

Economic Contributions & Multiplier Effects of the Beef Industry in Pennsylvania

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EXECUTIVE SUMMARY

In order to define appropriate firm, industry, and public policy strategies to strengthen opportunities for economic development and improve the competitiveness of the Pennsylvania (PA) beef industry, it is essential to understand the economic contributions and evolving linkages among agricultural producers, intermediary agents and processors, and downstream buyers. To help preserve and expand the opportunities for more productive correspondence with the wider economic development community, we provide state-level analyses within the various beef industry supply chain sectors, as well as in aggregate. Data from federal and state sources are utilized and are carefully analyzed to discuss a variety of economic metrics, assess inter-industry linkages, and calculate economic contributions to the PA economy

A comprehensive definition of the beef industry in PA was constructed to include beef farming, feedlot operations, primary beef processors (slaughter and meat processing facilities), and meat byproduct processors (rendering firms and animal food manufacturers) where beef-based inputs serve as an important input to their operations. A customized economic input-output model was developed to assess economic contributions of individual and aggregate industries across a number of metrics.

PA harbors a well-integrated beef industry supply chain from beef animal production to meat and meat byproduct processing. This is evident when considering the relatively strong individual beef industry multipliers estimated post the farm gate. Further, beef farm and feedlot operations alone supports nearly 14,000 jobs in the state, translating into nearly \$1 billion of total (direct, indirect, and induced) industry output. Weather and global market conditions play a strong role in year-to-year industrial activity, but even in a year like 2017, where returns to operators at the farm level were negative, the beef industry in whole supported nearly \$9 billion in industrial activity, 37,000 jobs, and contributed over \$2.6 billion to the state's GDP.

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INTRODUCTION

In order to define appropriate firm, industry, and public policy strategies to strengthen opportunities for economic development and to improve the competitiveness of the Pennsylvania (PA) beef industry, it is essential to understand the economic contributions and evolving linkages among beef producers and processors, as well as related input suppliers and downstream buyers interacting with beef industry firms. To help preserve and expand the opportunities for more productive correspondence with the wider economic development community, I provide state-level analyses for the beef production sector, two beef processing sectors, two beef byproduct processing sectors, an aggregate of all five. Industry-specific data from IMPLAN (2017) and USDA (2019) are utilized, along with a customized PA input-output model to carefully analyze a variety of economic metrics, to assess inter-industry linkages, and to calculate total economic contributions attributable to the PA beef industry and their corresponding multiplier effects.

The beef industry is part of a large farm and food industry in PA. Beef farming and feedlot operations are a large contributor to agricultural (farm) industry in the state. In 2017, output exceeded \$642 million and employed over 12,000 workers, representing over 9% and 15% of the total farming industry in the state, respectively. Comparatively to other livestock/meat production sectors, production values for hogs, sheep, and other non-poultry livestock were \$489 million, chickens were \$534 million, and eggs were \$475 million (USDA 2019).

Much of PA beef production is processed through PA slaughter and processing facilities. As defined in more detail below, the beef industry's direct economic contributions from slaughter and processing facilities, as well as byproduct processing (i.e., rendering, animal food) exceeded \$5.5 billion in industry output and supported nearly 9,000 jobs. Finally, dairy steers and cull cows from the large dairy industry in PA account for strong industry linkages when utilized through PA beef farm operations, feedlots, and, ultimately, slaughter and processing facilities.

In addition to the beef industry's sizable direct economic contributions (i.e., over \$6 billion in industry output), backward-linked industry transactions with local input supplying firms and labor generate additional contributions induced by the direct activity. This report provides an assessment of the overall contribution of the PA beef industry based on the framework utilized in Schmit (2016) and using economic data from 2017. Such an assessment aids in the understanding of the industry's economic contributions and the linkages it has with industries outside of the beef industry supply chain. The report continues with a description of the methodological approach used for the multi-sector analysis, including a description of the specific beef industry sectors included. The economic contribution results follow, along with a decomposition of the multiplier effects by industry. We close with some implications of the results and summary conclusions.

METHODOLOGICAL FRAMEWORK

Input-output (IO) models provide an insightful way to depict and 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. The methodology's analytical capacity lies in its ability to estimate the *indirect* and *induced* economic effects stemming from the *direct* expenditures that lead to additional purchases by users in an economy (Schmit and Boisvert 2014). Our description of these effects for the beef industry in PA include four common economic measurements - output, labor income, total value added, and employment (**Box 1**).

The indirect and induced changes in economic activity result from what are commonly known as *multiplier* effects throughout the various sectors in the economy. Indeed, it is the cumulative impacts across all affected industries that are of most interest (direct + indirect + induced). The indirect impacts could be in the form of additional purchases of a variety of goods and services or in the form of the increased labor income generated due to the increased economic activity. To the extent that the additional labor income is spent within the defined local economy, additional effects are created, commonly referred to as induced impacts. Magnitudes of the indirect and induced effects will differ by industry sector.²

Using the IMPLAN databases, it is possible to examine transactions among 536 industrial sectors of an economy as defined by the North American Industry Classification System (NAICS), the standard used by Federal statistical agencies to classify business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy. The customized PA model developed for the beef industry analysis represents a fully disaggregated 536 industry model.³ When presenting the results, however, the empirical results are aggregated to the 2-digit NAICS level (excluding the beef industry sectors) for ease of exposition.

Box 1. Metrics Considered in the Analysis	
Output	The value of industry production in producer prices; for manufacturers = sales + changes in inventory, for service sectors = sales, for retail & wholesale sectors = gross margin.
Labor Income	All employment income; employee compensation (total payroll cost) + proprietor income (self-employed + unincorporated business owners).
Value Added	Gross regional product derived from income paid to owners of the factors of production. Output - cost of intermediate inputs. Includes labor income, other property type income, and taxes.
Employment	The average annual number of monthly jobs, both full and part time. Not full-time equivalents.
Source: IMPLAN (2019)	

CONTRIBUTION ANALYSIS

One approach to assessing an industry’s effects is through an economic contribution analysis. In deference to an *impact* analysis that considers marginal changes in deliveries to final demand⁴ induced by a policy or private policy/initiative, 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) by using data internal to the underlying input-output (IO) model to identify all backward linkages in the study area; i.e., it identifies the total direct, indirect, and induced effects (**Box 2**).

In a contribution analysis, existing total output, not just final demand, 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. In our application, IO

² For a more detailed discussion of input-output analysis used within the context of this report, see Schmit and Boisvert (2014). For a comprehensive application of input-output methods and theory, see Miller and Blair (2009).

³ Technically, we develop a Social Accounting Matrix (SAM) model within IMPLAN, rather than an IO model. The SAM has an input-output model at its core, but because the SAM distinguishes household purchasing patterns by income group, the impacts and multipliers based on the SAM reflect the multipliers throughout the economy with somewhat greater precision than do those based on an IO model (Miller and Blair, 2009, chapter 11).

⁴ Final demand is defined as the value of goods and services produced and sold to final users (institutions) during the calendar year. Final use means that the good or service will be consumed and not incorporated into another product (IMPLAN 2016).

analysis is used to assess how the value of the PA beef industry (beef production and related processing) permeate throughout the state’s economy. In addition to presenting the total economic effects over the four metrics described above (**Box 1**), we also describe the distribution of indirect and induced effects to highlight to what industries the multiplier effects accrue to.

The contribution analysis conducted here follows the methodological framework outlined in Schmit (2016). Following IMPLAN’s recommended procedures for a multi-industry economic contribution analysis, two preliminary model customization steps are required before estimating the indirect and induced effects.⁵ First, commodity production for each beef supply chain industry is modified so that each industry produces only its primary commodity; i.e., no byproducts. This is necessary since trade flows within IMPLAN apply to commodities, not industries. In other words, commodities are traded (not industries), and industries may produce more than one commodity.⁶ Second, within the trade flows data, the Regional Supply Coefficient (RSC) for each commodity contained in

the contribution analysis is set to zero. The RSC indicates the proportion of the local supply of a commodity that goes to meet local demands (final or intermediate). Changing the RSC implies that all specified industry sectors will have sales only to export markets (domestic or foreign), with zero intermediate output. While not true in reality, computationally it ensures that no sector will purchase from these industries beyond the industry’s total output, including the primary industry itself (e.g., beef farmers buying cattle from other beef farmers). In essence, this technical modeling requirement forces the model to not be able to create any additional local impact for any of the sectors included in the contribution analysis and, effectively, eliminates double counting of backward linkages. For example, if we count the direct effect of beef farming output (cattle), of which some (or all) is sold to local processors, we cannot count the value of beef animal again in the processors indirect effects.

Since all intermediate sales have been changed to final sales in this approach, the direct and indirect effects reported in a contribution analysis have slightly different interpretations than those for traditional impact analyses, as described in **Box 2**. Specifically, the direct effects (with respect to output) represent

Box 2. What are direct, indirect, and induced effects?	
Direct effects	The set of expenditures applied to the predictive model for analysis. It is a series (or single) of production changes or expenditures made by producers & consumers as a result of an activity or policy. The values are determined by an analyst to be a result of this activity or policy.
Indirect effects	The impact of local industries buying goods and services from other local industries. The cycle of spending works its way backward through the supply chain until all money leaks from the local economy, either through imports or by payments to value added.
Induced effects	The response by an economy to an initial change (direct effect) that occurs through re-spending of income received by a component of value added and generally limited to labor income (employee compensation and proprietor income). This money is recirculated through the household spending patterns causing further local economic activity.
Source: IMPLAN (2019)	

⁵ For details go to <https://implanhelp.zendesk.com/hc/en-us/articles/115002801513-IMPLAN-Pro-Considerations-of-Industry-Contribution-Analysis>.

⁶ Most industries produce one primary commodity and a small amount of byproducts, or secondary commodities. These are defined for each industry within IMPLAN based on the Bureau of Economic Analysis, U.S. Department of Commerce, National Income and Product Accounts. For example, the beef farming industry, produces primarily “beef cattle” (99.2% of all output), plus a small amount of “support activities for agriculture” (0.8%) such as technical production services, pasture management, etc.

all sales by the industries of interest (in our case, beef industry sectors). Total gross output is used as the direct effect, including final demand and the indirect and induced effects associated with that final demand. The indirect effects represent all sales by the backward-linked supply chain industries. In other words, all indirect purchases in upstream sectors outside of the beef industry sectors considered in the direct effect. The induced effects (by households) have their common interpretation; i.e., additional industry sales due to consumption spending out of labor income.

BEEF INDUSTRY SECTORS

Five distinct, yet linked, beef industry supply chain sectors were defined for this study. First, we include beef cattle production, including cow-calf, stocker, and feedlot operations, as well as dual-purpose farms raising cattle for both milk and meat purposes. Notably, federal and state data sources combine these operations, so separating farm operations from feedlot operations is not available unless additional primary data collection efforts are implemented. The value of output includes sales cattle for meat (feeder and finished) as well as for breeding purposes (e.g., seedstock producers).

Second, we include multiple beef processing sectors; i.e., those involved in transforming live animals to carcasses (slaughter facilities), carcasses to meat products (processor facilities, and meat products into further processed meat products (rendering, byproducts, and animal food).⁷ Fortunately, poultry production and processing are accounted for separately from other livestock products within federal reporting databases (and IMPLAN). However, output from slaughter, processors (from carcasses), and rendering facilities includes multiple livestock species inputs; for PA, these include beef, hogs, and (to a lesser degree) sheep and goats. This makes sense from a data collection perspective as these types of facilities process more than just beef animals, carcasses, or byproducts therefrom. However, from an analytical perspective focused on the beef industry, only the value beef activities should be included. In essence, the analyst must disaggregate the multiple-livestock operations into beef-only operations and other-livestock operations. It is certainly the case in PA that some operations process only beef, but industry-aggregate data include beef-only firms with others who are not beef-limited.

Accordingly, to estimate the value of beef activities within the animal slaughter, processing, and rendering industries we considered the total gross commodity demands in PA (by all industries and institutions, including households) for “beef cattle” relative to “other animal production,” comprised of hogs, sheep, goats, and other non-poultry livestock. Such an approach is conceptually appealing and practically reasonable; i.e., the more demand for beef cattle in PA, the more beef and beef products will be processed through these facilities. The percentage of total commodity demand specific to beef was 67.3%, as estimated from the 2017 customized IMPLAN IO model.⁸ Accordingly, the total value of output in livestock slaughter, meat processing, and rendering facilities was multiplied by 0.673 and allocated to beef industry direct effects.

While this procedure computes the beef-only direct effects, an additional model adjustment is necessary for slaughter and meat processing industries since their production functions (that defines what inputs these industries purchase) still includes purchases of beef cattle and other animals (as they are multi-

⁷ Facilities that both slaughter animals and process carcasses are included within the slaughter industry sector.

⁸ Specifically, from IMPLAN, we divided the Total Gross Commodity Demand (TGCD) for beef cattle by the sum of TGCD for beef cattle and for other animal production (excluding poultry). The result is somewhat less than the ratio based on local production in the farming industries (57%), but slightly less than the ratio of intermediate input purchases (local and nonlocal) by animal slaughter and meat processing facilities in the state. Since processors purchase

livestock oriented firms). For example, for animal slaughter (except poultry) operations, every \$1 of industry output requires the purchase of \$0.453 of beef cattle and \$0.194 of other animals (i.e., hogs, sheep, goats). This presents an internally inconsistent parameterization as the firms purchase both beef cattle and other animals, but produce only beef based on the 67.3% direct effect conversion above. Accordingly, we set input purchases of other animals to zero within their production functions and rebalance the remainder of input purchases. In other words, all other input purchases are increased proportionately to account for the \$0.19 reduction in other animal purchases. Doing so retains the original output proportions to total intermediate input purchases and allocations to value added, while not ascribing indirect effects to the PA beef industry for purchases of non-beef livestock.

Animal food manufacturing industries include dog and cat food manufacturing and other animal food manufacturing (primarily livestock feeds but also other pet food). Computing the direct effects from them attributable to the beef industry from these industries is more complicated as their outputs encompass meat, grain, sugar, and other food commodity inputs. Accordingly, we first consider the level of their input purchases from the slaughter and meat processing industries relative to other inputs and value added allocations. For example, dog and cat food manufacturing requires the purchase of \$0.001 and \$0.210 worth of the livestock slaughter and meat processing outputs, respectively, for every \$1 of output they sell. Similarly, other animal food manufacturing requires the purchase of \$0.0003 and \$0.051 worth of the livestock slaughter and meat processing outputs, respectively, for every \$1 of output they sell. Accordingly, the total value of output in these industries is first multiplied by 0.211 and 0.0513, respectively, to apportion the total value to meat industries, and that value multiplied by 0.673 (from above) to apportion get direct effects specifically to the beef industry.

Since the output for beef farming (direct) is also an input cost for processors (indirect), it is important in our total industry contribution analysis not to double count these values. The same concept holds for purchases by meat rendering facilities or animal food manufacturers from meat processors. Similarly, intra-industry purchases and sales must also be accounted for to avoid double counting; e.g., every \$1 of beef farm output requires the purchase of \$0.18 from other beef farmers. The methodological procedures outlined above account for these issues and utilized in the aggregate, all-beef industry estimation. The total output and employment (direct effects) are summarized for each beef industry sector in **Table 1**.

Table 1. Direct effects for PA beef industry, 2017.			
Industry Code	Description	Employment (jobs)	Output (\$ Million)
11	Beef Farm & Feedlot Production	12,040.9	642.0
89	Beef Slaughter	3,972.9	2,685.4
90	Beef Processing	4,368.9	2,243.1
91	Beef Rendering & Byproducts	232.6	109.4
65, 66	Animal Food Manufacturing	391.9	530.1
	Beef Industry All	21,007.1	6,210.0
Source: IMPLAN (2019) and author calculations			

The consideration of attributing other downstream industries (post-manufacturing) to the beef industry is inappropriate; e.g., food distributors, retail groceries, restaurants, and catering firms. To begin, the underlying products of interest (beef products in this case) are no longer transformed, but merely distributed and offered for sale. As such no added value to the beef product/industry necessarily accrues. If anything, one may consider the transport, wholesale, and retail trade margins, but not the costs of goods sold, associated with these downstream firms, and then apportioning those margins to beef

transported or sold relative to all products handled. However, even then, data limitations are problematic empirically and, conceptually, in the absence of beef, products can be replaced with other local non-beef products or beef-import equivalents. For these reasons, I exclude these downstream sector margins. To be sure, transport, wholesale, and retail margins are included in the estimates presented as they associate with purchases by beef industry firms (i.e., margins linked backwards in the supply chain rather than forwards), the conceptual basis for IO model applications. To the degree others think differently, the results presented here may be considered somewhat conservative.

ECONOMIC CONTRIBUTION

The direct effects outlined above were included in single and multi-industry contribution analyses in the customized PA IO model within IMPLAN, importantly accounting for inter-industry linkages among the beef industry supply chain sectors to avoid double counting. All monetary measurements are presented in 2017 dollars, the most recently available data during the time of this research. Individual and aggregate beef supply chain industry contributions are shown in **Table 2**. Individual industry contributions allow a more detailed comparison of the relative size of contributions across industries, and their related indirect and induced effects. Importantly, however, the Individual industry estimates reflect industry linkages with both non-beef and other beef industries upstream in the supply chain. The relative contributions within industries can provide insight into the input-based nature of their production processes. For ease of exposition, we leave a detailed examination of each of the sector's results to the interested reader. However, note that the relative composition of indirect and induced effects reflect, in part, differences in the labor use intensity across industries (i.e., value of intermediate input purchases versus value added outlays per dollar of output).

TOTAL ECONOMIC CONTRIBUTIONS

The economic contribution of the beef industry on total industrial sales (output) in PA was estimated to be \$8.8 billion in 2017 (**Table 2**). The \$6.2 billion of direct contributions support an additional \$1.6 billion and \$1.0 billion in indirect and induced industry sales, respectively, through non-beef industry linkages. Individual beef industry sector contributions (i.e., for farm production, slaughter, processing, and byproduct manufacturing) are also shown in **Table 2**. Note that while the direct contributions across industry segments are additive (i.e., for the direct effects, the five individual values sum up to the total direct effect), the same is not true for the indirect and induced impacts. For example, when looking at the beef slaughter sector in isolation, a portion of the \$1.1 billion in indirect output includes backward-linkages to the beef farm and feedlot sector through slaughter firm purchases from them. Thus, when looking at the composite industry results, those indirect effects for slaughter facilities are already accounted for in the direct effects for farming. Simply summing the individual indirect and induced impacts across agriculture's three components would result in double counting.

The contribution output multiplier for the aggregate beef industry in PA (i.e., the sum of the direct, indirect, and induced effects divided by the direct effect) is 1.42, meaning that for every dollar generated in the beef industry (broadly speaking), an additional \$0.42 is generated in backward linked (non-beef) industries (**Table 2**). Decomposing the multiplier into its indirect and induced components, the indirect effect is \$0.25 (from business-to-business activity) and the induced effect is \$0.17 (from labor income spending). Put differently, 60% of backward linkages (0.25/0.42) accrue to business-to-business linkages, and 40% from labor income spending. Individual component contributions and multipliers vary based on the type of spending, industry linkages, and the degree that spending is local (within the state).

Table 11. Economic contribution of the beef industry in Pennsylvania, 2017.					
Category and Sector	Direct Effect¹	Indirect Effect²	Induced Effect³	Total Effect⁴	Contribution Multiplier⁵
Output (\$ million)					
Beef Farm & Feedlot Production	642.0	235.6	66.8	944.5	1.47
Beef Slaughter	2,685.4	1,125.4	502.4	4,313.1	1.61
Beef Processing	2,243.1	878.1	448.7	3,569.9	1.59
Beef Rendering & Byproducts	109.4	71.5	37.1	217.9	1.99
Animal Food Manufacturing	530.1	228.3	90.6	849.0	1.60
Beef Industry All	6,210.0	1,552.9	1,046.5	8,809.4	1.42
Employment					
Beef Farm & Feedlot Production	12,040.9	1,477.9	470.2	13,989.0	1.16
Beef Slaughter	3,972.9	10,604.6	3,542.3	18,119.8	4.56
Beef Processing	4,368.9	5,666.7	3,163.6	13,199.1	3.02
Beef Rendering & Byproducts	232.6	363.8	261.1	857.5	3.69
Animal Food Manufacturing	391.9	1,035.5	638.6	2,066.0	5.27
Beef Industry All	21,007.1	8,596.2	7,391.7	36,995.1	1.76
Labor Income (\$ million)					
Beef Farm & Feedlot Production ⁶	-2.1	74.9	23.9	96.7	NA
Beef Slaughter	244.7	305.8	179.7	730.2	2.98
Beef Processing	261.4	230.2	160.5	652.1	2.49
Beef Rendering & Byproducts	14.4	26.3	13.2	53.9	3.75
Animal Food Manufacturing	32.4	66.8	32.4	131.6	4.06
Beef Industry All	550.8	599.8	375.0	1,525.6	2.77
Total Value Added (\$ million)					
Beef Farm & Feedlot Production	259.5	118.5	40.0	417.9	1.61
Beef Slaughter	404.0	561.5	300.8	1,266.2	3.13
Beef Processing	340.1	400.0	268.7	1,008.8	2.97
Beef Rendering & Byproducts	15.5	35.6	22.2	73.2	4.73
Animal Food Manufacturing	117.9	101.9	54.2	274.1	2.32
Beef Industry All	1,136.9	862.0	627.7	2,629.6	2.31
Source: Implan (2017), author calculations					
¹ Direct effects represent total activity (sales, employment, labor income, value added) by the respective industry.					
² Indirect effects represent all activity by the backward-linked supply chain industries.					
³ Induced effects represent additional industry activity due to consumption out of labor income.					
⁴ For each industry, the sum of the direct, indirect, and induced effects equals the total effect. Summing the direct effects across industries will equal the total shown (from Table XX); however, summing the indirect and induced effects across industries will not as we account for existing inter-industry linkages within the beef supply chain.					
⁵ The contribution multiplier is calculated as the total effect divided by the direct effect.					
⁶ Negative returns to proprietors (-\$15.4 million) resulted in a negative total labor income. In this case, multipliers are not applicable for proprietor income, where indirect and induced effects are set to zero. The indirect and induce effects shown are generated from employee spending.					

Total employment contributions of the beef industry in PA were estimated at 36,995 jobs (including full-time, part-time, and seasonal jobs), 21,007 jobs through direct beef industry employment, and an additional 15,988 through indirect and induced (non-beef) industries (**Table 2**). As with industry output, the majority of backward linkages occur through business-to-business activity (indirect effects), but both are sizable. Both slaughter and processing have employment multipliers in excess of 3.0, importantly

supporting farm-level jobs. Likewise, the two byproduct processing industries have employment multipliers above 3.6, importantly influenced by purchases from beef slaughter and processing. Both instances highlight the strong, local linkages among industries within the beef industry supply chain. When within-industry linkages are excluded (i.e., the Beef Industry All scenario), each job in the beef industry contributes another to 0.76 jobs in non-beef industries in the state (0.41 indirect, 0.35 induced). Slightly larger relative contributions of induced employment effects than output effects relative to indirect effects (46% versus 40%), is consistent with relatively higher labor-intensive industries related to household spending (e.g., healthcare, retail spending, etc.).

Now consider labor income, which includes employee compensation (wages and benefits) and proprietor (self-employment) income. The entire industry generated \$550.8 million in direct labor income and expands to \$1,525.6 million when all backward linkages are considered. The strong labor income multiplier of 2.77 indicates that for every additional dollar of labor income generated in the beef industry, \$1.77 of labor income is generated elsewhere in the PA economy. Sixty-two percent of the multiplier effect is generated through indirect effects (\$1.09), relative to 38% for induced (\$0.68). It is worth noting that 2017 was a particularly bad year for beef farm & feedlot owners where negative net returns to (-\$15.4) exceeded employee compensation (\$13.3), hence the -\$2.1 direct effect for labor income. Under this situation (for the farm level estimation), multiplier effects are not applicable (i.e., indirect and induced effects from proprietor income are set to zero), and those presented come only from spending by employees. For comparison, the labor income multiplier for 2013 was 2.30 and, for a similar level of industrial output, would imply an increase in total labor income effects at the farm level (i.e., direct, indirect, and induced) of around \$209 million and increase the beef industry aggregate amount by 13%.

Finally, consider total value added, which includes labor income, but also other property type income (e.g., corporate profits, capital consumption, interest), and government taxes and fees. It is equivalent to the contributions to the state's Gross Domestic Product (GDP). Here, the beef industry contributes \$1,136.9 million to the state's total GDP through its direct activity, and additional indirect and induced contributions of \$865.0 million and \$627.7 million, respectively. This implies that for every dollar of GDP contributed by the PA beef industry generates an additional \$1.31 in backward linked non-beef industries.

DISTRIBUTIONAL IMPLICATIONS

While **Table 2** provides the total contributions of indirect and induced effects as a result of the individual and aggregate beef supply chain industry's direct contributions, it is informative to examine what industries contributed to those effects. In other words, through examining the relative sizes of the backward linkages across non-beef industry sectors. The distribution of indirect and induced effects, by industry, are described below for the aggregate beef industry supply chain.

Figure 1 and **Figure 2** provide the distribution of indirect and induced effects, by industry, generated by the beef industry's direct activities. Industries are aggregated to the 2-digit NAICS level and the distributions are provided for output and employment, respectively. In general, the ordering of industries from left to right follow from production sectors on the left to service sectors on the right. In between are industries such as utilities, construction, manufacturing, wholesale trade, retail trade, and transportation and warehousing. While the relative magnitudes of effects are similar across industries for output (**Figure 1**) and employment (**Figure 2**), they are not identical due to differences in employment requirements (per dollar of output) across sectors.

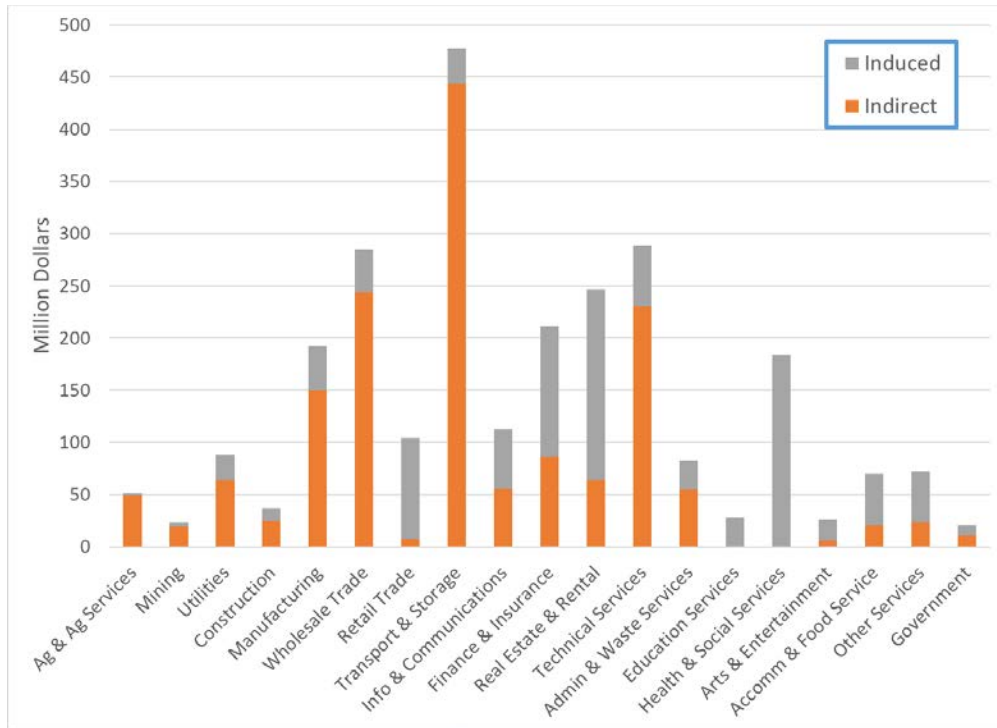


Figure 1. Indirect & induced output effects from the PA beef industry, 2017.

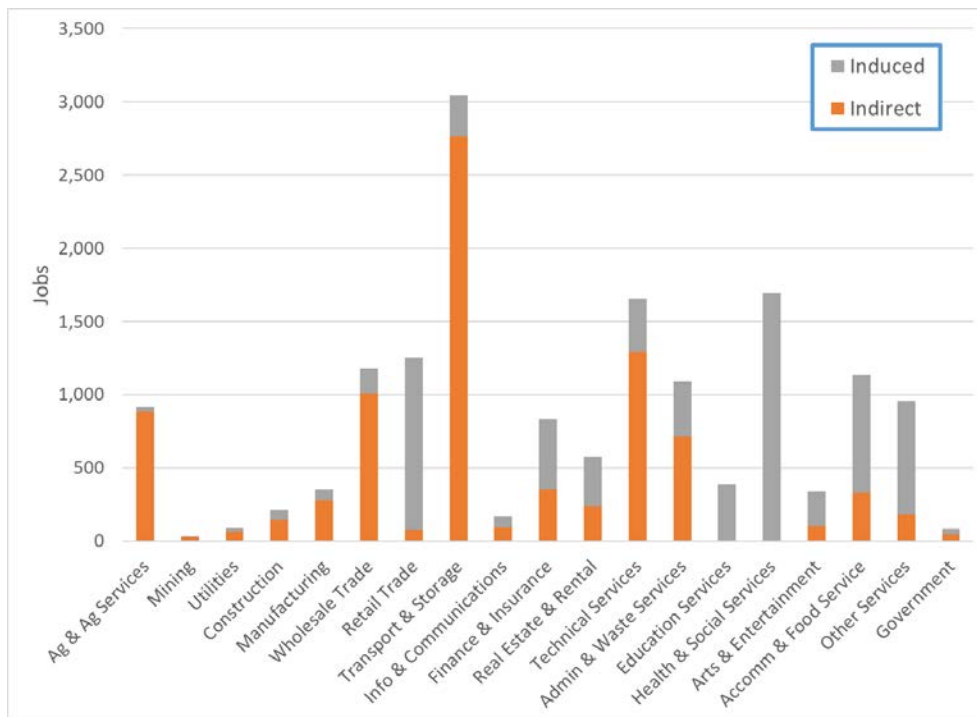


Figure 2. Indirect and induced employment effects from the PA beef industry, 2017.

The indirect effects (in orange) and induced effects (in gray) are separated to highlight the degree to which the effects derive from beef industry intermediate input demands versus accrual from labor income spending. Considering the indirect effects more closely is useful to understand the business-to-business

transactions in the state promulgated by the beef industry. In deference, spending out of labor income is invariant to where the direct effect occurs (i.e., household spending is the same whether the labor income came from a beef industry firm or not). Accordingly, much of the discussion below highlights the indirect industry effects.

Transportation and Storage has the highest backward linkages (for output and employment). This makes intuitive sense given hauling requirements (as cattle and processed meat products) and cold storage demands of finished products. Purchases from wholesalers and distributors (wholesale trade) and for technical services (e.g., veterinary, legal, accounting, management, and advertising) follow next for both output and employment, but with slightly different relative proportions. The relatively high wholesale trade level is consistent with a predominance of purchases by farms and processors from wholesale distributors rather than retail establishments. Notably, the contribution to wholesale trade represents the wholesale margin only, and not the value of the products purchased from them, those will show up in relation to the industrial sectors from where they are produced. Manufactured products follow for output, consistent with a range of manufactured products used by farms (e.g., chemicals, supplies) and processors (e.g., packaging materials, ingredients). Purchases accruing to other agricultural production (non-beef) or agricultural support sectors consist primarily of grain and other crop (e.g., hay) purchases, as well as dairy animals utilized in meat production (i.e., cull cows and bull/steer calves).

The largest induced effects follow intuitively from major household budget allocations; i.e., insurance, real estate (rent and imputed rental value for owned homes), healthcare, outside the home dining, and various retail purchases (e.g., food, clothing, etc.).

CONCLUSIONS

Economic contribution analyses identify the portion of a region's economy that can be attributed to an existing industry or combination of industries through its direct, indirect and induced effects. A comprehensive definition of the beef industry in PA was constructed to include beef farming, feedlot operations, primary beef processors (slaughter and meat processing facilities), and meat byproduct processors (rendering firms and animal food manufacturers) where beef-based inputs serve as an important input to their operations. A customized economic input-output model was developed to assess economic contributions of individual and aggregate industries across a number of metrics.

PA harbors a well-integrated beef industry supply chain from beef animal production to meat and meat byproduct processing. This is evident when considering the relatively strong individual beef industry multipliers estimated post the farm gate. Further, beef farm and feedlot operations alone supports nearly 14,000 jobs in the state, translating into nearly \$1 billion of total (direct, indirect, and induced) industry output. Weather and global market conditions play a strong role in year-to-year industrial activity, but even in a year like 2017, where returns to operators at the farm level were negative, the beef industry in whole supported nearly \$9 billion in industrial activity, 37,000 jobs, and contributed over \$2.6 billion to the state's GDP.

The general objective of this research was to better understand the beef industry's total economic contributions to the PA economy and to demonstrate the strong ripple (multiplier) effects the industry has given its backward-linked supply chain effects and related industry spending out of labor income. In addition, a closer examination of the distribution of the indirect and induced effects promotes a better understanding with what sectors these ripple effects arise from. While individual industries with strong ripple effects in the state may be desirable industries to target for expansion from a policy perspective, it

is important to emphasize that the sizes of these multipliers says nothing about the likelihood or means by which they will/can be expanded (Schmit and Boisvert 2014). The likelihood of expansion of the sectors depends on where markets may be expanding and the extent to which these are the ones in which the multipliers are large. Indeed, an equivalent economic impact could be achieved by supporting the industries that supply those that are targeted for expansion thereby increasing local purchases and the size of the expanding industry's economic multipliers. 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 (Schmit, et al 2019). The extent to which public policy can help in expanding opportunities is also important.

Throughout this report we have examined the several multiplier effects associated with the various beef-based economic sectors in PA. In closing, however, it is important to re-emphasize that it is most appropriate to use these multipliers to examine the impact of marginal (rather small) changes in any particular industry. Relatively large changes in an industry are most likely to be accompanied by structural changes in the nature of the economy's inter-industry transactions. Under these conditions, it may be more problematic to base estimates of the economic impacts on current estimates of economic multipliers.

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