The Economic Contribution of Pennsylvania State University

David Swenson[*]

February 2019

[*] Consulting privately for this study and an associate scientist in the Department of Economics at Iowa State University and a lecturer in the School of Urban and Regional Planning at the University of Iowa.

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Summary of Findings

This study measures the multiplied-through economic contribution of The Pennsylvania State University in fiscal 2017. It also separately compiles the total economic contribution of Penn State Health. The analysis is based on highly detailed spending, staffing, and attendance information for Penn State and all of its 24 campuses. Findings in the report are summarized, as well, for each of the affiliated campuses that make up the full Penn State educational community.

The analysis was done using the latest input-output model of the Pennsylvania economy, which was modified to accommodate the unique attributes of a public education system and a publicly funded health care delivery system. There were three specific economic activity areas studied: (1) the economic contribution of Penn State as an educational, research, and public service institution; (2) the localized value of non-university student spending to their host communities; and (3) the economic contribution of Penn State Health services. In addition, Penn State and Penn State Health construction, renovation, and equipment purchase economic contributions were separately assessed.

These are the highlights of the report:

Penn State as an education, research, and service institution in fiscal 2017 had $3.66 billion in direct economic output, employed 50,748 persons, and educated 98,783 students. When all multiplied-through relationships with the remainder of the Pennsylvania economy were compiled, Penn State accounted for (see Table 5)

- $6.64 billion in total industrial output
- $4.46 billion in total value added (which is analogous to GDP)
- $3.23 billion in total labor income (a subset of value added)
- 72,617 jobs in the Pennsylvania economy

These total economic contributions were then allocated to the 24 Penn State campuses (see Table 7).

The study next estimated the value of non-university student spending for academic year 2016/2017. This analysis covered the 84,482 students physically attending one of the 24 campuses and excluded World Campus students. Students living off-campus were expected to spend on average $8,687 each in their resident communities while in school, and those on campus $3,172. Across all students and all campuses, student spending summed to $619.39 million. When all multiplied-through relationships with the remainder of the Pennsylvania economy were compiled, Penn State students explained (see Table 9)

- $739.27 million in total industrial output
- $467.01 million in total value added (which is analogous to GDP)
- $192.12 million in total labor income (a subset of value added)
- 5,258 jobs in the Pennsylvania economy

Student spending total economic contributions were allocated to the 24 Penn State campuses (see Table 11)

Penn State education, research, and other service operations, along with student spending economic contributions, can be added together after discounting employed student spending that was already a

component of Penn State operations total values. After those adjustments were made, Penn State plus student spending generated (see Table 12)

- ⟩ $7.34 billion in total industrial output
- ⟩ $4.90 billion in total value added (which is analogous to GDP)
- ⟩ $3.92 billion in total labor income (a subset of value added)
- ⟩ 77,798 jobs in the Pennsylvania economy

The adjusted combined Penn State operations and student spending economic contributions were allocated to the 24 Penn State campuses (see Table 14).

A separate analysis was made of Penn State Health's economic contribution to the state economy. This analysis was based on its audited annual financial statement coupled with separate reports of total payroll and employment for fiscal 2017. Those data were used to modify the input-output model to create a public hospital sector that aligned with Penn State Health's annual direct output, which was set at $2.06 billion and which required 13,355 employees to produce. When all of the multiplied through relationships with the rest of the state economy were compiled, Penn State Health contributed (see Table 18)

- ⟩ $3.75 billion in total industrial output
- ⟩ $2.49 billion in total value added (which is analogous to GDP)
- ⟩ $1.76 billion in total labor income (a subset of value added)
- ⟩ 24,696 jobs in the Pennsylvania economy

Separately, Penn State and Penn State Health construction, renovation, and equipment spending were also modeled. After controlling for likely purchases from state contractors and vendors, capital spending explained (see Table 21)

- ⟩ $517.02 million in total industrial output
- ⟩ $286.83 million in total value added (which is analogous to GDP)
- ⟩ $198.98 million in total labor income (a subset of value added)
- ⟩ 3,381 jobs

The combined current economic activity for Penn State operations, student spending, and Penn State Health operations can be summed for a grand total economic contribution declaration. These values do not include the capital spending effects just listed as they are always reported separately from current economic activity. Collectively Penn State operations, student spending, and Penn State Health operations explained, for fiscal 2017, a total economic contribution of (see Table 20)

- ⟩ $11.10 billion in total industrial output
- ⟩ $7.39 billion in total value added (which is analogous to GDP)
- ⟩ $5.68 billion in total labor income (a subset of value added)
- ⟩ 102,494 jobs in the Pennsylvania economy

The $7.39 billion in total value added (or GDP) generated by all linked activities to Penn State, student spending, and to Penn State Health operations represented 1.0 percent of the state's total GDP for fiscal 2017 of $740.4 billion.

When one sums all of the value added generated in fiscal 2017 by Penn State operations, student spending, Penn State Health operations, and from all capital expenditures, Penn State's total multiplied-through economic activity supports $394.7 million in expected state government tax collections (see Table 22).

Finally, two sets of county-level economic consequences were generated in the report. The first measures county economic consequences related to Penn State purchases of supplies and services from county vendors. The second looks at the induced effects of Penn State employees converting their payrolls into household consumption at the county level. These itemized, county-level economic contribution estimates are found in Appendix B.

Introduction

Major state universities are also major state economic drivers. They are multi-funded organizations depending on state support, student tuition, fees and charges, scholarships and fellowships, federal and other research sponsorships and grants, and donations. They educate, research, entertain, enliven, host, and culturally and artistically stimulate students, area and statewide residents, and visitors. This is an analysis of the statewide economic contribution of The Pennsylvania State University. The assessment will determine the value of Penn State as measured by all of its spending, the jobs it requires to fulfill its mission, the resulting salaries that it generates, and additional external economic outcomes that are clearly linked to Penn State's activities.

Measuring the economic value of universities involves using a properly-constructed input-output modeling system that is specified for the region of study, in this case the commonwealth of Pennsylvania. This analysis measures the worth of Penn State in the aggregate, and it allocates those economic contributions back out to specific campuses so that sub-state regional economic contributions are also declared. In so doing, this analysis strives to maintain the best standards for university impact assessments that are feasible from the data that were made available for this analysis. [1]

This study will produce total economic contribution estimates for fiscal 2017 for Penn State in the following categories:

- Penn State ongoing operations expenditures using highly detailed spending data controlling for whether the purchases were made from in-state or out-of-state suppliers, coupled with information on all income and benefits payments to employees and jobs by campus.
- Student spending estimates that are based on national spending patterns for young adult households using national household spending data gleaned from the Current Expenditure Survey of the Bureau of Labor Statistics
- Penn State construction spending for new facilities and for renovations
- Penn State Health ongoing operations expenditures, to include a separate estimate of its capital spending

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[1] University economic impact analysis standards were the focus of the "Workshop on University Economic Impact: Input-Output Analysis and Other Ways to Tell Your Story," Friday, May 3, 2013. Washington, DC. The workshop was a cooperative effort the Association of Public Land Grant Universities and the American Association of Universities. That initiative produced, **Economic Impact Guidelines**, published jointly by the APLU and the AAU in December, 2014, retrievable from here: http://www.aplu.org/projects-and-initiatives/economic-development-and-community-engagement/economic-engagement-framework/related-resources/cicep-impact-guidelines-201412.pdf

Persons with an interest in understanding issues and concerns associated with compiling credible university economic evaluations are encouraged to read Siegfried, John J., Allen R. Sanderson, Peter McHenry. "The Economic Impact of Colleges and Universities." **Economics of Education Review**. 26 (2007) 546-558.

The ongoing operations expenditures coupled with the student spending estimates will be combined with Penn State Health results into a grand total summary of Penn State's contribution to the state's economy. Separate summaries will also be made of the construction and capital equipment spending impacts. As has been indicated, sub-state summaries will also be made that allocate university operations economic contribution amounts and the student spending results to the 24 separate campuses that comprise The Penn State University.

Readers will notice that there are no visitorship economic estimates associated with athletics, artistic and cultural events, workshops, or other activities that draw non-students to Penn State's campuses. [2] Those estimates are easy to enumerate by kind, but not by their economic worth without having conducted extensive and scientifically valid surveys of the visitors to all of the major activities throughout the year from which one could then draw defensible spending summaries. As no surveys of visitor spending exist, no estimates will be attempted. While university visitorship is a notable and visible component of the perceived economic worth of Penn State, it is nonetheless a comparatively small fraction of the total economic contribution the university accounts for in the state.

Data Sources and Key Assumptions

All of the data for this assessment were obtained from Penn State and Penn State Health administrative departments. University officials were asked to supply spending data in as high as detail as feasible, and in fact delivered a complete, line-item accounting of all spending by item purchased, the amount of purchase, and the zip code of the vendor. This allowed for a much more accurate determination of the amount and type of in-state spending than would otherwise be produced from the original modeling system.

The several data sets that were received contained more than 500,000 spending items. To code the individual expenditures to align with the modeling system, a random sample of 1,000 expenditures was drawn from each supplied data set and coded to fit one of 86 industries in the model. The distribution of those sampled expenditures was then applied to the entire data set to arrive at the estimates of spending by type of spending for each of the supplied expenditure sources. These, then, were the totals by spending type that were ultimately entered into the modeling system.

Campus specific information was also obtained for the total number of jobs by student and nonstudent employment, payroll and benefit totals, and basic operations expenditures by campus for fiscal 2017.

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[2] Visitorship can be a problematic measure when using a statewide model to measure a university system, as was deployed here. Technically, "visitors" would come from outside of the region of analysis, which in this case is Pennsylvania. Persons from Pennsylvania who visit any of the 24 campuses have not added anything to the state's economy, per se, they have merely allocated a portion of their travel and leisure spending to a particular place. For example, thousands of resident parents deliver their children to the different campuses and bring them home. In so doing they incur costs, some of which accumulate to the campus communities and some of which occur elsewhere. Similarly, very large fractions of athletic event attendance is explained either by students or existing state residents. If so, those in-state visitors are not contributing any more to the state's economy by attending the athletic event than they are if they engaged in any other in-state leisure activity.

Current operations spending is distinguished from other construction and capital spending, and detailed summaries of those activities were also provided. In the case of all construction and renovation spending, the supplied data set indicated whether the prime contractors were in-state or out-of-state, which again assisted in producing overall economic contribution estimates that were more accurate than would be the case when relying on the assumptions that are built into the modeling system for construction and renovation spending.

All modeling for this was done using the most recent IMPLAN, Inc., data set for the commonwealth of Pennsylvania. IMPLAN is a modeling software system and a data supplier for input-output modeling. It is the most widely used input-output model by academics and applied researchers, and it is thoroughly modifiable to more accurately reflect an analysis scenario. The model has data on 536 separate industrial sectors nationally, 503 of which are in evidence in Pennsylvania, but there is no sector for public universities. The modeling system therefore must be amended or used differently than is conventionally the case to properly measure the economic contribution of public universities.[3]

For the Penn State operations analysis, the IMPLAN model was used to construct what is called a "bill of goods" assessment.[4] That means that Penn State's total economic contribution was measured by entering, for each of the expenditure data sets that were supplied and on an item-by-item basis, actual expenditures across 86 possible spending groups. In so doing, a Penn State's total economic contributions were iteratively constructed taking into account all of its in-state purchases, all Penn State employment and payroll, and the multiplied through consequences of those expenditures (for purchases and for payroll) on the remainder of the state's economy.

It is generally recommended that localized models be used when assessing university economic values, not statewide models, to prevent over-estimation. For example, if one were measuring the economic contribution of Iowa State University, where I work, one would normally include only those counties from which the bulk of the university's employees were drawn, not the entire state of Iowa. However, Penn State encompasses 24 campuses across the entire state, which justifies using a statewide model instead of piecing together 24 separate sub-state models. In short, Penn State is substantially different than other typical universities in many other states in that it is a statewide system of many campuses instead of a highly localized entity. A statewide model here does not overly bias the resulting economic impact declarations upward.

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[3] The IMPLAN model has a sector that includes private junior colleges, colleges, universities, and professional schools. That sector combines elite universities, small liberal arts or religious colleges, technical schools, and trade schools. Public universities are subsumed as a component of state government educational spending, but the model does not, as they are governmental entities, contain data on non-payroll expenditures – hence the need to properly adjust the model or use more of the model's analytic functions when measuring public universities as compared with private post-secondary schools.

[4] A bill of goods assessment is preferred to using default spending estimates that exist in the IMPLAN system for industries that are either not well represented or are significantly different in structure than the industry averages already contained in the model.

The phrase economic contribution is used in this report rather than the more commonly employed "economic Impact." For analysts, economic impact generally refers to a change in output in a particular sector that produces a positive or negative change in regional economic amounts. That is not what is measured in this study. This study is measuring the current multiplied-through value of Penn State as a subset of the entire state economy; hence, its economic contribution to the state's total.

Penn State Education Spending, Employment, and Attendance

Economic contribution analysis begins with a clear description of the elements of economic output generated by Penn State. Table 1 summarizes the initial values describing economic activity at Penn State in fiscal year 2017. The table does not include Penn State Health values or capital spending. Those amounts will be presented in subsequent sections. After compiling all of the purchases and other payments data bases, the university spent $922.43 million on service and commodity supplies. It further made payments to workers in the form of payroll and benefits of $2.65 billion, and there was another $82.34 million in additional value added amounts that represented interest payments on indebtedness and revenues over expenditures associated with university auxiliary enterprises. In all, Penn State's direct output for modeling purposes for fiscal year 2017 was set at $3.66 billion.

TABLE 1

Penn State Direct Output, Fiscal 2017

(in thousands):	
All inputs	922,428
Payroll and benefits	2,652,616
Other components of value added	82,338
Total	$ 3,657,381

Table 2 reveals that there were 50,748 total non-student and student jobholders at Penn State. While the modeling process relies on the total job counts initially, controlling for student employment and the amount of pay that they received is necessary to prevent double counting of student spending economic contributions when arriving at grand totals for Penn State later in this study.

TABLE 2

Penn State Total Employment, Fiscal 2017

Non-student	38,315
Graduate student	1,495
Other student	10,938
Total	50,748

Table 3 lists students by their basic residency status. There were 98,783 students in the entire Penn State system in academic year 2016-2017, but for this study, World Campus students have been excluded from the economic contribution analysis. Of the 84,482 students physically attending one of the 24 Penn State campuses, just under a quarter resided on campus in dormitories or university apartments. When calculating student spending economic contributions, controlling for on-campus and off-campus residency affects the total amounts allocated for student spending in the remaining local economies. As on-campus students, most especially dormitory residents, have large fractions of their living costs already subsumed as a component of Table 1, estimates of those students' spending in the remainder of their area economies is lower than for those living off-campus.

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TABLE 3

Penn State Students, Academic Year 2016-2017

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Off Campus Students	63,717
On Campus Students	20,765
Subtotal	84,482
World Campus Students	14,301
Total	98,783

Finally, Table 4 shows the allocations of direct output, jobs, and students that are used as elements for estimating the economic contributions of the 24 Penn State campuses to their respective regional economies.

Table 4

Values for All Penn State Campuses

Campus	Direct Output (in thousands)	Jobs	Students
University Park	2,666,343	35,863	47,095
Abington	56,001	878	3,893
Altoona	64,570	1,139	3,482
Beaver	13,438	375	655
Berks	44,969	933	2,719
Brandywine	23,685	422	1,438
DuBois	12,759	224	585
Erie	85,762	1,872	4,502
Fayette	13,758	294	652
Greater Allegheny	13,112	289	497
Great Valley	13,689	155	387
Harrisburg	92,311	1,559	5,077
Hazelton	18,121	426	755
Lehigh Valley	17,070	334	919
Mont Alto	17,997	319	917
New Kensington	14,311	294	595
Schuylkill	16,700	313	732
Shenango	9,028	170	490
Wilkes-Barre	11,693	207	467
Scranton	18,726	195	1,029
York	19,878	371	983
Carlisle/Dickinson Law	22,765	160	219
College of Medicine	230,415	1,863	929
PA College of Technology	160,281	2,093	5,465
Total	$ 3,657,381	50,748	84,482

Understanding Economic Contribution Terminology

The overall value of Penn State to the state economy is measured using a properly specified input-output model. Input-output models produce reams of useful information, but the most salient results for decision makers are (1) total industrial output, (2) labor income (3) value added, and (4) jobs.

Total industrial output for most industries is the contemporary value of what was produced in a calendar year, whether it was sold or not (as in the case of inventory additions). For public institutions we normally define their annual expenditures, less capital and equipment purchases, as their annual output value plus any additions to value added from profits from enterprises.

Labor income includes the wages and salaries of employees, along with normal proprietor payments for the management of their businesses. Labor income also includes the value of all employer-provided benefits like health insurance and retirement contributions plus employers' contributions to social insurance.

Value added is the most appropriate measure of regional economic value generated from economic activity. It includes all labor income, plus returns to investors and indirect tax payments to government that are part of the production process. Value added is the same thing as Gross Domestic Product (GDP).

Jobs, or employment, represent the number of positions in the economy, not the number of employed persons. As many people have more than one job, there are always more jobs in the economy than employed persons. Jobs are not full time equivalencies in input-output models, they are, however, annualized counts per industry.

We also get detailed breakdowns of the aforementioned economic data subdivided into their direct, indirect, induced, and total economic effects.

Direct effects refer to the operational characteristics of the firm or institution that we are studying; in this case it is Penn State.

Indirect effects measure the value of demands that the direct firm or institution places on supplying industries in the study region.

Induced effects accrue when workers in the direct and indirect industries spend their earnings on goods and services in the region. Induced effects are also called household effects.

Total effects are the sum of direct, indirect, and induced effects.

The term multiplier is often employed when referring to economic values or economic impacts. A multiplier is the total effect divided by the direct effect for jobs, labor income, value added, or output. It is a ratio that helps us to understand how strongly industries or institutions are linked with one another in a study region. In addition, a multiplier helps us to anticipate how much the overall economy is expected to change per unit change in the direct effects (a dollar of output, a dollar of personal income,

a dollar of value added, or a job). Multipliers help us gauge the potential change in the regional economy attributable to a change in direct activity in a particular industry or institution when firms expand or contract. Firms or institutions with strong linkages to area supplying firms or that pay relatively high earnings typically yield high multipliers. Firms that are otherwise not connected strongly regionally or that pay lower than average wages will have lower multipliers. Urban areas with their more developed economies have, on the average, much higher multipliers than rural areas, and state-level multipliers are generally higher than multipliers for sub-state regions.

As has been mentioned, it is conventional for many people to call the results of input-output analyses the "economic impacts." In practice, however, when measuring public institutions like universities, it is advisable to reserve that designation for increments to productivity that exceed the university's primary mission of educating in-state students and conducting research and providing services that are mainly beneficial to the state as a whole. Public universities produce increments to state productivity that otherwise would not have occurred when they educate (at higher prices) out of state students, which then results in an export sale of educational services, or when they are able to attract research sponsorships from federal or private sources. It is difficult to properly allocate the amount of economic activity that is genuinely net new (or export sales satisfying) productivity to the state due to research funding, other program sponsorships, or through attendance without conducting an extensive and detailed audit of universities' labor allocations, overall spending, and the beneficiaries of that spending in their academic, housing, research, and all other support activities.

This study measures Penn State's total economic contribution to the state economy in light of all of its spending and its linked activity to the rest of the state for fiscal 2017. This total amount is called variously the economic value, the economic effect, the economic contribution, or even the economic footprint of universities. The economic impact of Penn State, as conventionally measured by economists, is a subset of its total economic contribution and is not estimated in this study.

The Economic Contribution of Penn State

University Operations: Penn State Combined

The first and largest measure of Penn State's economic value begins with normal university operational spending, which is the annual spending necessary to maintain basic and ongoing university activities. Table 5 displays all of the rounds of estimates that yield Penn State's operations total economic contributions. Penn State directly required 50,748 jobholders making $2.65 billion in labor income to produce $3.66 billion in output in fiscal 2017. In so doing, the university system indirectly required $451.01 million in state-supplied inputs, which in turn employed 4,248 workers making $210.0 million in labor income. When the direct sector workers (Penn State) and the supply sector workers (the indirect values) converted their labor incomes into household spending, they induced another $2.53 billion in statewide output requiring 17,622 workers making $868.05 million in labor income. Summed, Penn State operations generated $6.64 billion in output and $4.46 billion in value added, of which $3.73 billion was labor income to 72,617 jobholders statewide.

TABLE 5

Penn State Total Economic Contribution from University Operations, Fiscal 2017

	Jobs	Labor Income	Value Added	Output
Direct	50,748	2,652,615,536	2,652,697,874	3,657,381,498
Indirect	4,248	209,996,801	292,168,350	451,014,449
Induced	17,622	868,046,974	1,514,179,445	2,528,313,867
Total	72,617	$ 3,730,659,311	$ 4,459,045,669	$ 6,636,709,814
Multipliers	1.43	1.41	1.68	1.81

The multiplier is the total value divided by the direct value in each category. The output multiplier of 1.81 means that for every $1.00 of direct output at Penn State there was $0.81 in output stimulated in the rest of the state economy. The multiplier of 1.68 for value added means that each $1.00 of value added generated by Penn State supported an additional $0.68 in value added in the rest of the state economy. The labor income multiplier of 1.41 means that for every $1.00 of labor income paid at Penn State there was $0.41 in labor income supported in the rest of the economy. Finally the jobs multiplier of 1.43 means that for every job at Penn State there was 43/100th of a job supported elsewhere in Pennsylvania.

University Operations by Campus

Table 6 allocates all of the values in the direct line of Table 5 to the 24 Penn State campuses. These allocations are based on the actual distributions of jobs, payroll, and the estimated total annual expenditures by campus for fiscal 2017.

TABLE 6

Penn State Campus Direct Economic Contributions from University Operations

	Direct Jobs	Direct Labor Income	Direct Value Added	Direct Output
University Park	35,863	1,941,325,869	1,941,386,128	2,666,342,752
Abington	878	39,478,128	39,479,353	56,001,417
Altoona	1,139	50,037,048	50,038,601	64,569,948
Beaver	375	12,584,107	12,584,497	13,438,329
Berks	933	37,710,777	37,711,947	44,969,078
Brandywine	422	18,619,972	18,620,550	23,684,966
DuBois	224	10,864,061	10,864,399	12,758,562
Erie	1,872	72,925,211	72,927,475	85,761,824
Fayette	294	11,312,650	11,313,001	13,757,910
Greater Allegheny	289	12,808,108	12,808,506	13,111,512
Great Valley	155	12,408,248	12,408,633	13,688,529
Harrisburg	1,559	72,766,152	72,768,411	92,310,516
Hazelton	426	15,329,317	15,329,793	18,120,856
Lehigh Valley	334	13,255,811	13,256,222	17,069,991
Mont Alto	319	15,321,871	15,322,347	17,997,240
New Kensington	294	10,823,787	10,824,123	14,311,454
Schuylkill	313	13,210,469	13,210,879	16,700,104
Shenango	170	7,258,163	7,258,389	9,027,727
Wilkes-Barre	207	9,635,846	9,636,145	11,693,023
Scranton	195	12,725,914	12,726,309	18,726,390
York	371	15,142,066	15,142,537	19,877,881
Carlisle/Dickinson Law	160	8,894,848	8,895,124	22,764,938
College of Medicine	1,863	137,799,699	137,803,976	230,415,412
PA College of Technology	2,093	100,377,413	100,380,529	160,281,138
Total	50,748	$ 2,652,615,536	$ 2,652,697,874	$ 3,657,381,498

Table 7 reveals the estimated total economic contribution of the individual campuses where the sum of all of the campus detail equals the totals line in Table 5. The total economic contribution values have been allocated by each campus's respective share of direct jobs, labor income, input demands, and output. This table minus Table 6 yields the indirect effects and the induced effects for each campus. This table divided by the values in Table 6 results in the actual multipliers for each category for each school. For example, the total jobs of 52,231 for University Park divided by the direct job value of 35,863 equals a jobs multiplier of 1.46. Thus, for every job at University Park, an estimated 46/100th of a job was supported elsewhere in the regional economy.

TABLE 7

Penn State Campus Total Economic Contributions from University Operations

	Total Jobs	Total Labor Income	Total Value Added	Total Output
University Park	52,231	2,706,824,948	3,188,558,563	4,960,205,208
Abington	1,169	57,777,958	69,957,387	90,559,640
Altoona	1,500	73,712,320	89,434,793	107,261,342
Beaver	441	20,165,674	25,085,890	23,579,372
Berks	1,184	56,924,556	69,587,661	74,115,557
Brandywine	557	27,396,123	33,226,655	37,958,591
DuBois	309	15,576,228	18,735,682	20,756,282
Erie	2,338	111,326,225	136,553,487	141,845,688
Fayette	365	17,335,886	21,288,617	22,902,967
Greater Allegheny	382	18,821,413	22,818,083	22,840,057
Great Valley	281	15,936,938	18,445,272	24,733,920
Harrisburg	2,111	105,406,023	127,207,837	154,154,182
Hazelton	515	23,998,634	29,656,084	30,541,295
Lehigh Valley	420	20,120,678	24,637,805	27,803,820
Mont Alto	438	22,024,296	26,513,837	30,132,034
New Kensington	359	16,820,231	20,740,765	23,474,718
Schuylkill	405	19,686,906	23,971,927	27,650,845
Shenango	221	10,780,274	13,113,078	15,056,915
Wilkes-Barre	280	13,968,267	16,861,353	19,170,143
Scranton	314	17,007,149	19,972,823	30,777,229
York	473	22,790,311	27,835,354	32,466,660
Carlisle/Dickinson Law	236	12,322,875	14,654,367	41,050,585
College of Medicine	3,219	179,590,811	208,992,547	424,723,809
PA College of Technology	2,871	144,344,586	173,791,075	252,948,955
Total	72,617	$ 3,730,659,311	$ 4,459,045,669	$ 6,636,709,814

When interpreting and sharing the total values in Table 5 or Table 7, it is tempting to use the largest number, in this case the $6.64 billion in total industrial output. There is, however, no regularly-reported value of total output in the state by government agencies that report on the economy. To measure the value of Penn State as it compares to the rest of the state economy, the preferred indicator is the value added amount of $4.46 billion as that number is analogous to gross domestic product (GDP), a number that is produced quarterly and annually for the states by the U.S. Bureau of Economic Analysis.

Student Spending: Penn State Combined

All students spend money in their campus communities. This spending is called the student life economic contribution. Determining the level of non-university spending made by students, however, is not a straightforward task. University admissions offices make reasonable estimates of the costs of

attending college by major spending category, but those estimates may not reflect the spending that students make locally while in residence and attending school. A school could survey students to determine major spending categories, but surveys are expensive and household spending surveys of this sort are highly inaccurate – most of us are neither inclined nor able to reliably itemize our spending over the course of a month, let alone for a longer period of time.

As an alternative to using institutional data, national expenditure data for households where the householder was age 24 or younger was used from the Bureau of Labor Statistics. The annual Consumer Expenditure Survey was adjusted to reflect expected spending levels for 15 broad categories for off-campus students and for on-campus students for a nine-month period.[5] Using that information, spending was determined for the average on-campus and off-campus Penn State student.

Table 8 illustrates that, for a nine-month period, off-campus students would be expected to spend $8,687 and on-campus students $3,172. Multiplied by the number of students in each category yields $619.39 million in student life related spending for academic year 2016-2017.

TABLE 8

Penn State Total Student Spending, Academic Year 2016-2017

	Annually	Total Students	Estimated Total Spending
Off Campus Students	$ 8,687	63,717	553,521,736
On Campus Students	$ 3,172	20,765	65,870,979
Total		84,482	$ 619,392,714

This spending was then entered into the IMPLAN model across 15 separate categories. The results are contained in Table 9. At the outset it is important to note that the direct output value of $505.48 million is much less than the $619.39 million in estimated spending. That is because a substantial fraction of student spending will be for retail goods, and the total value of the retail goods sold is not counted as output in the regional economy.[6] That noted, we see that student spending directly supported 4,060

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[5] Several reasonable spending-while-in-school adjustments were made to the national averages. For example, it is much less likely that a student purchases an automobile or buys car or health insurance locally while attending college than would be the case for non-university households. Additionally, owing to multitudes of leisure time opportunities at colleges, those spending categories were significantly reduced. Conversely, as students spend extended periods of time on campus, their propensity to dine out was increased by 25 percent. Simple adjustments like these were made to the BLS data set to reflect expected student spending.

[6] Retail and wholesale goods are "margined" in the modeling structure. The cost of the good sold as well as all of its wholesale and transport charges are apportioned to the areas in the economy and the regions in which they originate. Very few non-food retail goods are likely manufactured within the regions of study; consequently, most transportation and manufactured goods values are likely outside of the study region. For the student expenditures, model default margins were used for each retail category.

jobs in the campus communities and $505.48 million in output from all of their purchases.[7] That initial spending further stimulated the state's supplying sectors in the amount of $166.74 million in output requiring another 923 workers making $56.05 million in labor income. When the direct workers and the indirect workers converted their labor incomes into household spending, they induced $154.31 million in additional output necessitating 1,092 more jobs making $52.99 million in labor income. Summed, student spending generated $826.54 million in output and $519.68 million in values added, of which $223.3 million was labor income to 6,075 Pennsylvania jobholders.

Penn State Student Spending Economic Contribution, 2017

	Jobs		Labor Income		Value Added		Output
Direct	4,060		114,274,245		326,231,024		505,478,830
Indirect	923		56,045,758		100,997,621		166,743,501
Induced	1,092		52,990,814		92,455,708		154,314,204
Total	6,075	$	223,310,263	$	519,684,352	$	826,535,981
Multipliers	1.50		1.95		1.59		1.64

The student spending multipliers across all of the categories are quite robust. They are higher than the values for Penn State operations in all categories except for output.

These data partially overlap with the findings in Table 5 because students with Penn State jobs will have generated induced impacts from spending their paychecks. It is not proper to sum Table 5 and Table 9 to arrive at a grand total for Penn State without first calculating the value of that overlap. That offset will be reflected in subsequent tables summarizing total university operations and student spending economic contributions for Penn State and for its campuses.

Total student spending economic contributions are allocated to each of the 24 campus using the basic spending assumptions in Table 8 times the numbers of on-campus and off-campus students in each school.

Table 10 itemizes the expected amount of direct student spending by campus and the required local jobs necessary to satisfy that spending.

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[7] No adjustments were made for on-line purchases in these estimates. It assumed that spending is made in the college community. This may be growingly unrealistic in the case of book purchases, for example, but evidence suggests that large fractions still of those student expenditures are made in university or local bookstores.

TABLE 10

Penn State Campus Direct Economic Contributions from Student Spending

	Direct Jobs	Direct Labor Income	Direct Value Added	Direct Output
University Park	2,277	64,096,276	182,982,559	283,522,421
Abington	184	5,170,267	14,760,119	22,870,074
Altoona	168	4,723,075	13,483,473	20,891,975
Beaver	31	882,818	2,520,277	3,905,045
Berks	131	3,692,358	10,540,974	16,332,717
Brandywine	68	1,923,032	5,489,887	8,506,309
DuBois	27	768,538	2,194,029	3,399,539
Erie	219	6,167,718	17,607,651	27,282,184
Fayette	30	856,559	2,445,311	3,788,888
Greater Allegheny	24	668,283	1,907,819	2,956,071
Great Valley	18	508,418	1,451,435	2,248,926
Harrisburg	240	6,741,089	19,244,516	29,818,425
Hazelton	36	1,024,323	2,924,245	4,530,973
Lehigh Valley	43	1,207,328	3,446,688	5,340,473
Mont Alto	44	1,235,408	3,526,852	5,464,682
New Kensington	28	781,676	2,231,534	3,457,651
Schuylkill	35	989,991	2,826,235	4,379,112
Shenango	23	643,733	1,837,734	2,847,477
Wilkes-Barre	22	613,517	1,751,473	2,713,820
Scranton	48	1,351,839	3,859,241	5,979,702
York	46	1,291,407	3,686,719	5,712,388
Carlisle/Dickinson Law	10	287,709	821,354	1,272,648
College of Medicine	43	1,220,465	3,484,193	5,398,585
PA College of Technology	264	7,428,418	21,206,708	32,858,744
Total	4,060	$ 114,274,245	$ 326,231,024	$ 505,478,830

Table 11 allocates the multiplied through consequences of direct student spending to the 24 campuses. Again, as discussed above, this represents total student spending, which includes values that have already been described when measuring total university operations spending by campus. Adjustments considering these overlaps are contained in the following section that estimates net total Penn State operations and student spending economic contributions.

TABLE 11

Penn State Campus Total Economic Contributions from Student Spending

	Total Jobs	Total Labor Income	Total Value Added	Total Output
University Park	3,408	125,254,437	291,490,280	463,602,961
Abington	275	10,103,534	23,512,794	37,396,105
Altoona	251	9,229,650	21,479,104	34,161,607
Beaver	47	1,725,169	4,014,788	6,385,351
Berks	196	7,215,462	16,791,717	26,706,516
Brandywine	102	3,757,914	8,745,363	13,909,129
DuBois	41	1,501,847	3,495,077	5,558,772
Erie	328	12,052,714	28,048,898	44,610,586
Fayette	46	1,673,854	3,895,368	6,195,418
Greater Allegheny	36	1,305,932	3,039,146	4,833,633
Great Valley	27	993,530	2,312,128	3,677,341
Harrisburg	358	13,173,174	30,656,415	48,757,732
Hazelton	54	2,001,692	4,658,307	7,408,841
Lehigh Valley	64	2,359,312	5,490,557	8,732,498
Mont Alto	66	2,414,185	5,618,256	8,935,599
New Kensington	42	1,527,520	3,554,822	5,653,794
Schuylkill	53	1,934,602	4,502,178	7,160,524
Shenango	34	1,257,958	2,927,500	4,656,065
Wilkes-Barre	33	1,198,911	2,790,087	4,437,515
Scranton	72	2,641,711	6,147,751	9,777,737
York	69	2,523,617	5,872,924	9,340,637
Carlisle/Dickinson Law	15	562,230	1,308,413	2,080,976
College of Medicine	65	2,384,985	5,550,302	8,827,520
PA College of Technology	395	14,516,325	33,782,177	53,729,123
Total	6,075	$ 223,310,263	$ 519,684,352	$ 826,535,981

University Operations Plus Student Spending

The annual contribution of Penn State and student spending can be summed to arrive at a fiscal year 2017 grand total contribution to the state economy. As some of the estimated student spending is already subsumed within initial Penn State operations results (Table 5) because of student employment, those overlapping values were extracted to avoid double counting.

Table 12 shows the total economic contribution of both Penn State operations and the student impacts after eliminating all double counting. In all, after all multiplied-through interactions are summed, $7.34 billion in total output and $4.90 billion in value added are supported, of which $3.92 billion is labor income to 77,798 Pennsylvania jobholders. As the table combines two different sets of economic activity, there is no corresponding multiplier line as was the case with Table 5 and Table 9

<p align="center">TABLE 12</p>

<p align="center">Penn State Combined Operations and Student Spending Economic Contributions, Fiscal 2017</p>

	Jobs	Labor Income	Value Added	Output
Direct	54,211	2,750,072,332	2,930,918,312	4,088,470,300
Indirect	5,034	257,794,448	378,302,409	593,218,735
Induced	18,553	913,239,265	1,593,028,683	2,659,918,044
Total	77,798	$ 3,921,105,574	$ 4,902,249,404	$ 7,341,606,607

Table 13 allocates the data from the first line above to all of the Penn State campuses.

TABLE 13

Penn State Campus Direct Economic Contributions from University Operations and Student Spending

	Direct Jobs	Direct Labor Income	Direct Value Added	Direct Output
University Park	37,692	1,992,798,833	2,088,340,522	2,894,046,665
Abington	1,055	44,474,206	53,740,596	78,097,629
Altoona	1,289	54,257,200	62,085,250	83,236,579
Beaver	401	13,326,844	14,704,743	16,724,607
Berks	1,048	40,953,856	46,969,476	59,314,900
Brandywine	487	20,444,792	23,829,544	31,756,461
DuBois	249	11,571,077	12,882,653	15,886,331
Erie	2,054	78,044,376	87,540,605	108,407,991
Fayette	322	12,106,322	13,578,611	17,268,829
Greater Allegheny	310	13,399,828	14,497,699	15,730,092
Great Valley	173	12,907,566	13,834,072	15,898,129
Harrisburg	1,777	78,894,341	90,261,653	119,417,250
Hazelton	455	16,144,540	17,656,984	21,727,538
Lehigh Valley	374	14,393,467	16,503,718	22,102,083
Mont Alto	360	16,470,851	18,602,198	23,080,012
New Kensington	319	11,526,865	12,831,138	17,421,360
Schuylkill	344	14,084,175	15,704,966	20,564,944
Shenango	191	7,860,429	8,977,591	11,691,779
Wilkes-Barre	227	10,210,302	11,276,007	14,234,326
Scranton	242	14,047,527	16,498,873	24,571,355
York	413	16,333,403	18,543,287	25,147,377
Carlisle/Dickinson Law	168	9,118,638	9,534,048	23,751,987
College of Medicine	1,902	138,907,225	140,967,537	235,306,348
PA College of Technology	2,357	107,795,670	121,556,542	193,085,725
Total	54,211	$ 2,750,072,332	$ 2,930,918,312	$ 4,088,470,300

Table 14 distributes the net grand total economic contribution for all of Penn State operations and all student spending to the 24 campuses. These are the by-college total economic contribution estimates that align with the totals line of Table 12. Individual campuses would use these values to promote the worth of their operations to their respective regional economies and stakeholders.

TABLE 14

Penn State Campus Total Economic Contributions from University Operations and Student Spending

	Total Jobs	Total Labor Income	Total Value Added	Total Output
University Park	54,968	2,807,415,791	3,422,673,064	5,332,501,626
Abington	1,434	67,540,566	92,674,804	126,693,820
Altoona	1,724	81,958,583	108,623,894	137,787,151
Beaver	480	21,616,764	28,462,500	28,953,220
Berks	1,356	63,261,425	84,333,468	97,575,475
Brandywine	654	30,961,880	41,524,155	51,158,231
DuBois	347	16,957,790	21,950,654	25,871,346
Erie	2,610	121,328,598	159,828,905	178,879,701
Fayette	407	18,886,639	24,897,196	28,644,467
Greater Allegheny	414	19,977,617	25,508,655	27,122,128
Great Valley	307	16,912,879	20,716,571	28,347,008
Harrisburg	2,437	117,380,858	155,073,496	198,481,956
Hazelton	558	25,591,378	33,362,366	36,439,435
Lehigh Valley	481	22,343,606	29,810,518	36,033,002
Mont Alto	499	24,269,485	31,738,473	38,443,918
New Kensington	396	18,193,932	23,937,335	28,560,589
Schuylkill	451	21,394,098	27,944,590	33,971,211
Shenango	253	11,957,102	15,851,557	19,413,455
Wilkes-Barre	311	15,090,777	19,473,496	23,326,137
Scranton	384	19,589,849	25,982,886	40,335,617
York	536	25,118,138	33,252,194	41,084,141
Carlisle/Dickinson Law	248	12,760,228	15,672,236	42,664,560
College of Medicine	3,278	181,757,202	214,037,312	432,718,644
PA College of Technology	3,266	158,840,388	207,523,343	306,599,770
Total	77,798	$ 3,921,105,574	$ 4,902,249,404	$ 7,341,606,607

Construction and Renovation Economic Contributions

The preceding values represent the worth of annual activity at Penn State and student spending. When doing this type of analysis, it is procedurally appropriate to separate out capital development-related expenditures as they are not ongoing and they are not considered part of an organization's or institution's annual productivity. These kinds of expenditures are lumpy in nature, i.e., they cycle up and down over time based on institutional growth as well as the health of the greater economy, and they are temporary in that the projects and the jobs they support exist only so long as the construction or renovation activity is taking place. Furthermore, the long-term economic worth of capital development projects is measured in terms of the sustained operational activity that it facilitates: new or sustained

laboratories, classrooms, or other ongoing university services and the associated employment contained within them.

Table 15 reveals that Penn State had $446.1 million in capital development or renovation expenditures in fiscal 2017. For the purposes of modeling, however, the data need to be segregated into that which was bid or otherwise purchased from an in-state supplier and that which was not. Accordingly, $239.93 million was initially awarded to Pennsylvania firms or vendors while $206.18 million was not. In modeling this activity, the state model was "shocked" by the state level purchases across the construction and renovation categories and then separately by the out-of-state values. A final table of capital development economic contributions was compiled by adding portions of the out-of-state model outcomes to the in-state values. The logic of this is that out-of-state contractors will subcontract with nearby suppliers and they will also directly hire in-state labor for the projects. For this estimate, it was assumed that 30 percent of out-of-state contractors' labor in fact was from Pennsylvania labor supplies and that 30 percent of their construction-related inputs were purchased from Pennsylvania firms.

TABLE 15

Penn State Total Construction and Renovation Spending, Fiscal 2017

In-state contractor	239,827,382
Out-of-state contractor	206,181,791
Total	$ 446,009,173

Table 16 shows the results. The addition of local labor from out-of-state contractors boosts the direct output to $263.16 million, which was generated by 1,765 direct construction or renovation jobs earning $107.18 million in labor incomes. After all indirect and induced rounds are multiplied through, Penn State capital spending resulted in $496.47 million in total industrial output and $273.86 million in value added, of which $191.58 million was labor income to 3,275 Pennsylvania jobholders.

TABLE 16

Penn State Construction and Renovation Spending Economic Contributions, Fiscal 2017

	Jobs	Labor Income	Value Added	Output
Direct	1,765	107,779,391	137,020,217	263,160,751
Indirect	589	38,448,087	60,854,477	114,784,116
Induced	922	45,355,360	75,985,173	118,526,625
Total	3,275	$ 191,582,837	$ 273,859,867	$ 496,471,491
Multiplier	1.86	1.78	2.00	1.89

Construction activity typically has strong multipliers owing to the demand for state-supplied inputs and to comparatively high labor incomes per job in the construction and in the supplying sectors.

The Economic Contributions of Penn State Health

The overall economic contribution of Penn State Health is an important component of the overall contribution of Penn State to the state's economy. A different approach was used for this analysis than was the case with Penn State operations. Penn State Health's total operational values were discerned from analyzing its annual audited financial statement rather than categorizing all of its line-item expenditures by in-state and out-or-state vendor. A separate public hospital sector was created in the input-output model that contained all of the expected input purchase categories for all Pennsylvania hospitals, but was further adjusted by Penn State Health's total estimated output for fiscal 2017, all payments to jobholders in the form of wages, salaries, and benefits, and the number of jobs at Penn State Health. Accordingly, the Penn State Health hospital sector was differentiated from all other private hospitals in the state. As model-determined, expected purchasing coefficients were used, so too were the model's default assumptions as to whether inputs were or were not purchased from state suppliers.

Penn State Health Operations

Table 17 summarizes the basics of direct output that were entered into the input-output model. Direct output was $2.06 billion, of which $1.16 billion was payroll-related, $312.32 million represented other value added components (interest payments plus operating surplus), and $591.15 million represented the value of all input purchases.

<div align="center">

TABLE 17

Penn State Health Direct Output, Fiscal 2017
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Output (in thousands):	
All inputs	591,145
Payroll and benefits	1,159,746
Other components of value added	312,319
Total	$ 2,063,210
Total Jobs	13,355

Table 18 itemizes Penn State Health's total economic contribution. It had $2.06 billion in direct output in fiscal 2017, which was produced by 13,355 jobholders earning $1.16 billion in labor income. It required or otherwise stimulated $475.92 million in in-state supplies, which in turn needed 2,825 workers making $174.29 million in labor income. When the direct workers (Penn State Health) and the indirect workers (the supplying sectors) converted their labor incomes into household spending, they induced $1.21 billion in additional output and $425.24 million in labor income to another 8,516 jobs. Summed, Penn State Health accounted for $3.75 billion in statewide output and $2.49 billion in value added, of which $1.76 billion was labor income to 24,696 jobholders.

TABLE **18**

Penn State Health Total Economic Contribution from Operations, Fiscal 2017

	Jobs	Labor Income	Value Added	Output
Direct	13,355	1,159,745,699	1,472,064,699	2,063,210,000
Indirect	2,825	174,286,596	282,335,875	475,921,002
Induced	8,516	425,239,588	738,194,682	1,212,361,039
Total	24,696	$ 1,759,271,883	$ 2,492,595,256	$ 3,751,492,041
Multipliers	1.85	1.52	1.69	1.82

Multipliers are also displayed. The jobs multiplier is quite robust primarily because of comparatively high pay per job at Penn State Health as well as the expected strong linkages to in-state supplying sectors.

Penn State Health Capital Spending

As with Penn State, a separate data base of capital spending by Penn State Health was provided. This spending mostly represented durable equipment purchases more so than construction or renovation. Again, capital costs in the forms of new construction, renovation, or equipment purchases are always reported separately from operations impacts. These capital expenditures enable operations, and they may fluctuate markedly from year to year.

The expenditures were provided by line item, which allowed for greater specification in the input output model once they were coded and categorized; however, whether the spending was or was not made to an in-state supplier was not provided, so model default probabilities were used for each spending item in estimating the likely statewide economic contributions associated with the purchases.

In all, there were $71.73 million in capital purchases in fiscal 2017. After entering this spending by category of spending into the model, total direct output produced in Pennsylvania was $11.46 million. The difference between the spending amount of $71.73 million and the direct output value of $11.46 was due to the probability that the required equipment was supplied by an in-state firm and whether the item was purchased from a wholesale supplier versus directly from a factory. (Remembering that the cost of the good sold (or purchased) is not counted as output for wholesalers.) In all, after all multiplied-through effects were compiled, Penn State Health's capital spending accounted for $20.55 million in total state output and $12.97 million in value added, of which $7.40 million was labor income to 105 additional jobholders.

TABLE **19**

Penn State Health Total Economic Contribution from Capital Expenditures, Fiscal 2017

	Jobs	Labor Income	Value Added	Output
Direct	46	4,007,081	7,362,167	11,460,967
Indirect	23	1,614,201	2,513,216	4,011,818
Induced	36	1,780,492	3,091,163	5,076,298
Total	105	$ 7,401,773	$ 12,966,546	$ 20,549,083

Summary of All Economic Contributions

This short section summarizes all of the economic activity reported in this study. The operational total contributions of Penn State, its students, and Penn State Health are below in Table 20. These combined activities generated $11.10 billion in total industrial output in Pennsylvania and $7.39 billion in value added, of which $5.68 billion was labor income to 102,494 jobholders.

TABLE **20**

Penn State, Student Spending, and Penn State Health Total Economic Contributions, Fiscal 2017

	Jobs	Labor Income	Value Added	Output
Penn State	72,617	3,730,659,311	4,459,045,669	6,636,709,814
Student Spending	5,181	190,446,263	443,203,735	704,896,794
Penn State Health	24,696	1,759,271,883	2,492,595,256	3,751,492,041
Total	102,494	$ 5,680,377,457	$ 7,394,844,660	$ 11,093,098,648

Table 21 sums the construction, renovation, and equipment purchase effects. Those outlays by Penn State and by Penn State Health generated $517.02 million in state output and $286.83 million in value added, of which $198.98 million was labor income earned by 3,381 jobholders.

TABLE **21**

Penn State and Penn State Health Total Capital Spending Economic Contributions, Fiscal 2017

	Jobs	Labor Income	Value Added	Output
Penn State	3,275	191,582,837	273,859,867	496,471,491
Penn State Health	105	7,401,773	12,966,546	20,549,083
Total	3,381	$ 198,984,610	$ 286,826,413	$ 517,020,574

State Tax Collections

The ongoing economic activity of Penn State, student spending, and Penn State Health will in turn generate state tax collections. So, too, will Penn State's and Penn State Health's capital spending.

We arrive at a basic estimate of likely tax receipts by calculating separate state tax incidences for the Pennsylvania Commonwealth. These tax incidences are the total collections for the state divided by the state's gross domestic product (GDP) for a corresponding fiscal period. The incidences were derived from the 2015 Historical State and Local Government Finance Tables for Pennsylvania found at the U.S. Census Bureau. Once discerned, those incidences were multiplied times the total value added amounts that are found in the totals rows of both Table 20 and Table 21.

Penn State, student spending, and Penn State Health generated more than $7.4 billion in total value added, which would be expected to generate $379.9 million in state tax collections. Capital spending at PENN STATE and at Penn State Health generated $286.8 in total value added, which would support an additional $14.7 million in state tax receipts. Combined state receipts supported by the value added supported by Penn State, student spending, Penn State Health, and by capital spending sum to $394.7 million.

TABLE 22

Expected Pennsylvania State Government Tax Collections Attributable to Penn State, Student Spending, Penn State Health Total Economic Contributions, and All Capital Spending Effects

Taxes Attributable to:	Penn State, Student Spending, and Penn State Health Effects	Penn State and Penn State Health Capital Spending Effects	Total State Taxes
All Taxes	$ 379,944,348	$ 14,737,034	$ 394,681,382
General Sales	103,800,091	4,026,130	107,826,222
Selective Sales	89,482,794	3,470,800	92,953,594
Individual Income	120,884,330	4,688,783	125,573,112
Corporate Income	26,411,071	1,024,415	27,435,486
Motor Vehicle Licenses	9,394,014	364,369	9,758,383
All Other Taxes	29,972,048	1,162,536	31,134,584

The tax receipts in Table 22 represent expected total collections given the value added supported by all Penn State-related activities. It is important to note that these tax receipts help pay for the state-supported services consumed by all of the households and businesses in Pennsylvania, to include all those employed by or otherwise affected by Penn State.

Conclusion

Using conventional input-output modeling methods, Penn State, plus all student spending and coupled with Penn State Health spending, contributed $11.09 billion in total industrial output to the state economy and sustained 102,494 jobs in fiscal 2017. It produced $7.39 billion in value added (which is analogous to GDP), of which $5.68 billion was labor income. To put this into perspective, the commonwealth of Pennsylvania generated $740.47 billion in gross domestic product during the fiscal 2017 period according to the U.S. Bureau of Economic Analysis. Penn State, student spending, and Penn State Health value added combined, and after accounting for all multiplied-through consequences, accounted for 1.0 percent of the state's economic activity as measured by its value added (or GDP).

Visitorship values to Penn State as well as costs incurred by families utilizing Penn State Health services have not been estimated. As mentioned previously, credible estimates of these values require reliable expenditure surveys of attendees and clients. As none exist, there are no data from which to make those estimates. It must be re-emphasized, however, that those economic consequences are comparatively small in light of what has already been measured in this report.

There are other values to universities. They may attract compatible commercial or industrial activities, they provide an environment for entrepreneurship among faculty and staff, and they create a range of positive community-wide outcomes that affect housing values, area social outcomes, and overall community well-being. While these are all desirable spillovers, they are distinct from the operations of Penn State proper and are not considered quantitatively or substantively in this study.

A final note: Appendix B contains tables that allocate two categories of Penn State spending to individual counties. Measured are the localized economic activity stimulated due to Penn State purchases in the counties and the effects of Penn State employee spending in their counties of residences.

Appendix A: Major Assumptions, Considerations, and Concerns

Notes on Estimating Operations and Student Spending Economic Contributions

This study benefitted from extensive cooperation and responsiveness from Penn State officials in terms of the overall complexity and thoroughness the data supplied. This allowed for more detailed and focused estimates of the worth of university spending to the Pennsylvania economy than would be the case were one reviewing summary documents of university activities. In all, seven complete expenditure data sets were supplied that contained 537,500 separate spending items. For six of the spending groups, a random sample of 1,000 expenditures was chosen and then coded to reflect the overall expected spending for each set of spending data provided. One data set had only 530 categories, so those data were not sampled. For all of the sampled data sets, the resulting distributions of spending were applied to the each data set's total spending. The 86 spending codes are displayed at the end of Appendix A.

As only Pennsylvania spending for inputs was analyzed, the sample and allocation framework used to apportion total spending for inputs may deviate some from the actual spending pattern by category to a degree, but not the magnitude of spending.

Once total spending for supplies and inputs was determined, those data were coupled with labor income and benefits spending, interest payments on indebtedness, and with declared revenues over expenditures in auxiliary enterprises to arrive at total fiscal year 2017 Penn State direct output for modeling purposes.

A separate data set for all 24 campuses was provided by Penn State officials that summarized annual operating expenditures by campus. Those values were used to allocate total Penn State direct output to the individual campuses. The remainder of each campus's direct values, all labor income payments and jobs, were provided in separate files and matched to each campus. These data then became the factors for allocating the total Penn State economic contributions back out to the individual campuses.

The allocating process was straightforward. For each campus, their average shares of direct jobs, labor income, and input purchases (output minus value added) was used to apportion job, labor income, and value added total contributions. Total output allocation was based on the average of each campus's direct output shares and its input purchases. In so doing, the campus level total contributions were functions of the interplay among actual jobs, pay levels, and each campus's expected demand for inputs.

Student spending amounts and allocations are not variable across campus. Expected student spending amounts were held constant by kind of student across all of the campuses; accordingly, their campus-level impacts are driven by the total multipliers displayed in Table 9.

Broad categories of student spending are displayed in the following table.

Student Spending Summary				
Spending Categories		9 months off campus		9 months on campus
Housing Related		46%		0%
Dining in and out		25%		26%
Transportation		6%		17%
All Other		24%		57%
Total Spending	$	8,687	$	3,172

Notes on the Penn State Health Operations Estimates

Penn State Health did not provided line item spending data. Instead, Penn State Health's direct output was discerned from their annual financial statement and from supplemental data on their total employment and labor income costs. This is typical of how major hospitals are evaluated. However, for publicly-owned hospitals, it is also necessary to distinguish their hospital operations in the model from all other hospitals. The modeling system contains information for private hospitals which range widely in size and in the scope of the health delivery services that they provide. For this study, a separate Penn State Health sector was added to the model that reflected the already calculated direct output of Penn State Health, its labor costs, its employment, and a determination of all other value added costs (revenues over expenditures plus interest payments on debt). The purchase probabilities for the hospital sector were then allocated over the remaining input purchase values (direct output minus value added equals inputs purchases). Further, the model contains probabilities of in-state purchases by industrial category; those values were not modified for the analysis.

Notes on Construction, Renovation, and Equipment Spending

As mentioned several times in the report, capital spending is to be kept separate from ongoing operational spending. In analyzing Penn State's expenditure data, it was not possible to differentiate clearly items like ongoing equipment replacements (furniture, fixtures, etc.) nor to isolate spending on computer software, which ideally would be separated from normal operations spending. Those values are therefore contained within the Penn State operations total economic contributions.

Penn State did provide a very detailed spending of construction and renovation by type of spending and by whether the contractor was or was not in-state. This allowed for a much better estimate of the short-term construction effects than is often the case. In addition, there were Penn State Health projects in this data set, so the construction and renovation includes spending for both sets of Penn State activities.

When analyzing individual construction projects, analysts will ideally require highly detailed information on who the contractors are for which parts of the project, the amount of local labor that will be utilized, the amount of spending that is, in fact, facility related versus non-facility equipment, and the exact timing of the construction activity.

In this analysis, however, when analyzing a large group of capital development activities, the spending was organized into broad groups that align with the modeling system. In addition, as out-of-state contractors will nonetheless require local labor and local inputs, 30 percent of their labor and of their input purchases were added to the in-state contractor values to round out that estimate.

Capital purchase data provided by Penn State Health were primarily equipment related. Those purchases were coded as to whether they were likely purchased from an in-state wholesaler, manufacturer, or some other type of vendor. There was no indication as to whether Penn State Health equipment purchases were made from in-state suppliers, so model default purchasing probabilities were used for those spending categories.

Notes on Estimating State Tax Collections

State tax collections were estimated from the 2015 State and Local Government Finance spreadsheet maintained at the U.S. Census. Quarterly state gross domestic product (GDP) data aligning with fiscal 2015 were obtained the Bureau of Economic Analysis. Dividing Pennsylvania tax collections by the corresponding state GDP amount yielded average statewide tax incidences displayed in the table below.

State of Pennsylvania Tax Incidences Per Dollar of
Pennsylvania Gross National Product

All Taxes	0.0514
General Sales	0.0140
Selective Sales	0.0121
Individual Income	0.0163
Corporate Income	0.0036
Motor Vehicle Licenses	0.0013
All Other Taxes	0.0041

Expected state tax collections were estimated multiplying these coefficients times the respective value added (the same as GDP) totals that were found in Table 20 and Table 21.

The resulting values in Table 22 are the expected tax collections that would be associated with the in-state labor incomes and returns to investors. They represent gross collections and do not take into account the cost of state services consumed by the households and businesses generating those elements of value added.

Categories Used to Code Penn State Operations Expenditures in the IMPLAN Model

IMPLAN Condensed Industrial Sectors Used for Coding Penn State Spending Data

IMPLAN Industry Code	Industry Description	IMPLAN Industry Code	Industry Desctription
1	Crop Farming	409	Air transportation
11	Livestock	410	Rail Transportation
15	Forestry & Logging	411	Water transportation
17	Fishing- Hunting & Trapping	412	Truck transportation
19	Ag & Forestry Svcs	413	Transit & ground passengers
20	Oil & gas extraction	414	Pipeline transportation
22	Mining	415	Sightseeing transportation
37	Mining services	416	Postal service, couriers & messengers
41	Utilities	417	Warehousing & storage
52	Construction	423	Publishing industries
65	Food products	425	Motion picture & sound recording
106	Beverage & Tobacco	427	Broadcasting
112	Textile Mills	430	Telecommunications
119	Textile Products	431	Internet & data process svcs
124	Apparel	433	Other information services
131	Leather & Allied	434	Monetary authorities
134	Wood Products	435	Credit intermediation & related
146	Paper Manufacturing	437	Securities & other financial
154	Printing & Related	439	Insurance carriers & related
156	Petroleum & coal prod	440	Funds- trusts & other finan
161	Chemical Manufacturing	442	Real estate
188	Plastics & rubber prod	446	Rental & leasing svcs
199	Nonmetal mineral prod	447	Lessor of nonfinance intang assets
217	Primary metal mfg	461	Professional- scientific & tech svcs
231	Fabricated metal prod	462	Management of companies
262	Machinery Mfg	471	Admin support svcs
301	Computer & oth electron	472	Waste mgmt & remediation svcs
325	Electircal eqpt & appliances	475	Educational svcs
343	Transportation eqpmt	482	Ambulatory health care
368	Furniture & related prod	483	Hospitals
379	Miscellaneous mfg	485	Nursing & residential care
395	Wholesale Trade	488	Social assistance
396	Motor veh & parts dealers	493	Performing arts & spectator sports
397	Furniture & home furnishings	494	Museums & similar
398	Electronics & appliances stores	499	Amusement- gambling & recreation
399	Bldg materials & garden dealers	501	Accommodations
400	food & beverage stores	504	Food svcs & drinking places
401	Health & personal care stores	509	Repair & maintenance
402	Gasoline stations	513	Personal & laundry svcs
403	Clothing & accessories stores	517	Religious- grantmaking- & similar orgs
404	Sports- hobby- book & music stores	520	Private households
405	General merch stores		Government & non NAICs
406	Misc retailers		
407	Non-store retailers		

Appendix B. County-Level Payrolls from PENN STATE Spending and Employee Payrolls

Penn State Purchases Economic Contributions by County

Penn State provided the zip code of all vendor transactions. Zip code level data were aggregated to the county level for the economic analysis. Penn State purchases totals by county were collapsed into 16 common spending categories that were then entered into 67 separate county level models to produce the estimates of the total economic activity supported in the table below.

Total County-Level Economic Activity Supported by Penn State Purchases

County	Total PSU Purchases	Jobs	Total Economic Activity Supported		
			Labor Income	Value Added	Total Output
Adams	$ 491,473	8.5	$ 276,984	$ 384,869	$ 701,599
Allegheny	$ 24,826,004	374.4	$ 20,202,552	$ 28,268,931	$ 43,956,240
Armstrong	$ 1,016,924	17.9	$ 535,133	$ 761,180	$ 1,418,400
Beaver	$ 1,075,420	18.7	$ 639,976	$ 904,057	$ 1,619,474
Bedford	$ 950,595	17.1	$ 528,053	$ 722,230	$ 1,352,301
Berks	$ 5,497,385	93.6	$ 3,844,644	$ 5,474,422	$ 9,074,832
Blair	$ 10,871,545	189.4	$ 6,686,794	$ 9,566,308	$ 16,865,093
Bradford	$ 355,872	6.6	$ 192,297	$ 265,966	$ 513,191
Bucks	$ 8,309,385	136.4	$ 6,192,468	$ 8,691,813	$ 14,180,551
Butler	$ 2,628,361	41.8	$ 1,719,097	$ 2,413,138	$ 4,038,938
Cambria	$ 5,610,600	100.5	$ 3,663,248	$ 5,102,554	$ 9,049,868
Cameron	$ -	-	$ -	$ -	$ -
Carbon	$ 665,669	14.1	$ 359,831	$ 503,874	$ 922,379
Centre	$ 88,989,392	1,348.7	$ 55,762,886	$ 77,057,802	$ 127,934,192
Chester	$ 9,783,922	143.8	$ 7,528,763	$ 10,562,652	$ 16,098,475
Clarion	$ 57,222	1.0	$ 31,862	$ 45,185	$ 83,579
Clearfield	$ 2,549,648	42.8	$ 1,565,830	$ 2,182,111	$ 3,838,676
Clinton	$ 1,732,924	30.7	$ 932,380	$ 1,302,205	$ 2,400,239
Columbia	$ 745,386	12.9	$ 464,647	$ 625,608	$ 1,100,070
Crawford	$ 618,137	10.8	$ 359,290	$ 490,315	$ 884,583
Cumberland	$ 17,198,134	290.9	$ 11,863,674	$ 16,773,398	$ 27,760,560
Dauphin	$ 115,836,755	1,690.5	$ 80,609,779	$ 111,469,866	$ 184,439,616
Delaware	$ 4,207,354	67.0	$ 3,353,548	$ 4,698,186	$ 7,444,180
Elk	$ 531,760	9.6	$ 296,377	$ 395,780	$ 692,612
Erie	$ 7,273,444	128.5	$ 4,523,249	$ 6,475,817	$ 11,334,881
Fayette	$ 835,525	14.2	$ 494,415	$ 679,393	$ 1,222,276
Forest	$ 641	-	$ 299	$ 429	$ 697
Franklin	$ 1,135,439	20.0	$ 654,834	$ 900,298	$ 1,631,831
Fulton	$ 51,348	0.4	$ 18,615	$ 28,330	$ 66,254
Greene	$ 2,762	0.1	$ 1,528	$ 1,710	$ 3,751
Huntingdon	$ 2,395,584	41.9	$ 1,291,759	$ 1,770,944	$ 3,336,391
Indiana	$ 525,286	9.2	$ 321,214	$ 451,835	$ 760,409
Jefferson	$ 188,951	3.4	$ 103,873	$ 146,007	$ 270,668
Juniata	$ 2,322,989	49.8	$ 1,160,707	$ 1,554,765	$ 3,004,619

Total County-Level Economic Activity Supported by Penn State Purchases

County	Total PSU Purchases	Jobs	Total Economic Activity Supported		
			Labor Income	Value Added	Total Output
Lackawanna	$ 2,182,334	44.4	$ 1,615,264	$ 2,141,761	$ 3,714,745
Lancaster	$ 20,667,810	364.8	$ 14,417,488	$ 20,087,409	$ 34,028,547
Lawrence	$ 16,645,027	303.3	$ 9,743,423	$ 13,905,064	$ 25,614,683
Lebanon	$ 705,036	11.2	$ 410,409	$ 559,379	$ 988,416
Lehigh	$ 7,657,113	115.2	$ 5,843,559	$ 7,994,562	$ 12,545,952
Luzerne	$ 5,732,914	97.0	$ 3,904,707	$ 5,494,590	$ 9,551,397
Lycoming	$ 16,310,717	264.3	$ 10,135,508	$ 14,772,081	$ 26,004,716
McKean	$ 263,725	4.1	$ 118,521	$ 165,330	$ 321,057
Mercer	$ 995,731	17.5	$ 550,611	$ 787,888	$ 1,419,995
Mifflin	$ 2,743,985	46.7	$ 1,592,625	$ 2,152,957	$ 3,842,995
Monroe	$ 793,283	13.2	$ 464,815	$ 644,468	$ 1,128,665
Montgomery	$ 11,191,104	164.4	$ 9,160,575	$ 12,796,416	$ 19,468,383
Montour	$ 441,047	6.5	$ 281,154	$ 357,121	$ 575,436
Northampton	$ 1,218,546	18.6	$ 839,087	$ 1,156,097	$ 1,854,412
Northumberland	$ 713,257	11.9	$ 414,326	$ 569,709	$ 1,003,408
Perry	$ 461,452	7.9	$ 223,128	$ 308,198	$ 586,781
Philadelphia	$ 31,212,658	449.8	$ 23,851,836	$ 32,971,598	$ 50,914,280
Pike	$ 50,470	1.1	$ 22,833	$ 27,006	$ 71,462
Potter	$ 103,692	2.9	$ 51,854	$ 64,523	$ 140,250
Schuylkill	$ 803,206	13.7	$ 455,475	$ 631,570	$ 1,127,442
Snyder	$ 670,866	11.6	$ 361,745	$ 503,956	$ 926,131
Somerset	$ 309,504	5.2	$ 177,818	$ 258,797	$ 457,406
Sullivan	$ 14,039	0.4	$ 7,213	$ 8,873	$ 18,405
Susquehanna	$ 28,337	0.7	$ 14,416	$ 17,322	$ 35,525
Tioga	$ 251,063	4.6	$ 136,923	$ 194,414	$ 369,966
Union	$ 1,089,199	18.7	$ 599,945	$ 812,032	$ 1,499,154
Venango	$ 274,296	4.9	$ 145,718	$ 207,176	$ 387,599
Warren	$ 32,752	0.9	$ 17,044	$ 21,203	$ 44,505
Washington	$ 532,144	8.1	$ 359,453	$ 501,844	$ 801,501
Wayne	$ 15,831	0.1	$ 2,380	$ 13,444	$ 18,139
Westmoreland	$ 3,522,810	58.0	$ 2,095,116	$ 2,929,977	$ 5,077,497
Wyoming	$ 29,516	0.8	$ 14,813	$ 18,275	$ 37,958
York	$ 4,069,146	71.4	$ 2,720,890	$ 3,828,188	$ 6,527,348

Penn State Payroll Economic Contributions by County

The number employees by county of residence and their total payroll costs were provided by Penn State. The payroll amounts were modeled in each Pennsylvania county as household income shocks. The economic activity supported by those resident payroll values reflect the expected induced effects of household spending in each county.

Total County-Level Activity Supported by Penn State Payroll to County Residents

County	Total PSU Jobholders	Total PSU Payroll to Jobholders	Total Economic Activity Supported			
			Jobs	Labor Income	Value Added	Total Output
Adams	221	$ 5,259,113	27.8	$ 944,180	$ 1,712,679	$ 3,140,097
Allegheny	1,854	$ 24,100,102	216.3	$ 11,690,706	$ 19,663,397	$ 31,802,845
Armstrong	79	$ 2,109,750	11.6	$ 423,257	$ 730,388	$ 1,341,952
Beaver	416	$ 7,224,880	43.6	$ 1,674,505	$ 2,918,691	$ 5,269,248
Bedford	54	$ 1,325,082	6.9	$ 230,766	$ 415,184	$ 778,793
Berks	1,155	$ 28,536,798	211.4	$ 9,496,246	$ 16,590,872	$ 27,560,229
Blair	2,368	$ 93,286,077	612.1	$ 25,623,149	$ 43,076,717	$ 75,142,429
Bradford	91	$ 1,145,928	6.8	$ 267,008	$ 441,091	$ 808,734
Bucks	1,118	$ 12,068,002	95.8	$ 4,512,403	$ 7,725,131	$ 13,036,488
Butler	360	$ 4,104,778	27.9	$ 1,140,538	$ 1,942,545	$ 3,371,106
Cambria	205	$ 5,084,172	40.9	$ 1,661,209	$ 2,736,016	$ 5,047,103
Cameron	9	$ 247,904	0.8	$ 19,539	$ 41,048	$ 80,285
Carbon	88	$ 1,033,747	5.5	$ 193,795	$ 354,459	$ 675,596
Centre	29,143	$ 1,227,486,004	6,856.3	$ 299,034,196	$ 535,433,477	$ 905,481,034
Chester	1,162	$ 19,353,393	127.6	$ 7,521,989	$ 12,884,879	$ 19,896,564
Clarion	80	$ 1,077,407	6.6	$ 232,354	$ 421,903	$ 789,563
Clearfield	1,210	$ 56,010,808	381.2	$ 15,095,652	$ 25,028,952	$ 45,217,967
Clinton	420	$ 18,086,314	89.8	$ 3,124,023	$ 5,844,196	$ 10,368,880
Columbia	100	$ 1,630,572	10.2	$ 375,725	$ 626,010	$ 1,125,801
Crawford	139	$ 2,165,689	14.1	$ 542,352	$ 885,429	$ 1,589,674
Cumberland	913	$ 27,103,356	197.8	$ 9,203,975	$ 15,556,473	$ 25,564,518
Dauphin	2,471	$ 101,323,535	755.3	$ 35,783,149	$ 60,035,412	$ 100,435,269
Delaware	992	$ 12,478,516	96.5	$ 4,919,656	$ 8,408,772	$ 13,926,613
Elk	87	$ 892,972	5.2	$ 182,672	$ 303,536	$ 571,646
Erie	1,792	$ 53,525,322	427.4	$ 17,038,151	$ 28,924,991	$ 51,288,106
Fayette	264	$ 5,554,592	36.3	$ 1,310,494	$ 2,217,814	$ 4,104,021
Forest	6	$ 156,449	0.4	$ 12,386	$ 29,999	$ 50,535
Franklin	316	$ 8,216,490	52.2	$ 2,023,345	$ 3,276,521	$ 5,726,999
Fulton	21	$ 196,229	0.8	$ 26,805	$ 51,085	$ 101,786
Greene	26	$ 354,316	1.4	$ 57,369	$ 106,642	$ 190,011
Huntingdon	434	$ 21,609,473	112.4	$ 3,618,664	$ 6,521,170	$ 12,679,473
Indiana	63	$ 1,238,428	7.7	$ 311,699	$ 531,486	$ 941,863
Jefferson	101	$ 1,244,106	7.3	$ 249,197	$ 443,003	$ 806,270
Juniata	69	$ 1,553,908	7.0	$ 177,864	$ 358,652	$ 698,782

Total County-Level Activity Supported by Penn State Payroll to County Residents

County	Total PSU Jobholders	Total PSU Payroll to Jobholders	Total Economic Activity Supported			
			Jobs	Labor Income	Value Added	Total Output
Lackawanna	494	$ 8,401,821	72.4	$ 3,094,437	$ 4,957,480	$ 8,750,759
Lancaster	980	$ 23,196,650	172.7	$ 7,566,029	$ 12,414,167	$ 20,887,831
Lawrence	97	$ 1,204,190	8.0	$ 310,540	$ 542,601	$ 994,292
Lebanon	503	$ 19,229,099	120.4	$ 4,642,767	$ 7,858,148	$ 13,936,661
Lehigh	539	$ 8,553,637	70.0	$ 3,270,397	$ 5,521,940	$ 9,340,846
Luzerne	811	$ 17,476,208	137.7	$ 5,968,797	$ 9,919,509	$ 17,533,402
Lycoming	264	$ 3,569,581	27.8	$ 1,114,903	$ 1,969,278	$ 3,358,944
McKean	49	$ 540,755	3.2	$ 110,559	$ 187,638	$ 350,288
Mercer	270	$ 4,557,151	33.4	$ 1,310,505	$ 2,220,639	$ 3,964,675
Mifflin	462	$ 20,275,616	131.5	$ 4,908,686	$ 8,052,413	$ 14,534,193
Monroe	259	$ 2,302,389	14.2	$ 506,981	$ 917,186	$ 1,612,336
Montgomery	1,578	$ 27,134,213	208.1	$ 12,939,541	$ 21,645,349	$ 33,784,232
Montour	31	$ 197,228	1.3	$ 42,129	$ 69,453	$ 135,233
Northampton	471	$ 5,587,801	33.0	$ 1,379,137	$ 2,427,847	$ 4,122,527
Northumberland	115	$ 1,447,036	7.3	$ 257,107	$ 468,391	$ 837,003
Perry	83	$ 1,778,769	5.8	$ 162,763	$ 356,025	$ 648,098
Philadelphia	1,457	$ 13,649,216	96.1	$ 5,724,174	$ 9,705,119	$ 15,350,377
Pike	81	$ 659,430	2.8	$ 78,372	$ 168,481	$ 316,861
Potter	28	$ 158,338	0.7	$ 25,548	$ 47,775	$ 91,247
Schuylkill	469	$ 11,565,100	57.1	$ 2,127,545	$ 3,810,297	$ 6,800,367
Snyder	54	$ 1,001,627	5.8	$ 186,628	$ 335,523	$ 609,731
Somerset	55	$ 621,849	3.6	$ 131,723	$ 262,463	$ 459,180
Sullivan	15	$ 201,764	0.8	$ 26,765	$ 50,825	$ 95,178
Susquehanna	62	$ 791,536	2.8	$ 89,438	$ 178,121	$ 336,025
Tioga	38	$ 454,627	2.5	$ 87,968	$ 158,747	$ 294,971
Union	97	$ 2,111,651	13.6	$ 556,085	$ 884,145	$ 1,554,911
Venango	62	$ 633,227	3.8	$ 132,153	$ 237,648	$ 438,033
Warren	44	$ 193,757	1.0	$ 39,646	$ 68,615	$ 126,887
Washington	195	$ 1,978,107	12.2	$ 558,371	$ 977,815	$ 1,619,851
Wayne	53	$ 783,727	4.1	$ 155,387	$ 271,684	$ 481,797
Westmoreland	770	$ 11,096,951	73.1	$ 2,778,509	$ 4,783,588	$ 8,397,538
Wyoming	58	$ 1,384,487	5.6	$ 185,123	$ 370,977	$ 660,208
York	916	$ 16,900,439	115.1	$ 4,938,989	$ 8,465,573	$ 14,455,681

Appendix C: Understanding Input-Output Models

This analysis of Penn State used an input-output model of the Pennsylvania economy. Input-output models are very large and highly detailed data sets that estimate the buying and selling relationships Pennsylvania industries have with one another and with the rest of the world. All input-output models begin with an initial table of transactions where all inputs for an industry equal that industry's outputs. This balanced system of inter-industrial accounting is then transformed via what is called the *Leontief Inverse* to produce a table of total requirements for each industry in the model.   The basic structure of the modeling process is described here:

$$X=AX+Y$$

Which can be re-written for analytic purposes as

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

Where:

X= output; A= matrix of coefficients, and Y= final demand … and

I= an identity matrix that emerged from transforming the first equation into the second, operational equation.

All input-output models begin with this transformation. Jobs are added to the models as fixed factors associated with industrial output. They owe their initial structure to benchmark input-output accounts that are produced by the U.S. Bureau of Economic Analysis at the national level. State and substate estimates are than derived primarily by using Quarterly Census of Employment and Earnings data compiled by the Bureau of Labor Statistics, annual and quinquennial surveys of businesses and manufacturers, and other Department of Commerce data. Probabilities of intra-state and inter-state purchases are estimated in the modeling from transportation flow data from the US DOT.

There are several input-output modeling vendors. IMPLAN, Inc., the system used in this study, has been used widely by academics in the U.S. since the early 1980s, and it has a long track record of both accessibility, affordability, modifiability, and ease of use. The Bureau of Economic Analysis also produces sets of RIMS II (Regional Impact Modeling System) multipliers for states and substate areas. Unlike IMPLAN, RIMS II consists of tables of multipliers for a region that analysts then apply to the study scenarios. In this study, the IMPLAN structure proved ideal in that it allowed for the use separately of large sets of multipliers in the "bill of goods" analysis of the Penn State expenditures, and it allowed a model-by-industrial activity approach in the case of Penn State Health and for the capital-related spending.

Following are links to resources explaining input-output modeling basics, the IMPLAN model, and the RIMS II multiplier system at the BEA:

> From a well-respected Extension economist: http://edis.ifas.ufl.edu/fe168 . This short piece nicely illustrates the basics of how input-output models work and how they are applied.

- From IMPLAN describing some of the functional attributes of the modeling system and how the multipliers are generated and used: https://implanhelp.zendesk.com/hc/en-us/articles/115009505707-General-Information-About-Multipliers
- From IMPLAN listing all of the data components that go into an IMPLAN model: https://implanhelp.zendesk.com/hc/en-us/articles/115009674688-IMPLAN-Data-Components
- From IMPLAN where one can select from a list of topics to understand the many characteristics of a purchased data base from IMPLAN: https://implanhelp.zendesk.com/hc/en-us/sections/115000320233-U-S-Data
- From William Shaffer's on-line contribution in the Web Book of Regional Science on Regional Impact Models, especially Chapters 4-6: http://www.rri.wvu.edu/WebBook/Schaffer/index.html
- From the U.S. Bureau of Economic Analysis, a description of the benchmark input-output accounts of the U.S. can be found here along with links to current and historical benchmark input-output accounts: https://www.bea.gov/data/industries/input-output-accounts-data
- From the U.S. Bureau of Economic Analysis, a description of RIMS II multipliers and a users' guide to economic impact analysis: https://apps.bea.gov/regional/rims/rimsii/rimsii_user_guide.pdf
- Finally, persons interested in applied input-output analysis at the regional, state, or national level or in obtaining instructional material for using input-output models are welcome to contact the author of this study at dswenson@iastate.edu