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Economic impact of university veterinary diagnostic laboratories: A case study

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ABSTRACT

Veterinary diagnostic laboratories (VDLs) play a significant role in the prevention and mitigation of endemic animal diseases and serve an important role in surveillance of, and the response to, outbreaks of transboundary and emerging animal diseases. They also allow for business continuity in livestock operations and help improve human health. Despite these critical societal roles, there is no academic literature on the economic impact of VDLs. We present a case study on the economic impact of the Iowa State University Veterinary Diagnostic Laboratory (ISUVDL). We use economic contribution analysis coupled with a stakeholder survey to estimate the impact. Results suggest that the ISUVDL is responsible for $2,162.46 million in direct output, $2,832.45 million in total output, $1,158.19 million in total value added, and $31.79 million in state taxes in normal years. In an animal health emergency this increases to $8,446.21 million in direct output, $11,063.06 million in total output, $4,523.70 million in total value added, and $124.15 million in state taxes. The ISUVDL receives $4 million annually as a direct state government appropriation for operating purposes. The $31.79 million in state taxes in normal years and the $124.15 million in state taxes in an animal health emergency equates to a 795% and 3104% return on investment, respectively. Estimates of the economic impact of the ISUVDL provide information to scientists, administrators, and policymakers regarding the efficacy and return on investment of VDLs.

1. Introduction

Much of the work done by veterinary diagnostic laboratories (VDLs) is routine and contributes to animal agriculture by allowing for the movement of animals, diagnosis of disease, prevention and treatment of disease, and ongoing monitoring of the health status of animals. The work of VDLs becomes much more crucial when trade-limiting diseases occur. Under these circumstances, it might be impossible to send samples to other states for testing, and the presence of a VDL that rapidly identifies, helps control, and treats a disease is critical to the financial performance of the animal agriculture industry.

Funding to support VDL operations is typically derived from clinical diagnostic service fees and contracts and government appropriations. Whether these appropriations, or tax dollars, provide a sufficient return on investment depends on the contribution of VDLs to the productivity, growth, and ultimately size of an animal agriculture industry, which subsequently generates taxes that offset spending. The aim of this study is to provide a simple and transparent method to estimate the economic impact of VDLs, something currently absent in the literature. The Iowa State University Veterinary Diagnostic Laboratory (ISUVDL) is used as a case study. The ISUVDL was selected as a case study because it is located in one of the most intensively populated animal agriculture regions in the nation. As a result, the Iowa economy is highly dependent on the animal agriculture industry, which amplifies the importance of the economic impact of disease outbreaks.

2. The role and activities of the ISUVDL

Animal agriculture includes raising of livestock to provide meat, milk, fiber, and other products to consumers. Iowa is a major producer and net exporter of beef, pork, poultry, dairy, and egg products. Iowa hog and pig production totaled 12,511 million pounds (5,674,732 metric tons) in 2015 (USDA-NASS, 2016a). Iowa cattle and calf production totaled 1904 million pounds (863,708 metric tons) in 2015 (USDA-NASS, 2016a). In 2015, Iowa raised 9.1 million turkeys or 354 million pounds (160,567 metric tons) of turkey production (USDA-NASS, 2016b). Iowa sold for slaughter 11.3 million chickens, or 37 million pounds (16,904 metric tons) of chicken production, in 2015 (USDA-NASS, 2016b). Iowa egg production totaled 12,463 million eggs in 2015 (USDA-NASS, 2016b). Iowa produced 4841 million pounds

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(2,195,841 metric tons) of milk and 184 million pounds (83,234 metric tons) of milk fat in 2015 (USDA-NASS, 2016c).

The ISUVDL's services are used to help clientele enhance the health and well-being of their animals and business operations. The ISUVDL processes more than 75,000 case submissions and conducts more than 1.2 million diagnostic assays per year (personal communication, Dr. Rodger Main, Director of ISUVDL). Many of the diagnostic tests at the ISUVDL are conducted for complying with the regulations for the transportation, exhibition, and sale of animals and animal products. Examples include mandatory tests for salmonella enteritidis, tests for exhibition and interstate and international transportation of animals, and certificates of veterinary inspection. These tests are all routine, and many businesses would not be able to operate without them. These movements have also effectively integrated animal agriculture across state lines, thus allowing for specialization and reduction of costs. The ISUVDL is one of 11 Tier 1 laboratories in the United States National Animal Health Laboratory Network (USDA-NAHLN, 2011). Therefore, it also plays a role in various national programs for the surveillance of, and response to, diseases that affect animal productivity, trade, and public health.

Responding effectively to emerging and transboundary diseases requires surge capacity and diagnostic research to develop and validate new tests that are not available in private facilities within the state. The United States has experienced several emerging and transboundary diseases recently. Between 2013 and 2016 outbreaks of infectious animal diseases in the United States included porcine epidemic diarrhea (PED) virus, highly pathogenic avian influenza (HPAI) and Seneca virus A, which is a vesicular disease resulting in an unprecedented number of disease investigations for Foot and Mouth Disease (FMD). During the outbreak of HPAI in 2015, the ISUVDL provided large-scale tests of suspected flocks (Main et al., 2015). Poultry identified as positive were eliminated, and the disease was successfully controlled (USDA-APHIS, 2015). Sales of eggs from farms free of the disease would not have been possible without this testing. When PED virus emerged in 2013 (Stevenson et al., 2013), testing at the ISUVDL dramatically increased.

Animal agricultural in Iowa depends on the extensive movement of livestock. For example, approximately 46.6 million hogs and pigs were marketed in Iowa in 2015 (USDA-NASS, 2016a); and, 27.5 million hogs and pigs were brought into Iowa for feeding or breeding purposes. Cattle and calf marketings totaled 2.2 million in 2015, and 1.5 million cattle and calves entered the state that year (USDA-NASS, 2016a). Any factor that might restrict their export and out-of-state sales would be detrimental to the economy. Diseases such as African swine fever (ASF), classical swine fever (CSF), FMD, and HPAI are highly disruptive, trade-limiting diseases. The ISUVDL provides diagnostic support for the nation and the state during the incursion of such diseases. This may enable the transportation and sale of unaffected animals and animal products during a disease outbreak.

During an outbreak of disease, comprehensive surveillance and regionalization (zoning), when allowed, may be used to maintain safe trade in animal and animal products as was done during the HPAI outbreak in the United States in 2015 (Swayne et al., 2017). Countries that import from the United States would stop the import of diseased animals and animal products but may allow imports from regions proven free of the disease. Regionalization requires large-scale and rapid test methods that can be provided by the ISUVDL.

3. Materials and methods

This study employs a two-step analysis. First, economic contribution analysis is used to quantify the portion of the Iowa economy supported by the animal agriculture industry. Estimates of state government tax collections are generated from these economic contributions. In the second step, these contributions and tax collections are compared to stakeholder survey estimates of how much the ISUVDL contributes to the overall economic value of the animal production and processing sectors in Iowa. This provides a simple and transparent estimate of the economic impact of the ISUVDL, and an estimate of the return on investment of tax dollars spent on ISUVDL operations.

3.1. Economic contribution analysis

Economic contribution analysis is a method used to estimate the portion of the economy supported by existing businesses or industry sectors. IMPLAN®, which is an input-output model of the regional economy (IMPLAN®, Huntersville, NC) is used to complete the analysis. For the purposes of this analysis, economic contributions arise from the change in producer revenue caused by animal production sector and animal products processing sector gains or loses. When the sectors earn revenue through sales increases, that revenue is spent throughout the regional economy on wages, agricultural inputs, and consumption of goods and services. Therefore, if the sectors' revenues rise, so too will revenue and employment in other sectors of the economy. Input-output models allow for the estimation of direct, indirect, and induced effects by establishing the links between various sectors of the economy. See Miernyk (1965) and Shaffer (2010) for more discussion of input-output modeling.

Input-output models are a popular economic tool used in modeling economic contributions of animal agriculture (Knudson and Peterson, 2012; Decision Innovation Solutions, 2015, 2016; Milhollin et al., 2016; Indiana Business Research Center, 2017), veterinary medicine (Chastain et al., 2002; Tuck et al., 2012; Beyer et al., 2013; Hall, 2015), and animal disease outbreaks (Garner and Lack, 1995; Ekboir, 1999; Caskie et al., 1999; Mahul and Durand, 2000; Pendell et al., 2007).

The data used for input-output analyses are reasonably contemporaneous as they are based on the quarterly census of employment and wages data continuously collected and compiled by the U.S. Bureau of Labor Statistics, as well as: (*a*) a range of ongoing industrial surveys by the U.S Department of Commerce, the U.S. Bureau of Economic Analysis (BEA), the U.S. Department of Transportation, and the U.S. Department of Agriculture; (*b*) a range of other income-related data compiled at the state and substate levels by BEA; and, (*c*) the benchmark U.S. input-output tables that are updated quinquennially by BEA. These data provide the analytic foundation for the input-output model of the regional economy.

The model base data were for 2014. Animal production data were updated to reflect gross sales in 2015. Five categories for animal production were modeled: (*a*) swine; (*b*) cattle and calves; (*c*) poultry and eggs; (*d*) dairy cattle and milk; and, (*e*) all other animals. All other animals includes sheep and lambs, goats, equine, and all other animals.

The animal products processing (also referred to as manufacturing activity that depends on animal production as inputs) data were for 2014 and organized into three cohesive groups from several individual subsectors in the modeling system: (*a*) animal slaughtering and processing; (*b*) milk, cheese, ice cream, and all other related processed milk products processing; and, (*c*) poultry slaughtering and processing.

The animal production and the animal products processing industries all have strong buy-sell linkages with one another. The cattle sector, for example, buys animals from the dairy sector and vice versa. Animal products processing obviously buys animals and they buy from one another, as well. Accordingly, it is important to specify the modeling structure so that double counting is eliminated when estimating separate sector and combined sector economic contributions. The animal production and the animal products processing sectors were carefully modified in the model to minimize double-counting. These model modifications were done within the animal production sectors, between animal production and animal products processing sectors, and within the animal products processing sectors.

The modeling process produces estimates of labor income, which are payments made to all affected workers and proprietors. Labor incomes are subject to state personal income taxes, and the conversion of those incomes into household spending results in additional sales, use, and excise tax payments by consumers. U.S. Census data on state government tax collections for fiscal year 2014 as fractions of Iowa total personal income were used to produce estimates of the state government tax collections generated from the economic contributions measured in this study.

3.2. Stakeholder survey

The economic contribution of VDL's to animal agriculture are difficult to estimate, partly because they represent a service contribution and partly because the value of their efforts depends on a 'non-event' (Tuck et al., 2012). That is, testing and diagnosis improves animal health and reduces costs of production, but the economic costs of diseases prevented or how much they have been reduced are not observable. Further, the containment of something like FMD or avian influenza H5N1 would reduce potential catastrophes.

Given the uncertainty about outbreaks of trade-limiting diseases and the difficulty in measuring the importance of routine testing, this study relies, in part, on a stakeholder survey to estimate the economic contribution of the ISUVDL to the animal agriculture industry in Iowa. The role and functioning of the ISUVDL is not fully understood among the general population. Those who are in the best position to evaluate the contribution of the laboratory are those who use it. Therefore, a convenience sample of stakeholders including veterinarians and producers that actively use the laboratory and commodity group leaders who represent producers who benefit from the laboratory were surveyed. Input was sought from ISUVDL faculty and staff, who were familiar with users of the laboratory, to identify frequent users to be surveyed.

In December 2016, 45 stakeholders were identified and asked to provide estimates of how much the ISUVDL "contributes to the overall economic value of the livestock production and processing sectors in Iowa." The survey was sent as an email and stakeholders were given two weeks to respond. They were asked to provide an estimate for peacetime (i.e., a normal operating environment) and during an animal health emergency. An animal health emergency was described as "events such as the introduction of high-path avian influenza, foot and mouth disease, pseudorabies or hog cholera, may result in widespread culling, restrictions on animal movements, and on the interstate and international trade." Stakeholders who were surveyed were aware of the performance of the ISUVDL during recent outbreaks of PED virus and HPAI. The stakeholders surveyed were asked to provide an estimate (minimum, most likely, maximum) of how much smaller would the livestock production and processing sectors in Iowa be if the ISUVDL's services were eliminated, both under peacetime activities and in the event of an animal health emergency. The survey instrument is provided in Appendix A. The use of a proportional value in the survey was done to link the results of the survey to the estimates of the economic contribution of animal agriculture. These values were then compared to the economic contributions and state government tax collections to calculate the economic impact of the ISUVDL.

4. Results and discussion

4.1. Economic contribution of animal production and animal products processing

Economic contribution analysis measures the direct, indirect, induced, and total effects of an industry. The following definitions help guide interpretation of the results.

The direct effect is the output, value added, labor income, and employment (jobs) by the industry itself. In this study, it includes animal production and animal products processing. The direct effect is quantified based on the level of output of the industry. Indirect and induced effects measure the connections the industry has to others that supply it and its workers. The sources for inputs used by animal production and animal products processing, as well as their respective input purchases to supply operations, are the indirect effects. Direct sector and indirect sector workers use incomes to make household purchases; these are known as induced effects. Taken together, the sum of direct, indirect, and induced effects are known as total effects.

Table 1
Total Economic Contribution of Animal Production in Iowa, 2015.

Effect	Output Million $	Value Added Million $	Labor Income Million $	Jobholders
Swine				
Direct	7,442.02	6,482.77	3,492.84	53,315
Indirect	904.09	424.88	239.70	4158
Induced	2,540.64	1,432.10	788.21	20,819
Total	10,887.16	8,339.75	4,520.75	78,293
Cattle and Calves				
Direct	4,414.17	2,148.79	908.67	20,690
Indirect	1,625.00	712.08	368.52	7384
Induced	869.39	490.06	269.72	7141
Total	6,908.56	3,350.93	1,546.91	35,215
Poultry and Eggs				
Direct	1,855.87	788.42	310.00	1590
Indirect	1,150.90	328.55	177.58	2676
Induced	333.54	188.04	103.45	2735
Total	3,340.31	1,305.00	591.03	7001
Dairy Cattle and Milk				
Direct	834.90	467.71	248.36	1693
Indirect	319.45	116.60	65.18	1189
Induced	13.74	120.48	66.30	1755
Total	1,368.09	704.79	379.84	4636
All Other Animals				
Direct	69.92	60.91	32.82	628
Indirect	8.49	3.99	2.25	49
Induced	23.87	13.45	7.41	245
Total	102.28	78.35	42.47	922
Combined Animal Production (no double-counting)				
Direct	14,616.88	9,948.60	4,992.68	77,916
Indirect	2,781.38	938.58	546.55	9776
Induced	3,797.72	2,141.54	1,178.59	31,203
Total	21,195.99	13,028.71	6,717.82	118,895

Direct output is analogous to annual sales. Total output includes the interlinked industry sectors that support these levels of sales, to include all employee spending. Value added includes all labor income plus payments to investors (dividends, interests, and rents), and indirect tax payments to governments. Value added is analogous to gross domestic product (GDP) and is a preferred measure of economic worth of industrial activity. Labor income is wage and salary payments to workers, including employer-provided benefits. Salary-like payments to proprietors, like farmers, for their management of businesses are also counted as labor income payments. Input-output models measure the annualized job value in different industries. Many industries have mostly full-time jobs, but many others have part-time and seasonal jobs, as is the case in this study. Input-output models do not convert jobs into full-time equivalencies, but they do convert them into annualized equivalencies.

Table 1 shows the economic contribution of animal production in Iowa. Combined, animal production in Iowa produced $14,616.88 million in direct output in 2015, which required 77,916 jobholders making $4,992.68 million in labor income. This required $2,781.38 million in inputs, which in turn employed 9776 persons making $546.55 million in labor income. When the direct and the indirect jobholders spent their labor incomes, they induced $3,797.72 million in output and $1,178.59 million in labor income to 31,203 jobholders. After considering all multiplied through effects, Iowa's animal production industry contributed $21,195.99 million in total output to the state's economy and $13,028.71 million in total value added, of which $6,717.82 million was labor income to 118,895 jobholders.

Table 2 shows Iowa manufacturing activity that depends on animal

Table 2
Total Economic Contribution of Animal Products Processing in Iowa, 2014.

Effect	Output Million $	Value Added Million $	Labor Income Million $	Jobholders
Animal Slaughtering and Processing				
Direct	14,678.81	2,122.38	1,314.17	25,877
Indirect	1,533.84	617.48	437.61	8157
Induced	1,212.16	683.52	375.75	9905
Total	17,424.81	3,423.39	2,127.54	43,939
Milk, Cheese, Ice Cream, and All Other Related Processed Milk Products Processing				
Direct	2,591.61	342.59	210.37	3359
Indirect	810.30	332.07	216.13	3687
Induced	294.90	166.28	91.42	2410
Total	3,696.81	840.93	517.92	9456
Poultry Slaughtering and Processing				
Direct	694.30	132.69	109.60	2329
Indirect	138.37	57.69	40.88	776
Induced	104.12	58.71	32.28	851
Total	936.78	249.10	182.76	3956
Combined Animal Products Processing (no double-counting)				
Direct	17,964.72	2,597.66	1,634.14	31,565
Indirect	1,923.50	925.96	645.96	11,729
Induced	1,592.04	898.03	493.67	13,015
Total	21,480.26	4,421.65	2,773.78	56,308

production as inputs. These are important industries in Iowa, and they depend on a reliable supply of animals and animal products. Because the manufacturing sectors all contain upstream linkages to their respective animal production suppliers, and as those values have already been estimated, the total economic contributions of the animal products processing sectors have been calculated net of those animal production linkages. That means the resulting values contain no animal production linkages and therefore contain no double-counting with the animal production sector. In 2014, Iowa's animal products processing industry combined to produce $17,964.72 million in direct output, $21,480.26 million in total output and $4,421.65 million in total value added, of which $2,773.78 million was labor income to 56,308 jobholders.

Combined, animal production and animal products processing in Iowa produced $32,581.60 million in direct output, $42,676.25 million in total output and $17,450.36 million in total value added, of which $9,491.59 million was labor income to 175,203 jobholders.

4.2. State government tax collections

All incomes generated from animal production and animal products processing are subject to state personal income tax collections, and when workers convert their incomes into household spending they generate additional sales and use taxes for the state. Collectively, workers linked to the animal production industry generated $338.97 million in state tax receipts (Table 3). Those in the animal products processing industry accounted for $139.96 million in state taxes. The total tax contribution from both sectors was $478.92 million.

4.3. Stakeholder survey and estimated economic impact of the ISUVDL

It is important to note that so far this analysis has not provided any economic impacts. It has only provided economic contributions. Economic impact analysis looks at the net change in economic activity associated with a given activity. Usually an impact occurs because of a change in final demand, primarily sales to external purchasers. An economic impact scenario can also involve a with-without situation. For further reading on the differences between impact and contribution analysis, refer to Watson et al. (2007). To be an economic impact analysis, there must be a change in the regional economy that would not have occurred otherwise. To that end, we use a stakeholder survey to ascertain what the animal agriculture industry in Iowa would look like without the ISUVDL. Economic impact analysis requires this 'but for' test to be met (Tuck et al., 2012). The ISUVDL creates economic activity by contributing to the productivity, growth, and ultimately size of the animal agriculture industry in Iowa.

Completed questionnaires from 18 out of 45 stakeholders were returned, a 40% effective response rate. Table 4 shows characteristics of respondents and non-respondents to the survey. The industry segment represented was consistent across respondents and non-respondents. We did capture responses from mail-order hatchery producers and a layer breeder veterinarian, however, commercial layer and turkey producers and a dairy veterinarian and a commercial turkey veterinarian were non-respondents. While the total number of case submissions in fiscal years 2016 and 2017 were larger, for non-respondents than respondents, the number of case submissions per stakeholder were more similar at 1171 and 858, respectively.

Table 5 reports the results of stakeholders estimates of the ISUVDL's economic contribution to animal production and animal products processing in Iowa during peacetime and an animal health emergency. The results show a broad range of estimates, unsurprising given the uncertainties associated with valuing the contribution of an organization such as the ISUVDL. Because of the convenience survey sample design, unequal probability of selection for the survey was accounted for through weighting based on the number of case submissions in fiscal years 2016 and 2017 (personal communication, Dr. Rodger Main, Director of ISUVDL). Case submissions were used because they represent the number of times a respondent used the ISUVDL to make a decision. To illustrate the effect of the weighting on the results, Table 5 reports the simple average and weighted average of survey responses. Because the weighted average gives more influence to the frequency of use, which certainly informs their assessment about the contribution of the

Table 3
State Government Tax Collections from Total Labor Income Economic Contributions in Iowa.

Sector	General Sales and Gross Receipts Million $	Selective Sales and Gross Receipts Million $	Individual Income Million $	Total Taxes Million $
Swine Production, 2015	87.03	36.42	104.65	228.11
Cattle and Calf Production, 2015	29.78	12.46	35.81	78.05
Poultry and Egg Production, 2015	11.38	4.76	13.68	29.82
Dairy Cattle and Milk Production, 2015	7.31	3.06	8.79	19.17
All Other Animal Production, 2015	0.82	0.34	0.98	2.14
Animal Processing and Slaughtering, 2014	40.96	17.14	49.25	107.35
Milk, Cheese, Ice Cream and All Other Related Processed Milk Products Processing, 2014	9.97	4.17	11.99	26.13
Poultry Slaughtering and Processing, 2014	3.52	1.47	4.23	9.22
Combined Animal Production, 2015 (no double-counting)	129.33	54.12	155.52	338.97
Combined Animal Products Processing, 2014 (no double-counting)	53.40	22.34	64.21	139.96

Table 4
Stakeholder Survey Sample Characteristics.

Industry Segment	Number of Observations		Number of Case Submissions Fiscal Years 2016 and 2017	
	Respondent	Non-Respondent	Respondent	Non-Respondent
Industry Association				
Swine	2	1	0	0
Producer				
Swine	2	3	2730	1679
Commercial layers		1		525
Commercial turkeys		1		971
Mail-order hatchery	2		410	
Veterinarian				
Swine	7	13	11,302	22,312
Beef	3	5	619	3257
Dairy		1		558
Commercial layers	1	1	175	884
Commercial turkeys		1		1418
Layer breeder	1		201	
Total	18	27	15,437	31,604

ISUVDL, impacts are derived using the weighted average.

The values under peacetime are all greater than zero, and the most likely value is 6.64% with a minimum of 3.05% and a maximum of 12.59%. The values rise significantly to a most likely contribution of 25.92%, with minimum and maximum of 17.07% and 47.89%, respectively, in an animal health emergency.

An estimate of the economic and state tax impacts of the ISUVDL can be calculated using the stakeholder survey estimates together with the animal production and animal products processing economic contribution estimates for the state of Iowa. Estimates of the economic impacts are made by multiplying the stakeholder value of the ISUVDL, measured as a proportion of the overall contribution of the animal production and processing sectors, both under peacetime activities and in the event of an animal health emergency, by the direct output, total output, total value added, total labor income, and state taxes collected. As all of the results are fixed and linear in input-output modeling with regard to a change in direct output, changes in animal production and animal products processing output yield fixed proportional changes in the total income generated in the state and in the amounts of state taxes collected.

Using the most likely peacetime contribution of 6.64% suggests that the ISUVDL is responsible for $2,162.46 million in direct output, $2,832.45 million in total output, and $31.79 million in state taxes in normal years (Table 6). In an emergency, the 25.92% most likely contribution would equate to $8,446.21 million in direct output, $11,063.06 million in total output, and $124.15 million in state taxes. With total value added being a measure of the contribution to GDP made by an industry, the ISUVDL contributes $1,158.19 million in normal years and $4,523.70 million in an animal health emergency.

An estimate of the return on investment can be calculated using the contribution of the ISUVDL to the value of the animal production and animal products processing sectors in Iowa, together with investment in the ISUVDL. The Iowa Legislature contributes a direct appropriation to the ISUVDL which was funded at $4 million annually for the 2015, 2016, and 2017 fiscal years (State of Iowa, 2017). The ISUVDL has leveraged these funds to obtain other state, federal, and private sector resources to enhance capabilities and services and ultimately maximize impacts. Specifically, other funding to support ISUVDL operations are derived from diagnostic service fees and contracts including U.S. Department of Agriculture funded diagnostics and funding from the U.S. Department of Agriculture for ISUVDL's role as a Level 1 Lab in the United States National Animal Health Laboratory Network. For example, the U.S. Department of Agriculture increased payments for ISUVDL diagnostic services in fiscal years 2015, 2016, and 2017 in response to the PED virus and HPAI outbreaks, and a large-scale Influenza A surveillance program of U.S. swine. The Iowa State University College of Veterinary Medicine also provides faculty and staff salary support and provides and maintains the ISUVDL facilities.

For our return on investment calculation we use the Iowa Legislature direct appropriation of $4 million annually to the ISUVDL as

Table 5
ISUVDL Economic Contribution to Animal Production and Animal Products Processing during Peacetime and an Animal Health Emergency; Survey Results of Stakeholders.

Industry Segment	Weight	Peacetime, %			Emergency, %		
		Minimum	Most Likely	Maximum	Minimum	Most Likely	Maximum
Industry Association							
Swine #1	0.0000	5	12	60	40	60	90
Swine #2	0.0000	5	10	20	15	25	40
Producer							
Swine #1	0.0444	2	6	10	2	5	20
Swine #2	0.1324	2	10	18	10	15	35
Mail-order hatchery #1	0.0054	25	50	100	100	100	100
Mail-order hatchery #2	0.0211	10	20	50	75	80	100
Veterinarian							
Swine #1	0.0788	10	15	25	90	100	100
Swine #2	0.0914	5	7.5	10	10	15	20
Swine #3	0.0788	2	5	10	10	20	40
Swine #4	0.0018	0.38	0.75	1	3	5	7
Swine #5	0.0317	5	10	15	30	40	50
Swine #6	0.0788	1	2	5	5	7	25
Swine #7	0.3709	1	1	5	5	15	50
Beef #1	0.0169	10	40	50	25	70	95
Beef #2	0.0132	5	10	15	20	25	30
Beef #3	0.0100	5	20	25	15	25	30
Commercial layers #1	0.0113	5	15	30	50	75	100
Layer breeder #1	0.0130	0	5	10	10	50	100
Simple average		5.47	13.29	25.50	28.61	40.67	57.33
Weighted average		3.05	6.64	12.59	17.07	25.92	47.89

Table 6
Estimated Economic Impacts of the ISUVDL.

Impact Type	Minimum		Most Likely		Maximum	
	Peacetime	Emergency	Peacetime	Emergency	Peacetime	Emergency
Direct Output, million $	995.02	5,562.13	2,162.46	8,446.21	4,101.67	15,601.71
Total Output, million $	1,303.31	7,285.43	2,832.45	11,063.06	5,372.47	20,435.53
Total Value Added, million $	532.92	2,979.02	1,158.19	4,523.70	2,196.81	8,356.11
Total Labor Income, million $	289.87	1,620.35	629.96	2,460.53	1,194.89	4,545.05
State Taxes Collected, million $	14.63	81.76	31.79	124.15	60.29	229.33

the investment. The return in this case is the size of the Iowa animal agriculture industry which impacts the state economy through its direct, indirect, and induced effects and subsequent tax collections. The leverage of the state tax dollars by the ISUVDL to obtain other state, federal, and private sector investments increases the rate of return.

In the case of the ISUVDL, the funding to construct the facility does not enter into a return on investment calculation. This is because the initial capital investment is amortized over the life of facility. The overall footprint and infrastructure of the ISUVDL has not been substantially expanded or updated since the building was completed in 1976. The facility is assumed to be fully depreciated or at the end of its useful life.

A state (Iowa) taxpayer return on investment is calculated as follows. The $31.79 million in state taxes in normal years and the $124.15 million in state taxes in an animal health emergency that is attributed to the ISUVDL is divided by the annual $4 Iowa Legislature direct appropriation to the ISUVDL. The result is a 795% return on investment in normal years and a 3104% return on investment in an animal health emergency. Restated, state taxes generated outweigh state taxes spent by 8 and 31 times, respectively.

The sensitivity of these results to the range in values provided by stakeholders surveyed was also explored to provide some appreciation for the extent to which uncertainty associated with valuing the contribution of the ISUVDL influences the results. In addition to the baseline calculations using the most likely contribution values, other estimates were made by using the minimum and maximum contribution values. Using the minimum values, the ISUVDL is responsible for generating $14.63 million in state taxes in a normal operating environment and $81.76 million in the event of an animal health emergency. These values rise to $60.29 million and $229.33 million, respectively, using the maximum values provided by the surveyed stakeholders. This results in a range on the return on investment in normal years of 366% to 1507%. In the event of an animal health emergency, the range is 2044% to 5733%.

Several studies have been conducted to determine the economic benefits of agricultural research and extension (Huffman and Evenson, 2006; Alston et al., 2011; Plastina and Fulginiti, 2012; Wang et al., 2012; Anderson and Song, 2013; Jin and Huffman, 2016). In these studies, an increase in productivity was used to measure return on investment. For the return on investment in agricultural research, figures ranged from 21% to 67%. A higher rate of return (> 100%) was found for agricultural extension. Hence, the return on investment of the ISUVDL found in this study, even when considering the large range in stakeholder survey estimates, was quite large relative to alternative public investments in agricultural research and extension.

The animal agriculture industry collectively has a goal to produce a desired set of offerings at the least feasible cost to maintain industry-wide efficiency and sustain competitive advantages. It can easily be argued that the services VDLs provide supports the industry's ability to meet this goal. Specifically, by providing diagnosis of disease, prevention and treatment of disease, ongoing monitoring of health status, and hence more certainty about production in the broader supply chain, segments of the industry are more likely to make investments they otherwise would not have made, thereby, collectively growing the animal agriculture industry and significantly contributing to regional economies.

5. Conclusions

VDLs work to protect animal and human health through diagnosis of disease, prevention and treatment of disease, and ongoing monitoring of the health status of animals at the state, regional, national, and global levels. Citizens, veterinarians, and animal agriculture industries benefit from the services provided by VDLs. Although it is difficult to place a dollar figure on these activities, most agree the activities provided by VDLs are indispensable. The framework utilized here provides a method that can be used to identify the scope of economic contributions supported by VDLs, assemble the appropriate data, and measure the economic impact.

Increased pressures on private and public budgets have led to reduced funding at times and policymakers seeking to justify appropriations. Consequently, there is a need to provide funding agencies with evidence that the cost of operating VDLs is justified by the benefits derived. The most convincing argument for any investor is a substantial return on investment. We present a case study on the economic impact of the ISUVDL. We use economic contribution analysis coupled with a stakeholder survey to estimate these impacts. The conclusion of this study was that the most likely rate of return in Iowa of the ISUVDL is 795% in normal years and 3104% in an animal health emergency. Restated, benefits outweigh costs by 8 and 31 times, respectively. Determining whether current investments are too low and may undermine the competency of the ISUVDL to continue to add value is beyond the scope of this study but an important consideration for future research. Furthermore, it should be noted that a return on investment is not static, many variables can change a return on investment.

A limitation of this study was the lack of precise data to estimate how much the ISUVDL contributes to the overall economic value of the animal agriculture industry in Iowa. The survey of stakeholders provided information on which to base the estimated impact, however, the values reported varied widely, indicating a lack of certainty among stakeholders about the contribution of the ISUVDL. The low response rate also necessitates caution when interpreting results. Stakeholders were asked for global assessments even if their assessment would have differed by specific sector (i.e., swine, cattle and calves, animal slaughtering and processing, etc.). Future surveys could include this specificity as well as select from a laboratory user database based on more encompassing criteria such as those who have used services more than twice in the past two years.

An important extension to this research would be application of the methodology to a broader geographical area. Outbreaks of animal disease spread across state lines. Supporting the health, continuity, and competitiveness of animal agriculture depends on the extensive movement of animals and animal products across state lines. VDLs serve clientele and animal agriculture industries nationwide. Therefore, examination of the impacts in additional states would provide a more comprehensive assessment of the impact of VDLs. We believe this and future work will be useful to scientists, administrators, and policymakers regarding the efficacy and return on investment of VDLs.

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Appendix A. Stakeholder Survey Instrument

This email is sent on behalf of Drs. Lee Schulz, Dermot Hayes, and Derald Holtkamp to request two minutes of your time to complete a survey. Your responses will be used to help estimate the economic impact of the Iowa State University Veterinary Diagnostic Laboratory on the livestock and processing sectors in Iowa. To respond, simply hit reply − > enter your responses where indicated below − > and send.

We would like to get your best estimate of how much the Iowa State University Veterinary Diagnostic Laboratory (ISUVDL) contributes to the overall economic value of the livestock production and processing sectors in Iowa. We are asking that you provide an estimate of the ISUVDL's economic contribution, in percentage terms, relative to the overall size and scale of Iowa's livestock sector. We realize that this is a difficult question and therefore we would like you to provide a range of estimates. Please feel free to respond with tenths, hundredths, thousandths, ten-thousandths of a percent if relevant.

Question 1. Peacetime Activities

The ISUVDL is the only fully-accredited veterinary diagnostic laboratory providing comprehensive diagnostic services (all-species) in Iowa. The ISUVDL's services are used to help its clientele enhance the health and well-being of their animals and business operations through the mitigation of endemic and/or emerging diseases or toxicosis of high relevance to Iowa's livestock industries and public health. In peacetime (i.e., in absence of an acute animal health crisis actively impacting interstate and international trade), how much smaller would the livestock sector in Iowa be if the ISUVDL's services were eliminated? Please provide the minimum, maximum, and most likely percent value.

Minimum _____%
Most likely _____%
Maximum _____%

Question 2. Emergency Activities

Events such as the introduction of high-path avian influenza, foot and mouth disease, pseudorabies or hog cholera, may result in widespread culling, restrictions on animal movements, and on interstate and international trade. In addition to initial diagnosis, the ISUVDL would provide the diagnostic support needed for the nation's and state's response to such disease incursions and for producer and industry participation in continuity of business programs that allow for the permitted movement and/or sale of non-affected animals, meat, milk, or eggs. In a time of an animal health crisis, how much would you value the contribution of the ISUVDL measured as a portion of the size of Iowa's livestock sector. Provide the minimum, maximum and most likely percent value.

Minimum _____%
Most likely _____%
Maximum _____%
Thank you.

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