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IMPROVING ECONOMIC CONTRIBUTION ANALYSES OF LOCAL AGRICULTURAL SYSTEMS: Lessons from a study of the New York apple industry

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Abstract
Policymakers and economic development professionals are often confronted with fundamental questions about the efficacy of ag-based economic development initiatives in enhancing the economic vitality of communities relative to other forms of development. By better understanding the relationships of agricultural industries within local economies, community educators, industry leaders, and public officials can make more informed choices to enhance economic activity and impact. We illustrate a framework for conducting multi-industry economic contribution analyses to inform practitioners on what it is, when it should be used, and what it can tell you. As these types of analyses are popular, among industry and public agencies alike, promoting a replicable framework improves the compatibility and comparison of analyses across industries, geographies, and time. In addition, we describe the costs and rewards of primary data collection to support more refined and locally-specific impact estimates and illustrate its use to the apple industry in New York State. Finally, we describe how backward industry linkages lead to commonly referenced multipliers. In doing so, practitioners can better understand local supplying industries most important to the industry of inquiry and the supplying sectors most influenced by industry expansion efforts.

Key Words: agricultural development, multi-industry economic contribution, input-output analysis, economic multipliers

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Introduction and Literature Review

Policymakers and economic development professionals are often confronted with fundamental questions about the efficacy of ag-based economic development initiatives in enhancing the economic vitality of communities relative to other forms of development. What are the economic impacts of alternative development options, how should the impacts be measured, and what matters most are common questions. If the generative effects of ag-based economic development are comparable to or exceed non-ag-based efforts, it makes sense that they be 'at the table' when evaluating alternative opportunities. That said, a careful understanding and interpretation of economic impacts is required for informed decision making.

Take, for example, a policy decision directed towards the expansion of alternative manufacturing industries. If policy foci center on targeting development efforts to industries with the largest multiplier effect on jobs, attention to the milk manufacturing and flour milling sectors in New York State (NYS) would be appropriate, as both have similar and relatively high jobs multipliers of around six (IMPLAN, 2016). It is worth noting, that there exists a large dairy farming industry in NYS, but a relatively small amount of wheat production. So why a similar jobs multiplier? Interpreting a jobs multiplier of six implies that for every job created directly, an additional five jobs are created in backward linked local industries. However, the total number of jobs created is also dependent on the size of the industry expansion. Specific to NYS, 0.6 jobs are required in flour milling for every million dollars of output, while every million dollars of fluid milk sales requires 1.3 direct jobs (IMPLAN, 2016). In other words, to reach the same level of total job creation, the size of industry expansion in flour milling would need to be over twice that of fluid milk manufacturing.[1]

Furthermore, it is important to emphasize that the size of the multipliers says nothing about the likelihood or means by which the primary industries can be expanded. The likelihood of expansion of sectors depends on where markets are expanding and the extent to which these are the ones in which the multipliers are large (Schmit & Boisvert, 2014). Indeed, an equivalent impact could be achieved by supporting supplying industries to those industries targeted for expansion in order to increase the size of the expanding industry's generative effects. In short, development alternatives need to consider the local generative effects, the availability and expansion potential of locally procured inputs, and the absolute size of the industry expansion.

Numerous ag-based economic contribution analyses can be found online and conducted by various academic, government, industry, and consulting agencies. Several Land Grant universities have estimated the economic contribution of agriculture for their states, albeit with varied definitions of what constitutes agriculture and/or the analytical approaches employed (e.g., Econsult Solutions & Fox School of Business, 2018; Schmit, 2016; Deller, 2014; University of Arkansas, 2014; Fields, Guo, Hodges & Mohammad, 2013; Ferris & Lynch, 2013). Largely, such studies rely on

[1] Given the numbers above, a $10 million dollar expansion in flour milling will require 6 direct jobs, while a comparable expansion in fluid milk manufacturing will require 13. Multiplying the same jobs multiplier (6) to each number of new direct jobs created implies that 36 total jobs will be created in the economy as a result of the flour milling expansion versus 78 total jobs as a result of the fluid milk manufacturing expansion.

existing secondary data and software regarding industry spending and sales patterns (often IMPLAN).[2] Some recent commodity-specific examples include the US dairy industry (IDFA, 2017), the North American cranberry industry (Alston, Medellin-Azuara, & Saitone, 2014), and the Washington State apple industry (Globalwise, 2014) – again, primarily relying on existing secondary data.

Alternatively, Schilling, Sullivan, Komar, & Marxen (2011) analyze the agritourism industry in New Jersey, an example of an industry not defined explicitly in the North American Industry Classification System (NAICS) and, thus, requiring supplemental data collection to identify spending and sales parameters associated with the agritourism component of the farming industry.[3] Similarly, the economic contributions of cooperative businesses have been studied (e.g., Deller, Hoyt, Hueth, Sundaram-Stukel, 2009; Karaphillis, Duguid, & Lake, 2017). Since cooperatives are not confined to any one industry, researchers need to either identify the industries for which they are located and apply those sales and spending patterns to the cooperative activity, or collect data from cooperatives to quantify them explicitly.

Increasing discussions of ag-based economic development opportunities have also occurred in the context of how expanding local food systems can benefit agricultural producers and the local communities from where they reside. Alternative impact analyses have been applied to a range of local food system activities; e.g., direct marketing (Schmit, Jablonski, & Mansury, 2016; Hughes & Isengildina-Massa, 2015; Henneberry, Whitacre, & Agustini, 2009; Hughes, Brown, Miller, & McConnell, 2008, Otto & Varner, 2005), food hubs (Jablonski, Schmit, & Kay, 2016; Schmit & Jablonski, 2017), farm to school (Gunter & Thilmany, 2012), and livestock processing (Swenson, 2011). Thilmany McFadden, Conner, Deller, Hughes, Meter, Morales, Schmit, Swenson, Bauman, Phillips Goldenberg, Hill, Jablonski, & Tropp (2017) provide a comprehensive examination of these types of analyses and present a guiding toolkit to assist communities assessing these issues.

By better understanding the relationships of agricultural industries within local economies, community educators, industry leaders, and public officials can make more informed choices to enhance economic activity and impact. However, precise answers to these types of questions are elusive, often due to a lack of data to address them sufficiently. Accordingly, the evaluation of the economic contributions of industries and/or industry expansion efforts requires a careful consideration of the methodologies employed and data collected for their use.

We address these issues through three distinct yet inter-related contributions. First, the requirements and availability of appropriate data are of particular consequence to producing defensible economic impacts to specific areas and industries of inquiry. Understanding where local primary data can supplement or replace secondary data is important in order to improve the precision of results. That said, primary data collection comes with a cost, in both time and dollars. Through an application of the NYS apple industry, we describe the costs and rewards of primary data collection to support more refined and locally-specific impact estimates. We describe the nature of the financial data needed, highlight the costs and potential barriers in collecting data, and

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[2] The IMPLAN® economic impact assessment software system and associated data bases are often used by practitioners to construct local models and assess economic impacts. For more information, go to www.implan.com.
[3] For more information on NAICS industry categories go to https://www.census.gov/eos/www/naics/.

compare economic contribution results based on primary data and default data available in IMPLAN for our application.

Second, we illustrate a framework for appropriately conducting multi-industry economic contribution analyses; specifically, where outputs of some industries serve as inputs to others. We consider the apple industry in NYS, going from farm services, to farm production, to processing. Fruit production and processing are important agricultural industries in NYS, of which apples represent a major component. However, our focus is less on the actual levels of impact, but rather on the process and what practitioners need to consider to appropriately estimate economic contributions, avoid double counting, and interpret the results.

Our final contribution emphasizes the distributional impacts associated with an industry's direct contributions. The indirect and induced changes in economic activity result from multiplier effects throughout the various sectors in the economy. The indirect impacts are in the form of purchases of a variety of goods and services in backward-linked industries, while the induced impacts are in the form of the labor income generated by those businesses and spent by owners and employees for household goods and services. Multipliers are a useful way to sum up the total value of industry linkages; however, much can be learned from a closer examination of the individual components of those summed up values.

We continue now with a description of our analytical approach, including an exposition of what types of data were collected (primary and secondary) for our analysis and how we quantified the direct industry effects. We then present the results to the three contributions identified above. We close with a summary discussion and conclusions.

Applied Research Methods

Our approach incorporates all of the modules from Thilmany McFadden, et al. (2017). We received input from industry stakeholders (e.g., New York Apple Association (NYAA), NYS Cider Association) to frame our economic assessment (Module 1). We incorporated secondary data into our analysis from the US Department of Agriculture (USDA), US Department of the Treasury (USDT), and IMPLAN (Module 2).We developed and administered firm-level surveys for apple producers and intermediaries (Module 3) and engaged with additional stakeholders to supplement our primary data collection efforts (e.g., Cornell Cooperative Extension (CCE), the CCE Lake Ontario Fruit Team (LOFT), and Cornell University (Module 4). We constructed a customized state-level input-output (IO) model within IMPLAN, including a specific NYS apple farming industry extracted from the more aggregate fruit farming sector available in the software, and we accounted for product flows across industries to prevent double counting (Modules 5, 6, and 7).

IO models provide an insightful way to investigate the underlying processes that bind an economy together. Its strengths lie in a detailed representation of the primary and intermediate input requirements by production sector, the distribution of sales of individual industries throughout an economy, and the interrelationships among these industries and other economic sectors of an economy (Schmit & Boisvert, 2014). Our description of economic contributions follow four common economic measurements - output, labor income, and employment. Output is the value of industry production in producer prices; for manufacturing sectors it equals sales plus changes in inventory, for service sectors it equals sales, and for wholesale and retail sectors it equals the gross margin (i.e., sales less cost of goods sold). Labor income is the sum of employee compensation (i.e., total payroll cost) and proprietor income (i.e., income to self-employed and unincorporated business owners). Employment is the average monthly number of jobs in a year, both full and part time.

Contribution Analysis

In deference to an impact analysis that considers the change in new demand induced by policy or private initiatives, a contribution analysis for an industry (or collection of industries) describes that portion of an economy that can be attributed to the existing industry (or industries). While incorrect, the two terms are often used interchangeably in practice. For a contribution analysis, existing total output provides the initial direct effects of the analysis and, when compared to the entire economy, the results provide insight into the relative extent of the industry in the economy and the strength of its backward linkages. With respect to output, the direct effects represent sales by the industry or industries of interest, the indirect effects represent sales by the backward-linked industries, and the induced effects represent industry sales due to consumption out of labor income.

A collection of related ag-based industries represents a complex intersection of production inputs and services at the farm to produce a crop that is subsequently harvested, processed, and marketed to a series of downstream intermediaries (e.g., wholesalers and retailers) and institutions (e.g., governments and households). In a multi-industry analysis, it is important to understand where outputs in one industry represent inputs to another to avoid double counting. IMPLAN provides procedures to accommodate this within their software and further explanations are available in Schmit (2016) and Schmit, Severson, Strzok, & Barros (2018).[4]

Primary Data Collection

When conducting an economic impact or contribution analysis in IMPLAN, it is important to consider when the existing industry parameters are sufficient for analysis and when those parameters should be updated through supplemental data collection. Gross spending patterns in IMPLAN represent national industry averages. Accordingly, these averages more closely reflect firms that contribute a relatively large proportion of total output to a sector (i.e., typically large firms). Accordingly, a large fruit farm in Washington would have an identical gross spending pattern to produce its output as a small fruit farm in NYS. Given differences in climate, soils, crop varieties, and production practices, this is a difficult assumption to defend.

In addition, industries of interest may be reported within larger industry aggregates. Specific to our example, apple farming is included within *Fruit Farming* industry (4) in IMPLAN. For NYS, other fruit farming primarily consists of grapes, but also some cherry and stone fruit production. The question of adequacy becomes even more acute in this case; i.e., is the national average production function for all fruit farming (i.e., the spending on intermediate inputs and outlays to value added per dollar of output) adequate for application to apple farming in NYS? Likely not.

To account for these problematic issues, we developed a financial survey for NYS apple producers and intermediaries (i.e., storage and distribution firms and apple processors) to collect localized

[4] Instructions for doing a multi-industry contribution analysis within IMPLAN are available at https://implanhelp.zendesk.com/hc/en-us/articles/115009542247-Multi-Industry-Contribution-Analysis-In-IMPLAN-Pro

data.[5]. Collecting detailed financial data from firms is time consuming and difficult, particularly when it is not in a face-to-face format to address hesitations and when it asks for data not normally collected recorded by firms (e.g., local purchasing percentages of inputs). In addition, accounting for input expenditures within IMPLAN varies based on whether those purchases are from manufacturers, wholesalers, or retailers, therefore requiring a more complex financial survey (Schmit & Jablonski, 2017). While we were able to adapt surveys from prior work, tailoring the surveys to match the industries of interest and mapping financial business categories to IMPLAN categories takes considerable time. Several weeks were required to develop the surveys, program them in online (Qualtrics) and written formats, and vet them with industry partners.

We worked with the NYAA to administer the surveys and reach out directly to firms through emails, web postings, social media, and in-person requests). Recognizing these stakeholders are busy, communicating their incentives to participate is critical. Notably, the farms and intermediaries contribute financially to NYAA through the state's apple marketing orders. As the NYAA was planning to use the results for public and private marketing efforts, we thought this was a sufficient incentive to participate. It wasn't. Timing is also important. In hindsight, ours was poor, late summer to early fall - a busy time in preparation for harvest.

Several reminders were sent out and the survey deadline was extended, but with little result. Ultimately, our efforts were unsuccessful. Only 25 of the roughly 600 commercial apple growers in the state returned surveys. Less than one-half of those reported sales data, one-fifth reported input purchases, and one-sixth reported local purchase percentages. Ultimately, only four surveys were of use for our analysis, insufficient to produce defensible financial profiles. By now, months had passed.

We were extremely fortunate to discover additional resources. Routinely, the LOFT collects financial data from apple farms they work with and summarize it in the *Fruit Farm Business Summary* (*FFBS*) (LOFT, 2017). From this information, we created a representative NYS apple farming production function, even though local purchase percentages from IMPLAN were needed to apply to the intermediate input purchases defined therein.

The production function for apple farming was included as a separate industry in the IMPLAN model, specifically by extracting apple farming from the preexisting fruit farming sector. Doing so implies that all sectors purchasing fruit from farmers must be edited to reflect a combination of apple fruit and non-apple fruit purchases. In our model, 24 industries (of the 536 currently in IMPLAN) purchased fruit from farmers, as well as state and local governments and households. Disaggregating these purchases definitively across sectors would require surveying firms in all of the sectors that purchase fruit. This is a large task and one with an unnecessarily high cost to implement. Given that the total level of fruit purchases remained unchanged, changes in only the allocation between apple fruit and non-apple fruit s will have little effect on the overall model results. We allocated purchases of fruit to apple fruit and non-apple fruit based on relative values production in NYS.[6]

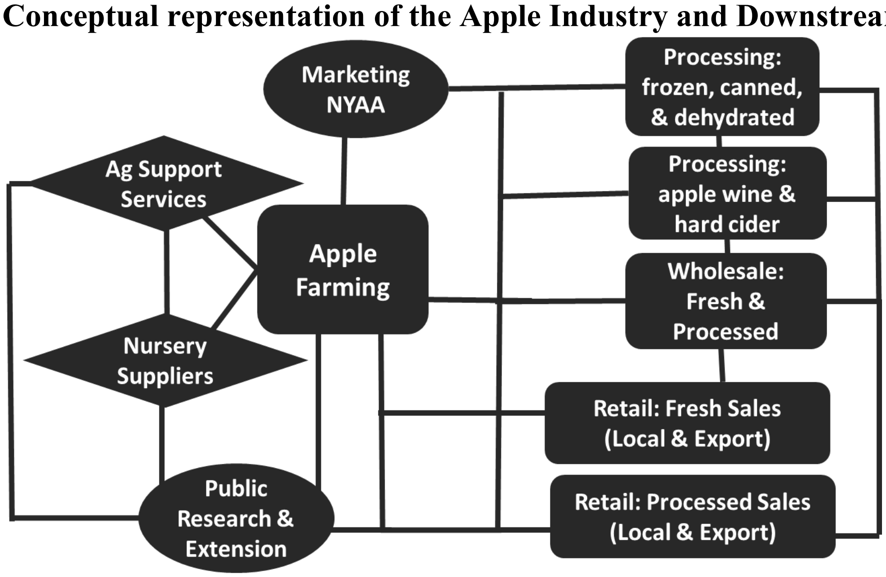
[5] Copies of the surveys are available in Schmit, et al. (2018).
[6] Instructions for reallocating purchases when creating a new sector in IMPLAN are available in Schmit & Jablonski (2017).

Responses by intermediaries to the financial survey were even poorer than that for apple farms: only 5 surveys were returned. Very little financial data was reported and certainly nothing of value to reasonably adjust IMPLAN's default parameters. However, relative to apple farming, this was deemed less problematic. National average production functions were seen as sufficient as processors likely had more similar production functions across geographic areas and the distribution of processors by size in NYS was similar to peer processing states. Since no apple-specific processing sectors are available within IMPLAN, we selected a set of fruit and vegetable processing sectors where apple-based products are prevalent.

Defining Direct Effects
In addition to evaluating the adequateness of an industry's sales and spending patterns, quantifying the level of the direct industry activity is required in economic contribution analyses. Economic impact analyses are based on a particular expansion scenario where the direct effects are defined internally; e.g., a new manufacturing plant with an expected volume of sales or workers employed. For a contribution analysis, existing estimates of industry activity (e.g., output, jobs, and labor income) within IMPLAN or other secondary sources are generally sufficient. Indeed, IMPLAN carefully sources secondary data from a collection of federal, state, and local sources to compile their estimates. However, when an industry of interest is contained within a larger industry aggregate, additional effort is required of the researcher. Other (more detailed) secondary data sources or primary data collection may be appropriate, depending on the nature of the industry defined.

Seven apple industry sectors were defined for our application, while recognizing their connections to other downstream industries. Figure 1 illustrates our conceptual representation. Nursery stock and agricultural support services represent inputs to apple farming, while processor and fresh market sales represent output markets. Since the value of output for the support services and nursery stock operations simultaneously represent expenditures for apple farming, it is important not to double count these activities using the methods for a multi-industry contribution analysis discussed above. Intra-industry sales between apple farmers must similarly be accounted for, as well as farm sales to apple processors.

Figure 1. Conceptual representation of the Apple Industry and Downstream Sectors



Results

The results presented here represent both intermediate and final results of our apple industry application. Through the discussion, our ambition is to help practitioners understand what an economic contribution analysis is, when it is used, and what it can tell you.

Quantified Direct Effects

Total output and employment (direct effects) for each apple industry are shown in Table 1, along with the sources of data used in their compilation. To improve understanding of the empirical process for broader application, we summarize the process we used in defining them. Additional details are available in Schmit, et al. (2018).

<u>Agricultural Support Services</u>**:** Support activities for apple farming are accounted for in *Support Activities for Agriculture & Forestry* industry (19) in IMPLAN. This includes scouting, planning, packing, grading, and storage services. The direct effect is computed as a proportion of total industry sales in (19) based on the ratio of apple farming to total farming output in NYS. The level of employment follows from IMPLAN's jobs to output ratio for (19). The production function for (19) and local purchase percentages in IMPLAN were utilized.

<u>Nursery Stock Suppliers</u>: Economic activity associated with nursery stock suppliers is included in *Greenhouse, Nursery, & Floriculture* industry (6) in IMPLAN. LOFT estimated a production of one million trees per year at a value of $7/tree. The production function for (6) and local purchase percentages in IMPLAN were utilized.

<u>Apple farming</u>: USDA's value of production for apple farming in NYS was used as the measure of output. Employee compensation from *FFBS* (LOFT, 2017) was combined with IMPLAN's compensation per worker for the fruit farming industry (4) to estimate total jobs. IMPLAN's local purchase percentages were utilized for the industry's input purchases.

<u>Frozen, Canned, & Dehydrated Processing</u>: Inspection of the commodities produced in IMPLAN's *Fruit & Vegetable Frozen, Canned, & Dehydrated Products Manufacturing* industries (79, 81, and 83, respectively) revealed considerable overlap with many NYS processed apple products (e.g., frozen concentrate, juices, jellies, slices, etc.).[7] From the sales patterns for the fruit (4) and vegetable (3) farming industries in IMPLAN, we estimated that 66% of total fruit and vegetable sales to NYS processors was fruit. From USDA (2017), we estimated that 68% of all fruit sales in NYS for processing purposes was apple fruit. Accordingly, we estimated apple processing output and employment as 45% (0.66 x 0.68) of the total industry output and employment in (79), (81), and (83). Production functions for (79), (81), and (83) and local purchase percentages in IMPLAN were utilized.

<u>Hard Cider and Apple Wine Processing</u>: Hard (alcoholic) cider, applejack, and apple wines fall under *Wineries* industry (109) in IMPLAN. Retail cider prices from Nielsen CGA (Brager & Crompton, 2017) were used in concert with Alcohol and Tobacco Tax and Trade Bureau cider volume data to estimate the value of total output (USDT, 2017). The production function for (109) and local purchase percentages in IMPLAN were utilized.

[7] For detailed information on commodities produced within IMPLAN industries go to https://implanhelp.zendesk.com/hc/en-us/articles/115009674428-IMPLAN-Sectoring-NAICS-Correspondences.

Table 1. Level of Direct Effects and Sources of Data, New York Apple Industry, 2016 dollars

Industry (Relevant IMPLAN Industry Code)	Direct Employment (jobs)	Direct Output ($ Million)	Sources for: Direct Effect	Sources for: Production Function	Sources for: Local Input Purchase Percentages
Apple agricultural support services (19)	265	11.9	IMPLAN	IMPLAN	IMPLAN
Apple nursery stock (6)	81	7.1	LOFT	IMPLAN	IMPLAN
Apple farming (7)	5,605	317.0	USDA	LOFT	IMPLAN
Apple processing: frozen, canned, & dehydrated (79, 81, & 83)	1,635	838.8	IMPLAN USDA	IMPLAN	IMPLAN
Apple processing: apple wine & hard cider (109)	425	129.8	CGA USDT	IMPLAN	IMPLAN
Apple industry marketing (457)	6	3.1	NYAA	IMPLAN	IMPLAN
Apple public research & extension (456)	16	2.2	CU CCE	IMPLAN	IMPLAN
Total	**8,033**	**1,309.9**			

Source: Schmit, et. al (2018). LOFT = Lake Ontario Fruit Team, Cornell Cooperative Extension, USDA = United States Department of Agriculture, CGA = Nielsen Commercial Grocers Association (Brager and Crompton, 2017), USDT = United States Department of the Treasury, Alcohol and Tobacco Tax and Trade Bureau, NYAA = New York Apple Association, CU = Cornell University, Office of Sponsored Programs, CCE = Cornell Cooperative Extension.

Industry Marketing: Industry marketing is conducted by the NYAA. They provided income, expense, and employment data to us. Income (i.e., output) primarily reflects marketing order assessments received from apple producers and processors. The expense categories were too aggregate to map to IMPLAN and local purchase percentages were not included. NYAA falls under *Advertising, Public Relations & Related Services* industry (457) in IMPLAN. The production function for (457) and local purchase percentages in IMPLAN were utilized.

Industry Public Research & Extension**:** Cornell University's Office for Sponsored Programs (OSP) provided the value, duration, and source of all outside grants and contracts awarded over the previous five years related to apple industry research (i.e., farm, processing, and marketing). Average annual funding was computed. In addition, CCE provided gross expenditures and employment for apple industry extension efforts. Both activities fall within *Scientific Research & Development Services* industry (456) in IMPLAN. The production function for (456) and local purchase percentages in IMPLAN were utilized.

Comparing Production Functions

A NYS apple farming production function was defined to include 24 input purchase and 4 value added categories. For ease of exposition, we provide a summary of those results in Table 2 and compare them to the default estimates provided by IMPLAN for fruit farming industry (4).[8] The parameters in the first three columns represent expenditures per dollar of output. The final two columns represent the absolute and percentage differences for the apple farming estimates, respectively, relative to those within IMPLAN.

Table 2. Apple Farming Production Function in NYS Compared to Fruit Farming Production Function in IMPLAN

Industry/Value Added Aggregate	Fruit Farming (IMPLAN)[a]	Apple Farming (NYS)[a]	Difference[a]	Percent Difference
Ag & ag support services	0.0552	0.0353	-0.0199	-36%
Utilities	0.0037	0.0054	0.0017	47%
Construction	0.0032	0.0131	0.0099	310%
Manufacturing	0.0256	0.1094	0.0838	327%
Wholesale trade	0.0042	0.0790	0.0748	1776%
Retail trade	0.0001	0.0042	0.0042	5200%
Transportation & warehousing	0.0020	0.0240	0.0220	1123%
Information	0.0003	0.0027	0.0024	841%
Finance & insurance	0.0063	0.0282	0.0219	347%
Real estate & rental	0.0026	0.0309	0.0284	1103%
Professional services (non-ag)	0.0022	0.0641	0.0619	2833%
Total intermediate inputs	0.10524	0.3962	0.2909	276%
Employee compensation	0.2975	0.3266	0.0292	10%
Proprietor Income	0.2616	0.1806	-0.0810	-31%
Other property type income	0.3216	0.0876	-0.2340	-73%
Taxes on production & imports	0.0141	0.0090	-0.0051	-36%
Total value added	0.8948	0.6038	-0.2909	-33%

Sources: IMPLAN (2016), Author calculations

[a] Dollars of expenditure or outlay per dollar of output

[8] For the interested reader, the fully detailed production function is found in Schmit, et al. (2018), page 56.

Looking first at the allocations between total intermediate inputs and total value added, it is clear that there are considerable differences between production functions. In the default fruit farming industry, around 10% of every dollar of output goes to purchase intermediate inputs, while 90% goes to one of four categories of value added. The comparable numbers for the apple farming industry we constructed with locally available data are 40% and 60%, respectively. The absolute level of these aggregated category differences alone is strong support that the default production function in IMPLAN is inadequate for our analysis.

More intermediate inputs are required for apple farming in NYS. In terms of expenditures per dollar of out, this is particularly true for purchases from manufacturers (+0.0838), wholesalers (+0.0748), and non-ag (e.g., accounting, legal) professional services (+0.0619). However, apple farms in NYS purchase less ag support services and products from other farmers (-0.0199). The degree to which such differences affect the contribution results will depend on how different the supply industries are and to the degree that those industries are local.

As a consequence of higher input expenditures, outlays to proprietor income (-0.0810) and other property type income; e.g., corporate profits, capital consumption allowance (-0.2340) are substantially reduced. While the former will reduce economic contributions since it is a component of labor income, the latter will not since other property type income and taxes on production and imports do not contribute to the generative effects. As the reduction in proprietor income (-0.0810) is more than the increase in employee compensation (+0.0292), the contribution result from these two categories will be less than that in the default case.

To understand the overall difference in results by using localized data, we conducted single industry contribution analyses for apple farming using the default fruit farming production function in IMPLAN and the apple farming production function we constructed. Since IMPLAN's local purchasing percentages for inputs were used in each case, the only differences from local purchase percentages will come from the degree that there are different supplying industries and for which their local purchase percentages vary. We start with the same direct output effect in each case, $317 million. The results are shown in Table 3. The change in total output was over 21% higher when using the production function we constructed, and largely a consequence of the higher level of intermediate input purchases. This is reflected in the levels of indirect effects for output (i.e., $116.0 million versus $23.3 million).

The overall change in labor income was also positive, at around 7%, but relatively lower than output since the direct effect is lower in the apple farming case (i.e., the combined change in employee compensation and proprietor income from Table 2 is negative). The overall gain is due to the much higher level of indirect effects for the apple farming production function. The negative effect on total jobs is due solely to the lower number of direct jobs for our constructed industry; i.e., the indirect and induced effects on jobs is higher for the apple farming production function. Since we applied the same output effect in each case and IMPLAN's estimated number of jobs per dollar of output for fruit farming is higher than ours, a higher level of direct jobs is computed.

Table 3. Economic Contributions for Apple Farming with Author-Constructed Production Function and IMPLAN's Fruit Farming Production Function

Impact Type	Employment (Jobs)	Labor Income ($ Million)	Output ($ Million)
NYS Apple Farming Production Function (Primary)			
Direct Effect	5,605	164.7	317.0
Indirect Effect	525	40.6	116.0
Induced Effect	886	52.1	141.0
Total Effect	7,016	257.4	574.0
IMPLAN Fruit Farming Production Function (Default)			
Direct Effect	6,388	181.6	317.0
Indirect Effect	244	9.9	23.3
Induced Effect	832	49.0	132.4
Total Effect	7,464	240.5	472.7
Percentage Change with Primary Data			
Total Effect	-6.01	+7.09	+21.41

Sources: IMPLAN (2016), Author calculations.
Note: Both models defined by same direct effect for output ($317.0 million)

Multi-Industry Economic Contribution

Table 4 presents the results of the multi-industry analysis. All monetary measurements are presented in 2016 dollars. We include both individual industry and total industry results. Individual industry contributions allow for a detailed accounting of their specific indirect and induced effects, but reflect industry linkages with both non-apple and apple industries.

Total economic contributions (i.e., direct, indirect, and induced effects) of the entire apple industry in NYS are $2.1 billion in output, $587.9 million in labor income, and 11,872 jobs. Computing contribution multipliers as the total effect divided by the direct effect, we find that for every dollar of output, dollar of labor income, and job in the apple industry, another $0.58, $0.48, and 0.85 jobs are supported in non-apple industries in NYS, respectively.

Important to the interpretation in Table 4, the direct effects across industry sectors are additive (i.e., the seven individual values sum up to the total), but the indirect and induced effects across industry sectors are not. For example, when looking at the frozen, canned, and dehydrated processing sector output contributions, a portion of the $318.5 million in indirect effects is the value of apple sales from farming through processor purchases of local apples. In other words, a portion of the indirect effects for processing are already included in the direct effects for farming. Summing the individual industry indirect and induced impacts would result in double counting. Indeed, part of the multiplier effects for each individual industry includes any apple industries backward linked to them. The contribution multipliers for the aggregate industry, however, reflect only non-apple industry backward linkages. Separate contribution analyses in IMPLAN must be conducted in IMPLAN for each industry category.

Table 4. Economic contribution of the apple industry in New York, by sector, 2016.

Category and Sector	Direct Effect[a]	Indirect Effect[b]	Induced Effect[c]	Total Effect	Contribution Multiplier[d]
Output ($ million)					
Agricultural support services	11.9	1.6	5.7	19.2	1.62
Nursery stock suppliers	7.1	0.6	2.9	10.6	1.49
Farming	317.0	116.0	141.0	574.0	1.81
Processing (frozen canned, dehydrated)	838.8	318.5	149.8	1,307.1	1.56
Processing (hard cider, apple wine)	129.8	52.9	36.2	218.9	1.69
Industry marketing	3.1	0.8	1.2	5.2	1.65
Industry public research & extension	2.2	1.1	0.3	3.6	1.65
Total	1,309.9	441.3	314.3	2,065.5	1.58
Employment					
Agricultural support services	265	7	36	308	1.16
Nursery stock suppliers	81	5	18	104	1.28
Farming	5,605	525	886	7,016	1.25
Processing (frozen canned, dehydrated)	1,635	1,441	940	4,016	2.46
Processing (hard cider, apple wine)	425	252	228	905	2.13
Industry marketing	6	5	8	19	3.19
Industry public research & extension	16	6	2	24	1.49
Total	8,033	1,849	1,989	11,872	1.48
Labor Income ($ million)					
Agricultural support services	7.7	0.5	2.1	10.4	1.34
Nursery stock suppliers	4.0	0.2	1.1	5.3	1.33
Farming	164.7	40.6	52.1	257.5	1.56
Processing (frozen canned, dehydrated)	106.9	113.8	55.4	276.0	2.58
Processing (hard cider, apple wine)	31.5	21.1	13.4	66.0	2.10
Industry marketing	1.5	0.3	0.5	2.3	1.52
Industry public research & extension	0.8	0.5	0.1	1.4	1.71
Total	317.2	154.8	115.9	587.9	1.85

Source: Schmit, et al. (2018)

[a] Direct effects represent total activity (sales, employment, labor income, value added) by the respective industry.
[b] Indirect effects represent all activity by the backward-linked supply chain industries.
[c] Induced effects represent additional industry activity due to consumption out of labor income.
[d] The contribution multiplier is calculated as the total effect divided by the direct effect.

Exploring Backward Linkages

In addition to understanding the total economic contributions of industries, it is useful to examine what industries contribute most heavily to those totals via backward industry linkages. Depending on the objectives of the research, examining the distribution of linkages for each industry, as well as for the aggregate, may be important. For ease of exposition, we focus our discussion on the aggregate industry results from our application.

Figure 2 and Figure 3 display the distribution of indirect and induced effects generated by the apple industry's combined direct activities by output and employment, respectively. The industries are aggregated to the 2-digit NAICS level. Importantly, the sum of the bars in the figures will be identical to the sum of the indirect and induced effects from Table 4 for the total apple industry category. The figures present a visual form of how the indirect and induced effects, and hence the multipliers, are constructed.

Figure 2. Indirect and Induced Output Effects by Industry for NYS Apple Industry.

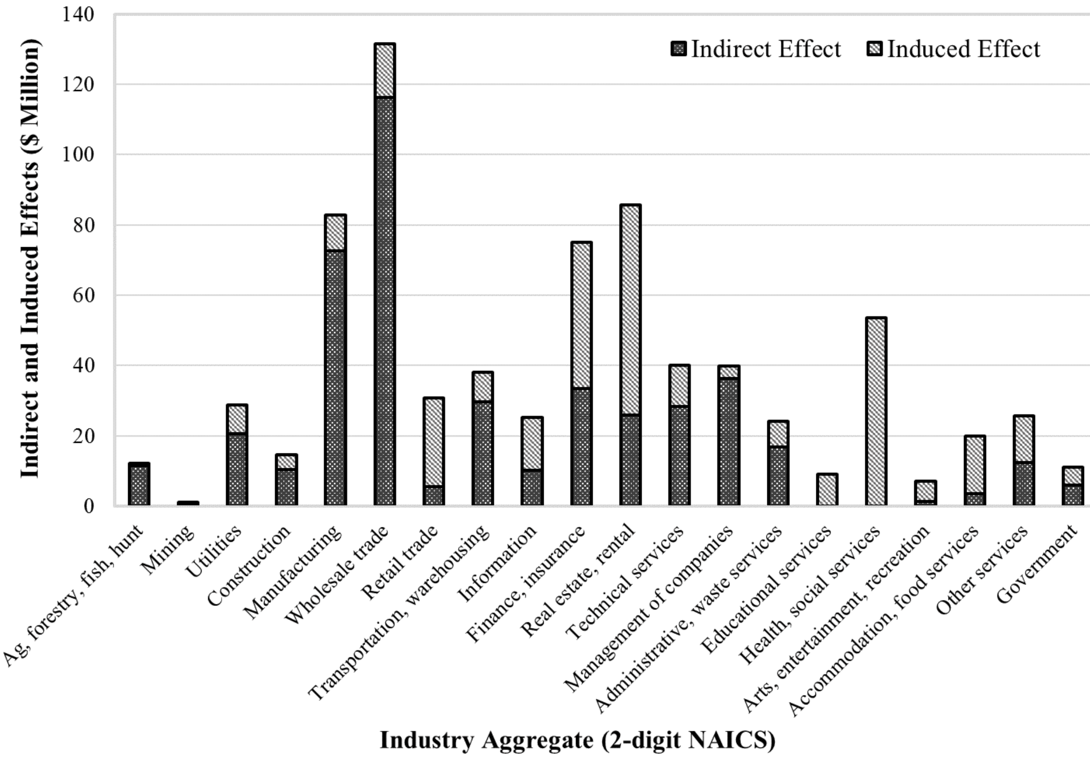
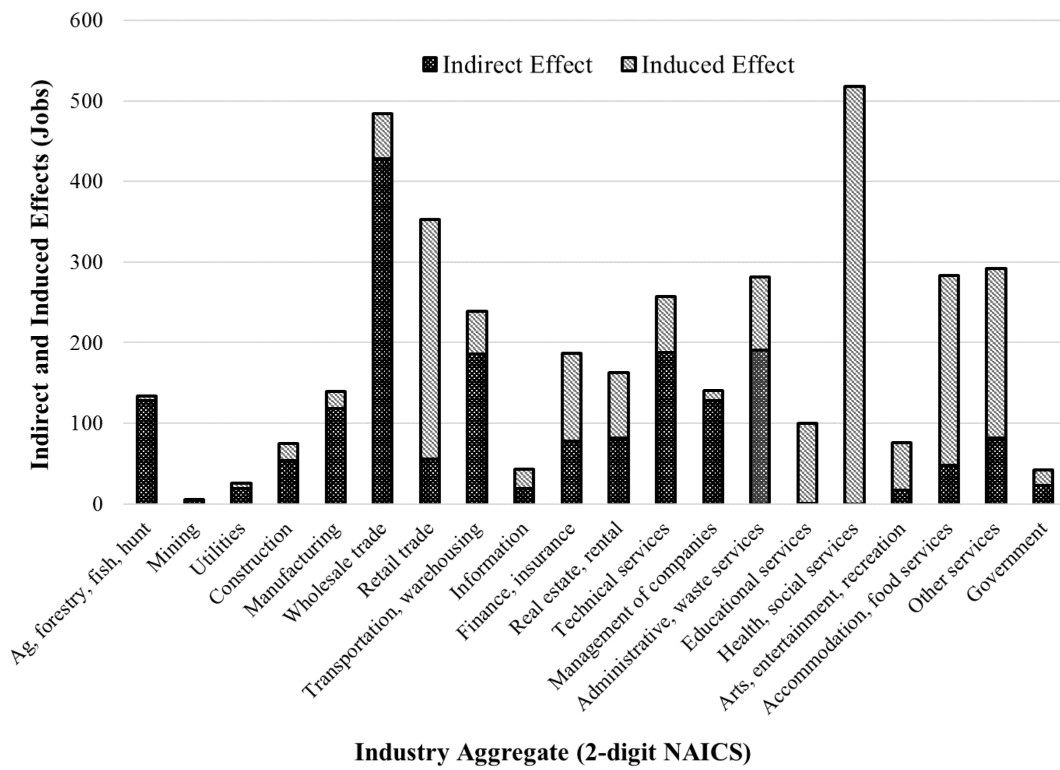


Figure 3. Indirect and Induced Employment Effects by Industry for NYS Apple Industry.



The indirect effects are shown in black and the induced effects are shown in gray. Considering the indirect effects more closely is useful to understand the business-to-business linkages originating from an industry's direct activities. In deference, spending out of labor income is invariant to the industry of origin. Accordingly, much of the interpretation and discussion highlights the indirect industry effects. In our application, wholesale trade has the strongest backward linkages for all firms in the apple industry. This makes intuitive sense as many input purchases by farms, processors, and other sectors are from wholesale distributors, rather than from retail establishments. Not surprisingly, most of the impact to wholesale trade is derived from indirect effects. Manufacturing firms have the next highest level of linkage effects, almost entirely from local business-to- business (indirect) linkages.

From the first bar in Figure 2, apple industry firms purchase a relatively small amount of inputs from other (non-apple) farm production sectors, and is comprised primarily of non-apple fruits and vegetable purchases by farms and manufacturers for processing and/or resale. Noting that the corresponding bar in Figure 3, highlights that those input purchases are from relatively high employing sectors (per dollar of output). Other business support sectors, such as transportation and warehousing, finance and insurance, and contracted professional services make up the bulk of the remaining indirect effects. The largest induced effects follow intuitively from major household budget allocations; i.e., insurance, real estate, healthcare, dining, and various retail purchases.

Discussion and Conclusions

Improving the understanding of intra- and inter-industry linkages within local economies is necessary for community educators, industry leaders, and public officials to make informed choices regarding ag-based economic development priorities and the projected impacts on economic growth and to community goals. More recently, focus has shifted to how improvements in or expansions of local and regional food systems can generate these desired impacts. A careful consideration of the methodologies to employ and data to collect are necessary to produce meaningful and defendable results.

In this paper, we highlight the application of best practices from Thilmany et al. (2017) to address agricultural industry interest in describing the nature of their economic contributions to local economies. In particular, we apply a multi-industry economic contribution analysis to the apple industry in NYS. We identify seven key individual industries within the broader apple industry collective and describe the process from inception to application to interpretation. As these types of analyses are popular, among industry and public agencies alike, promoting a replicable framework will improve the compatibility and comparison of analyses across industries, geographies, and time.

Our multi-industry application identified conditions where primary, localized data collection was needed relative to reliance on industry average parameters. With our specific application to the apple farming industry in NYS, we were able to document that relying on more aggregate industry relationships from secondary data sources biased downward total economic contributions (i.e., direct, indirect, and induced) for output and labor income, but biased upward total jobs. In all cases, however, reliance on pre-existing secondary estimates in our application biased downward the level of indirect and induced effects.

One cannot predict *a priori* whether your impact or contribution results will be higher or lower when collecting and utilizing primary data, but that's not the point. The point is that the results will be more accurate and defensible. In addition, constructing localized industry production functions provides specific information to the nature of the backward linkages and indirect industry effects, even before the IO model is constructed. That said, data collection comes with a cost and the efforts to plan and budget (in time and dollars) for such activities cannot be understated. When budgets are slim and/or time is tight, primary data collection may be infeasible, requiring the analysis to be done with existing resources and data. Depending on the objectives of your study, starting with pre-existing resources may be entirely sufficient. In any case, clearly documenting your inputs, assumptions, and analytical processes is key to a comprehensive analysis and in understanding the limitations of your results.

Often in multi-industry contribution analyses outputs from some industries represent inputs to others. Practitioners need to adequately understand where supply chain linkages occur and how to account for them to avoid double counting. In this paper, we highlighted existing resources available to assist practitioners in these efforts and explained the processes advocated in them with our application to the apple industry. In doing so, the actual empirical results we present are less important than the process we used to get to them.

Multipliers, while useful, are often relied on too heavily in decision making and without understanding of their construction, interpretation, and context. Our empirical application describes the construction of our contribution estimates and the multipliers accruing to them. In particular, we highlight the individual industry contributions that lead to a composite multiplier result. In doing so, particularly through the indirect effects, practitioners can better understand local supplying industries most important to the industry of inquiry and, therefore, most influenced by related industry expansions or contractions. Such an approach provides a useful way to describe economic contribution results and the composition of multiplier effects to a range of audiences.

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