Impact Type

There are various types of analysis that can be conducted which all fall under the I-O or SAM label. Impact analysis helps measure the economy-wide impacts of a change in final demand (positive or negative). Final demand is the demand for final goods and services. It consists of personal consumption expenditures, government consumption expenditures, investment (private and governmental), net additions to inventory, and net exports of goods and services. Final demand does not include industries' demand for goods and services as intermediate inputs to their production processes. Impact analysis can be run on an industry basis or a commodity basis. Keep in mind that industries can produce more than one commodity. The proportion of an Industry's output coming from production of each commodity it produces is called a byproduct coefficient. On the flip side, commodities are goods and services that can be produced by more than one industry or institution. The proportion of commodity supply coming from each source for a given commodity is called a market share.

Industry contribution analysis (ICA) or multi-industry contribution analysis (MICA) is a method used to estimate the value of an industry or group of existing industries in a region, at their current levels of production. When analyzing an industry that already exists within a study area, buybacks to that industry need to be eliminated such that there are no indirect or induced impacts on that industry. This means that no additional purchases to that industry will be generated. While these methods still look at backward linkages, the purpose differs from the standard economic impact analysis and requires modification of the model to disallow buy-backs if the modeling software does not have built-in ICA/MICA capability.This is discussed further in a later section.

Analysts might also consider other types of analysis: analyzing solely labor income, household income, or government spending. Labor income events are appropriate to model a change in labor payments isolated from industry production. An example would be a wage increase for current employees or an increase in a state's minimum wage rate. There will not be any new production, but the current workers will earn more. Household income can be modeled to show a change in spending of individuals isolated from industry production and payroll. Here analyses can be conducted at various income levels. Examples would be a government stimulus check or tax refund (Jolley, 2022; Paynter et al., 2014). The impacts of various levels of government spending can also be modeled.

4.4 Data and Industry Selection

Selecting the right input specification (e.g., which industry, commodity, household income group, etc.) is very important as this tells the model which production function or institution spending pattern to use during the analysis. Note that depending on the data source being utilized, production functions as well as output and employment data may split apart pieces of a single establishment into multiple industries. For example, the production function for the hotels and motel sectors in the U.S. include expenditures required to operate the lodging portion activity of hotels and motels only; it does not include purchases associated with the operation of any restaurants, casinos, or retail outlets that might exist as part of a hotel or motel; the latter are "redefined" into the industries that best represent those other activities. Thus, when modeling an establishment with multiple disparate activities (e.g., a hotel that has within it a casino and a restaurant), it is recommended to distribute the model inputs across the sectors that best represent each of those activities (e.g., the hotel and motel sector, the gambling services sector, and the appropriate restaurant sector), rather than modeling the combined value in the hotel and motel industry.

Also be careful to realize the dollar year of inputs, reconcile that with the data year of the model, and report the results in an appropriate dollar year. This will cover for inflation or deflation to ensure the inputs are analyzed in the appropriate dollar. For example, consider modeling tourist spending that is expected to occur in 2025 but data can only be obtained from a tourist spending survey conducted in 2021 using a model built with 2022 data; those tourist expenditure values must be converted to 2022 dollars, either outside of the model prior to inputting them into the model or by using built-in deflators in the model by way of specifying the dollar year of the input data to be 2021.

4.5 Model Nuances

Model Selection

Each commercial model has its own nuances and the choice of which to use comes down to model fit, cost, and user preference (Khalaf et al., 2022). There are a few off the shelf models available and many countries offer their own datasets for analysis.

Margins

Retail and wholesale industries can often be confusing due to margins. Margins represent the values attributable to retail, wholesale, and transportation services required to get a finished product from the factory floor into the hands of the final purchasers. When modeling anything that was purchased from a retailer or wholesaler (a common example is when analyzing visitor spending), it is critical that margins are applied appropriately so as not to assume that the entirety of the purchase price of a baseball hat at the stadium, for example, remains with the retail store, or that the hat was produced within the region, unless that is explicitly known. If margins are not applied, the local economic impact of that hat purchase would be overstated by attributing the entirety of its value to the local retailer.

If the item purchased is known with enough specificity that a commodity can be identified, it is appropriate to set up the event in that commodity and then apply margins to capture the commodity's increase in value, without a change in the commodity itself. This value chain includes the product value, transportation margins, wholesale margins, and retail margins. This will spread the purchase value among the producing industry, transportation, wholesale, and retail industries. The analyst can also adjust the local purchase percentages (LPP) for each of these industries if, for instance, they know that the item was not produced locally but was purchased from a local retailer. If, on the other hand, the item is a more general category (e.g., clothing and accessories), it is appropriate to set up the event in the appropriate retail industry and apply margins to that retail industry. In this case, only the retail margin portion of that purchase price will be applied to the retail industry, with the rest being leaked from the analysis to an unknown region where it was produced. Any economic activity associated with the model that does not generate additional effects inside of the study region is considered a leakage. Generally, these include taxes, savings, profits, imports, and commuting dollars, as well as production occurring outside the region.

Industry Aggregation and Other Customizations

Aggregating industries allows the user to combine industries together which may be beneficial in cases where the user only has data at a more aggregate level. This may be done using 2- or 3-digit NAICS (North American Industry Classification System) codes or a user-defined scheme. Aggregation can be especially helpful if only a very general idea of spending is available. For instance, a survey may show spending by visitors on food and beverages but the model has more than one appropriate industry for this spending. Aggregating all of the food and beverage industries together would be beneficial here to allow the analyst to include all of the visitor spending in one industry in lieu of making assumptions about the spending across various types of eateries.

Instead of relying on model defaults, advanced edits to the production function or other model components might also be warranted. In models that allow for customization, this could include entering detailed information about the change being examined, as well as editing the specific spending on intermediate inputs by commodity. When applying such edits,it is generally recommended to undertake such modifications at the point of analysis rather than at the point of model construction. This is especially relevant when the subject of analysis is a particular business, organization, or activity, as opposed to an entire industry. When the model is customized, all rounds of indirect and induced impacts to the customized industry will bear the same customizations, whereas if the customization is done at the stage of analysis setup, only the direct effects to the industry will bear the customizations. Customizing the analysis setup allows the user to incorporate various known specifics about that particular business, organization, or activity without assuming that the rest of the encompassing industry also bears those same specific features. Before customizing a model, it is strongly recommended that the analyst ensure a complete understanding of the data being edited (both in terms of the model's definition and the alternative data source's definition), the full implications of any such customization, and the full set of accompanying edits that may be required (for example, industry byproduct coefficients).

In the standard I-O model, households are the only institution that is internalized, meaning that this money continues to circulate and is not considered a leakage from the analysis. There are also other additional internalizations that can be made. The most common (and defensible) of these is for state and local government, which would show how tax revenues generated by the impact support additional government spending that continues to ripple through the economy. The internalization of government assumes that any tax revenue generated by an impact would spur additional government spending and any loss of tax revenue generated by an impact would cause a reduction in government spending. Because government spending is typically planned well in advance and as part of various budgeting processes, it may not be a tenable assumption that government spending would rise or fall in lock-step with the change to the economy being analyzed. I-O modeling has been used to determine how increased government spending in certain sectors, such as infrastructure, generates economic impacts (Brun et al., 2014).

4.6 Running the Analysis

It is the analyst's responsibility to understand the values being entered into the model and to ensure that they fit the model's definitions. For example, if the analyst is using an employment value that represents full-time equivalents (FTE), the analyst should convert those FTEs to the model's definition of employment prior to inputting the value into the model.

When examining the results, first check for face validity, ensuring that it makes logical sense. Typical output multipliers at the state level are between 1-3. At the national level they are between 1-4. So if an analysis shows an output multiplier of 15, something is likely incorrect. Overestimation is a main criticism of I-O analysis (Khalaf et al., 2022). Alternatively, if a model is analyzed in a manufacturing industry, notorious for large supply chains, comes back with an output multiplier of less than 2, again something might be incorrect in the setup.

4.7 Reporting Results

A solid report will include a nod to assumptions and definitions at the start. Also, stakeholders should be listed to acknowledge those funding the study or the analyst, as well as those likely to be interested in the results. Every report should contain a methodology section that specifies, at a minimum, the model name and pedigree, the year of data used, the geographies included in the analysis (whether grouped into a single study area or linked via MRIO), the input data used to set up the analysis, the type of event analyzed (impact, contribution, etc) and any modifications made to the model. Limitations of the input data or the analysis should also be included. All of this allows for replicability and interpretability of results. Finally, results and policy implications should close the report.

4.8 Other Cautions

Most academics and practitioners will assert that economic impact analysis is a mix of science and art. As such, it is important that assumptions be transparent and justifiable, so that analyses can be replicated. Analysts may also want to use a sensitivity analysis approach and consider Understanding the data and model is key to ensuring the most defensible results.

Existing vs. New Activity

First, ensure to only analyze new money to the study region unless performing an industry contribution analysis. As long as the money is new to the region, these funds create a measurable impact. Even if there is a genuine change to be analyzed, if that change involves a shift in activity from one firm to another or otherwise within the same region, it should be analyzed as a net analysis with a combination of positive and negative impacts (Khalaf et al., 2022).

Sometimes purchases made completely outside of the study region should be excluded completely. For example, if a large piece of equipment or machinery is purchased from outside of the region, it will not have any impact in the region of study as the entirety of that spending immediately leaves the region. It is therefore advised to exclude this spending completely. Even if the item is purchased from a local retailer or wholesaler, that does not mean it was produced locally; in such a case, the purchase price should be applied to the appropriate retail or wholesale sector and specified as being a purchaser prices (gross sales value) such that only the retail or wholesale margin is applied to the local retail or wholesale industry. If the model does not have built-in margining capability, the retail/wholesale margin percentage should be applied to the sales value prior to inputting into the model for analysis.

Another caution revolves around the substitution effect. The substitution effect states that an industry or commodity may lose market share as consumers switch to cheaper or just different alternatives. If the price of apples skyrockets, then people might merely eat more cherries, for example. Merely looking at the loss to the apple industry will not tell the full story as the cherry industry will see gains.

The same spending on different things will yield very different results. Consider two purchases of fifty thousand dollars each within a region. The first person spends fifty thousand dollars on a new car. The second spends that same fifty thousand dollars on an addition to their house. The direct impact would be fifty thousand dollars in both instances, examining this from the sales price of the car and the addition. Looking at this from the income side, however, the car purchase maintains only a small portion of the price of the car, assuming that it is produced outside of the study region. The house addition, however, keeps a much larger portion of the total price within the region as so much of the cost of construction is wrapped in labor costs.

The broken window effect is also important to consider. If a neighborhood kid breaks a window with a baseball, the window must be repaired. So, there is a positive economic impact from the purchase of the new window or the installation of the new window by a contractor. However, there is also a decrease in the spending power of the individual that had to pay for the replacement of the broken window, known as the invisible impact. This money may be spent from savings, but it also may be realized through a decrease in spending on other purchases. A similar scenario occurs with natural disasters, which generate a positive boom in construction and repair activities while simultaneously generating losses for insurance companies and affected homeowners and businesses. As reflected by their name, such invisible effects are not explicitly or automatically reflected in I-O analyses.

Opportunity Costs and Non-Market Impacts

Finally, the concepts of opportunity costs and non-monetary benefits should not be ignored. While there may be a great economic benefit from a given investment, there might have been an even greater benefit from some forgone investment. Furthermore, one investment may yield additional benefits or costs to the community that are not easily quantifiable in dollar terms (e.g., quality-of-life, equity). Ideally, each prospective investment should be analyzed for comparison purposes, and, where possible, additional non-monetary impacts should be discussed, even if it is not possible to assign monetary values to those impacts.

When a new business opens up in a region, it often cannibalizes sales from existing businesses. A net analysis takes a more holistic look at the effects resulting from a change in production or spending in the economy by considering both the positive and negative effects of a given scenario. As I-O models are linear in nature, the impact results from I-O models are not automatically net impacts. For example, if one were to run a positive impact for a new bed and breakfast coming into a region, the total impact results would not account for any negative effects that might occur in the hotel industry. Similarly, I-O models do not account for behavioral changes that might follow an economic impact, such as price changes, changes in spending and saving habits as prices or tax rates change, or in response to supply constraints. Computable general equilibrium (CGE) models attempt to account for such behavioral changes by incorporating demand elasticities and other tools for incorporating greater flexibility into the models.

Certain industries require special considerations due to the unique nature of their businesses. Construction impacts are most often temporary, so the results from construction projects, or any capital improvements, should be reported separately from operational impacts. This is to ensure that readers are not misled into thinking these results will recur annually. The production functions for the construction industries include components that are integral to the building, such as fire sprinklers, elevators, HVAC, built-in lighting, etc. They do not include the costs of land, furniture, industrial machinery, or other equipment necessary for the operations of the business or organization that will occupy the structure. Unlike other industries, for which contract labor appears as an intermediate input, construction contractors are included as part of the direct proprietor employment and income in the construction industry itself. Additionally, the sale and purchase of land or any real estate is considered an asset swap, as no real value is created. Therefore, it has no impact on the economy sans some real estate and legal fees.

Nonprofit organizations (NPOs), from hospitals to housing agencies, have their own set of nuances. Most are lacking proprietor employment and profit, as well as not paying certain taxes. NPOs need to be modeled carefully so as not to overestimate their impact by including values for these indicators. NPOs also rely on a lot of unpaid labor. Volunteer work, while immensely valuable to these organizations, has no explicit tie to output and is therefore not captured in I-O models. Efforts can be made to place a dollar value on their time using estimates for what it would cost the organization but for their volunteer base, if the argument can be solidly made that without them, the organization would cease to exist.

Colleges and university impacts also require special attention. These institutions not only have operations and likely large-scale construction impacts, but they also bring in students and visitors from outside the region (Khalaf et al., 2022; Jolley and Belleville Jr, 2021). For these studies, it is imperative to ensure that no double-counting or overestimation is occurring. For example, modeling the entire operations spending of a college as well as the student spending on room and board double counts the spending on dormitories and on-campus eateries. The substitution effect should also be considered in this instance. Viewing the existence of the college or university through the hypothetical extraction lens, if the college or university being examined were to vanish, would all of the students immediately be forced to attend a school out of the study region? This is unlikely, as a portion of them would attend a different school within the region and some might not attend school at all. Another common pitfall of college and university impacts is attempting to value the lifetime earnings of graduates. While undoubtedly there is a monetary increase for those with college degrees, again another school could have been substituted for the alma mater if it were not available, so attribution of these lifelong earnings is vastly overstating their impact.

Impacts that involve multiple events, like many tourism impacts, can easily incur scenarios for potential double counting. For instance, spending on tickets for sporting games may have a separate impact from the tourist perspective, but those ticket funds may also already be accounted for as part of the sports team's operations budget. In this scenario, that dollar value should only be counted in one or the other - as part of tourist spending or as part of team operations.

Economic Impact vs. Market and Feasibility Analysis

Economic impact analysis is not a substitute for a market study or feasibility analysis in determining the viability of a prospective project. An economic impact analysis may estimate the employment and economic output based on inputs from a prospective project, but it does not determine whether there is a market for the particular project or if the project will perform at the employment and sales levels modeled. Jolley and Klatt (2015) described the need for this distinction in a study of The Randy Parton Theatre in Roanoke Rapids, NC. Randy Parton (the brother of famous country singer Dolly Parton) was part of a failed theater and entertainment district complex financed through tax increment finance (Jolley and Klatt, 2015). The entertainment complex proposal was supported by an industry feasibility study and a university conducted economic impact analysis; yet, the project did not contain a market analysis. Over time, the project failed to sustain attendance and proposed supporting venues outlined in the project plan and modeled as part of the economic impact analysis never came to fruition (Jolley and Klatt, 2015).

5 Impact Analysis versus Contribution Analysis

In a typical final demand change (i.e., "impact") analysis, the analyst is modeling a new firm or a change in the level of output of a given firm. In such cases, the direct effect is the new firm's total output or the existing firm's change in output. In such cases, it is both likely and logical that the industry in which that firm belongs will experience total impacts that exceed the direct impacts. The industry will experience indirect and induced effects that stem from the direct effects.

Consider the example of upholstered furniture manufacturing in Catawba County, NC. This industry already exists in the county, with Sherrill Furniture being one of the existing firms there. Now suppose a new upholstered furniture manufacturer is planning to locate in Catawba County. This new plant would create new demand for some local businesses via the purchase of inputs into the upholstered furniture manufacturing process (the purchase of knitted fabrics, dimension lumber, and accounting services, for example), which may spur some of these local businesses to undertake building improvements or expansions, thereby generating demand for new upholstered furniture, which creates indirect demand for the upholstered furniture manufacturing industry. In addition to these indirect effects, the new plant would also attract some new workers to the region, thereby generating induced demand for the upholstered furniture manufacturing industry as households purchase upholstered furniture for their new homes. Such buyback effects to the industry are part of that industry's overall impact in the region.

However, there are occasions when an analyst would like to see the indirect and induced effects that the current level of output of an existing industry as a whole has on other industries in that region. In this case, the goal is to generate a total output effect on the primary industry of interest that is equal to the current level of production of that industry, while showing the indirect and induced effects that this current level of output has on other industries in the region. In other words, the only "effects" that the industry of interest should experience are the direct effects (e.g., current level of output), while other industries in the region experience indirect and induced effects associated with (i.e., in support of) the direct effects in the industry under study. In such a study, it does not make sense to allow feedback effects on the primary industry of interest, since an existing industry cannot experience a total output effect that exceeds its current level of output. The question of contribution analysis assumes by definition that the effect on the industry whose contribution is being measured is the entire value of its own output.

As another example, consider the closure of a firm. If the current level of industry output were to be modeled as a negative direct effect using the traditional impact analysis approach, the model would show a total loss to this industry that is greater than its current level of output – but it is not possible to lose more output (or employment) than currently exists!

Therefore, in these types of analyses, a special technique known as industry contribution analysis (ICA) or multi-industry contribution analysis (MICA) is recommended. The basic idea behind ICA is to disallow any indirect or induced purchases from the industry of interest in such a way that does not affect the indirect and induced effects on other industries. In the I-O literature, these methods often are called "mixed endogenous-exogenous models" (Miller and Blair, 2022). Some models, such as IMPLAN, have built-in procedures for ICA; it is merely a matter of choosing this analysis type when setting up the events. Contribution analysis has been used to demonstrate the economic contribution of industries such as forestry at the state level (Jolley et al., 2020; Michaud and Jolley, 2019).

6 Final Considerations

While I-O models lack the sophistication and flexibility of CGE models, their closest cousin, they typically contain higher levels of geographic and industry detail, can more easily be updated with greater frequency, and rely on assumptions that are transparent and easily understandable.

Like every modeling technique, I-O modeling has both strengths and weaknesses, and is underpinned by various assumptions. It is the authors' opinion that I-O modeling is a very powerful and useful tool when applied in appropriate settings, by knowledgeable and careful analysts, who communicate the underlying assumptions and methodologies and share the results responsibly.

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