IMPACT FROM INNOVATION: CARNEGIE MELLON UNIVERSITY'S ROLE AS A LOCAL AND GLOBAL ECONOMIC ENGINE

FINAL REPORT
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ECONSULT SOLUTIONS
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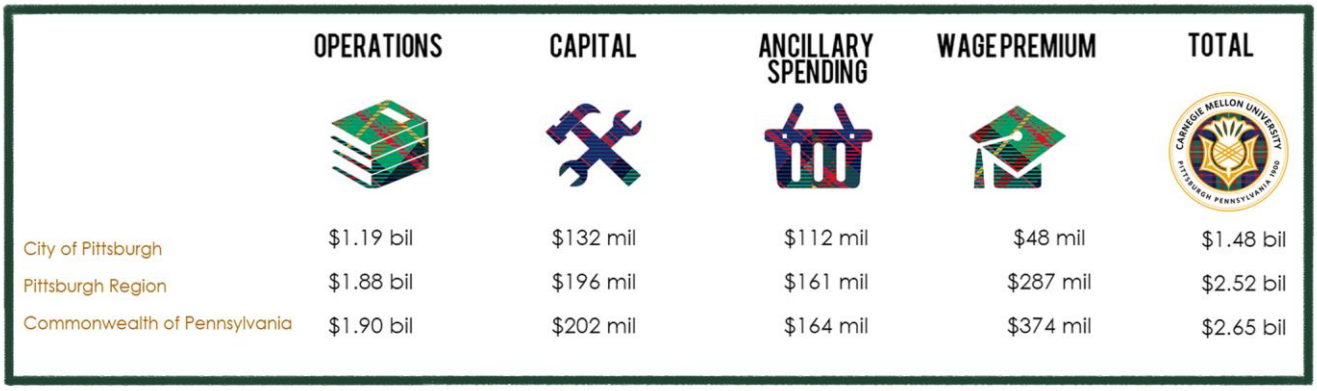
EXECUTIVE SUMMARY

World-class institutions of higher education such as Carnegie Mellon University (CMU) are widely known for their academic and research contributions. They are also major contributors to their local economies. This report estimates that CMU produces a $2.7 billion annual impact for the Commonwealth of Pennsylvania economy through its annual operations, its capital investments, the student and visitor spending it attracts, and the additional wage premium it confers on its graduates. The vast majority of that impact ($2.5 billion) takes place within the Pittsburgh region, and $1.5 billion is within the City of Pittsburgh (see Figure ES.1).

FIGURE ES.1 – CMU ANNUAL ECONOMIC IMPACT BY CATEGORY



This direct and indirect economic activity supports nearly 18,000 jobs in the Commonwealth, with total earnings of nearly $1.2 billion. Nearly 10,000 of those jobs are located within the City of Pittsburgh (see Table ES.1).

TABLE ES.1 – SUMMARY OF ANNUAL CMU ECONOMIC IMPACTS

	City of Pittsburgh	Pittsburgh Region	Commonwealth of Pennsylvania
Total Output	$1.48 Billion	$2.52 Billion	$2.65 Billion
Employment	9,910 jobs	17,250 jobs	17,790 jobs
Earnings	$814 Million	$1.16 Billion	$1.19 Billion

This economic activity in turn expands local and state tax bases. It is estimated that each year CMU is responsible for $61 million in tax revenues to the Commonwealth of Pennsylvania, and an additional $12 million in tax revenues to the City of Pittsburgh and Allegheny County. Thus, even though CMU itself is a not-for-profit institution, it is among the largest producers of tax revenues for the City and Commonwealth.

Beyond the scale of economic activity, how CMU produces these impacts matters. Drawing human and financial capital from all over the world, CMU serves as one of the world's great innovation hubs, producing research discoveries and supporting entrepreneurial activities whose influence on the world is as profound as it is far-reaching. New technologies associated with Carnegie Mellon are shaping the way we live and experience the world, and CMU is committed to helping translate intellectual property into commercial applications that fuel economic activity and address social challenges.

"CMU is an amazing hub of activity and smart people in computer science… we're proud to be a Pittsburgh-based company and to stick to our roots"
– Duolingo Founder Luis von Ahn

The Center for Technology Transfer and Enterprise Creation (CTTEC) serves as the locus within CMU for facilitating and tracking the movement of research and technology from within the University into the marketplace. CTTEC data indicates that CMU indirectly or directly helped to foster 148 start-up companies between FY 2012 and FY 2016, and that $1.05 billion in venture capital has been raised by 42 CMU-associated start-ups since FY 2011. Further, 74 percent of that funding ($783 million) was raised by firms located in Pennsylvania.

Carnegie Mellon also has a long history of making explicit efforts to connect its research capabilities with the innovation needs of leading private sector firms across a number of fields. CMU's more than 350 corporate partnerships include unique relationships with leaders firms in fields like advanced manufacturing, software engineering, and robotics.

The venture capital community, leading technology giants, and young knowledge workers all "vote with their feet" and have increasingly made massive investments dollars and effort in advanced-robotics technology with the potential to fundamentally change the way we live, experience the world, and move through it. CMU's reputation, expertise and talent pipeline in this and other growing fields have made Pittsburgh a prime destination for cutting-edge technology firms and in the process is fundamentally remaking Pittsburgh's brand in the global marketplace. Recent investments in Pittsburgh by the likes of Google and Uber have been directly tied to the presence and participation of CMU and in turn have turned Pittsburgh into a byword for innovation and cutting-edge technologies. This gives Pittsburgh a "first mover" advantage in these emerging industries, which has incredibly meaningful and long-lasting implications for Pittsburgh's competitive position and creates a virtuous cycle of drawing in more knowledge activity and in turn creating an even more compelling case for still others to be drawn in.

"'We have a lot of Carnegie Mellon alums at Facebook and a lot of them are some of our best engineers' (Facebook CEO Mark) Zuckerberg told reporters…Now it seems he wants to attract talent to work right here in Pittsburgh."

This work represents a continuation of Carnegie Mellon's decades-long participation in the transformation of Pittsburgh's regional economy from industrial powerhouse to knowledge center. Pittsburgh now is well-positioned to compete as an innovation hub against other world-class locations because of the concentration of intellectual capital and entrepreneurship activity represented by CMU, and the innovation ecosystem it has helped to foster. In this regard, while the headline economic impact numbers arrived at in this report represent the present aggregation of CMU's important role in the city, regional and state economy, its broader contribution is serving as a portal for the skills and knowledge activity that help the region to control its economic destiny moving forward.

"Pittsburgh has been revitalizing itself through technology for a very long time. The Steel City is now home to groundbreaking medical research and world-class universities. It's the birthplace of some of the most advanced artificial intelligence and robotics systems the world has ever seen. And you (CMU) are investing in your young people with after-school STEM programs and maker fairs, and Girls of Steel robotics teams."
– President Barack Obama

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1.0 INTRODUCTION

1.1 PURPOSE OF REPORT

The purpose of this report is to articulate the economic impact of Carnegie Mellon University (CMU) at the local, regional, and state level. World-class institutions of higher education such as Carnegie Mellon are widely known for their academic and research contributions. However, they are also major contributors to their local economies and are major regional employers. Therefore it is important to understand the positive economic ramifications of those contributions. This report quantifies the magnitude of impact stemming from CMU's annual operations, its capital investments, the student and visitor spending it attracts, and the additional earnings potential it confers on its graduates.

But how CMU produces these impacts matters even more than how much impact it produces. Drawing human and financial capital from all over the world, CMU serves as one of the world's great innovation hubs, producing research discoveries and supporting entrepreneurial activities whose influence on the world is as profound as it is far-reaching. This work has been fundamental to the decades-long evolution of the Pittsburgh regional economy and now yields a city and region that is synonymous with transformative technologies. Hence, in addition to calculating CMU's aggregate economic impact across multiple standard university impact study categories, this report speaks directly to CMU's influence at a global, regional, and local level.

1.2 ABOUT CARNEGIE MELLON UNIVERSITY (CMU)

Carnegie Mellon is a private research university that has served as a birthplace of innovation since its founding by Andrew Carnegie in 1900. Originally Carnegie Technical Schools (1900-1912), the university became Carnegie Technical Institute in 1912 and began granting four-year degrees. In 1967, it merged with the Mellon Institute of Industrial Research to form Carnegie Mellon University (CMU). Today, Carnegie Mellon educates more than 13,000 students representing more than 100 countries, and boasts top rated programs in diverse areas and cutting edge disciplines like computer science, information technology management, new media, drama, and engineering. Its main campus and the vast majority of its activities are located in Pittsburgh, Pennsylvania.

Carnegie Mellon is a global leader in research and innovation and in bringing groundbreaking ideas to commercial market. The university culture that promotes problem solving across and among different disciplines, dating back to the creation of artificial intelligence half a century ago, and seen today in fields such as smart cities, where machine learning, big data analytics, human-machine interaction, and policy innovations come together to create a connected web of new possibilities. CMU's award-winning faculty emphasizes not only the transfer of knowledge, but the tackling of scientific, technological, and societal challenges in new ways. This has yielded a proliferation of research and entrepreneurship activity at the intersection of deep scientific

understanding and market realities. In sum, CMU is committed to utilizing its intellectual capital to impact society in a transformative way – regionally, nationally, and globally – by engaging with partners outside the traditional borders of the university campus.

1.3 HOW CARNEGIE MELLON SERVES AS AN ECONOMIC ENGINE FOR THE CITY, REGION, AND STATE

Carnegie Mellon's size and scope alone make it a significant economic engine for the local, regional, and state economy. CMU is a major employer, purchaser of goods and services, and initiator of capital investment projects, all of which generate local economic activity. CMU also brings new spending into the region by attracting students and visitors, most of whom are from out of town and many of whom come from outside the United States. It also attracts and retains talented young graduates to the city, region, and state, thereby increasing both the intellectual capital and the local household income (and spending) that is located in the city, region, and state.

However, while all economic activity enriches a local economy in various ways, not all activity is created equal. Economic development experts worldwide are increasingly more cognizant of what Pittsburgh and Carnegie Mellon have long understood – that large-scale research universities are central components to a vibrant regional economy. The education and research activities undertaken by CMU are key export items in the modern knowledge economy, with tuition checks and research grants that could go anywhere in the country flowing into Pittsburgh. The innovation activity associated with and inspired by CMU also has significant spillover effects throughout the region, spawning new commercial activities and strengthening the region's competitiveness and attractiveness to outside firms. Indeed, over the past several decades, CMU's intellectual capital has been a foundational element of the Pittsburgh region's difficult but largely successful transition to a modern knowledge-based economy, and CMU (the institution and its leaders) continues to serve as a key participant in contemporary regional economic growth initiatives.

Looking ahead, Carnegie Mellon is well-positioned to continue to serve as an innovation engine with meaningful benefits at a global, state, regional, local, and neighborhood level. As the geography of innovation shifts from set-apart corporate locations in suburban settings to urban districts anchored by elite research universities, more and more future innovation work will take place in and around places like CMU.[1] Recent expansions by such companies as Google, General Electric and Uber in Pittsburgh are direct results of CMU's engagement with cutting-edge private research, and portend an additional clustering of high-end entrepreneurship and technology activity around campus, with significant local, regional, and statewide gains to follow.

[1] Katz, B. & Wagner, J. "The Rise of Innovation Districts: A New Geography of Innovation in America". *Metropolitan Policy Program*. Brookings Institution. 2014.

KALPANA INTERACTIVE VIRTUAL REALITY EXPERIENCE

Source: Carnegie Mellon

1.4 ORGANIZATION OF REPORT

The section that follows explains the methodological approach employed throughout this report to articulate and calculate economic impacts from Carnegie Mellon's various activities. Those impacts are covered in the following sections:

- *Section 3: Impact from Operations* reviews and quantifies the impact from CMU's ongoing operations, including employment, procurement, research, and administration of programs and initiatives.

- *Section 4: Impact from Capital Investments* reviews and quantifies impact from CMU's significant physical investments in construction, renovation, and maintenance.

- *Section 5: Impact from Ancillary Student and Visitor Spending* estimates impact from ancillary spending (i.e. spending that does not accrue to CMU) by both students and visitors to CMU's campus.

- *Section 6: Impact from Wage Premium and Talent Attraction* describes and estimates the economic benefits associated with CMU's education and credentialing function by quantifying the additional wages earned, retained, and ultimately spent within the local, regional, and statewide economy by CMU graduates.

- *Section 7: The Reach and Impact of CMU's Innovation Diaspora* describes the character and scale of CMU's contribution to scientific and technical innovation, with a particular focus on the role of CMU and its alumni in translating intellectual capital into commercially and societally beneficial uses.

- *Section 8: CMU's Essential Contribution to Regional Economic Transformation* describes CMU's historic and current role in Pittsburgh's transition to a modern knowledge economy through its civic leadership and intellectual capital.

- *Section 9: Impact from Local Engagement* describes CMU's commitment to its host community, underscoring the fact that strong town-gown relations represent a win-win situation for CMU and for the City of Pittsburgh.

- *Section 10: Conclusion* reviews and summarizes impacts, economic and qualitative, described within this report.

2.0 IMPACT METHODOLOGY

2.1 SECTION OVERVIEW

This section describes the methodology utilized to estimate the full range of economic activity and tax generation impact associated with Carnegie Mellon's direct economic activity. Economic impact estimates are generated by utilizing standard input-output models to translate an initial amount of direct economic activity into the total amount of economic activity that it supports. This includes multiple waves of spillover impacts generated by spending on goods and services and by spending of labor income by employees. The description that follows reviews the basic methodologies and tools used to construct and interpret economic and tax generation impacts of Carnegie Mellon University within the City of Pittsburgh, Pittsburgh region, and Commonwealth of Pennsylvania. Appendix A provides more complete detail on the economic and tax revenue impact methodology utilized in this analysis.

2.2 ECONOMIC AND TAX REVENUE IMPACT METHODOLOGY

Carnegie Mellon's scale and scope of activities make it an economic powerhouse within the City of Pittsburgh, the Pittsburgh region, and the Commonwealth of Pennsylvania. This report articulates and quantifies the direct spending impacts at different geographical levels associated with CMU's activity across a number of categories. Standard input-output modeling techniques are then used to estimate the spillover economic impacts of the direct spending within the City of Pittsburgh, Pittsburgh region, and Commonwealth of Pennsylvania, and to translate those effects into attendant employment, earnings and tax revenue impacts.

Input-Output Theory

In an inter-connected economy, every dollar spent generates two spillover impacts:

- First, some amount of the proportion of that expenditure that goes to the purchase of goods and services gets circulated back into an economy when those goods and services are purchased from local vendors. This represents what is called the "indirect effect," and reflects the fact that local purchases of goods and services support local vendors, who in turn require additional purchasing with their own set of vendors.

- Second, some amount of the proportion of that expenditure that goes to labor income gets circulated back into an economy when those employees spend some of their earnings on various goods and services. This represents what is called the "induced effect," and reflects the fact that some of those goods and services will be purchased from local vendors, further stimulating a local economy.

The role of input-output models is to determine the linkages across industries in order to model out the magnitude and composition of the spillover impacts to all industries of a dollar spent in any single industry. Thus, the total economic impact of CMU is the sum of its own direct economic footprint plus the indirect and induced effects generated by that direct footprint.

Input-Output Model Mechanics

To model the impacts resulting from the direct expenditures generated by Carnegie Mellon, Econsult Solutions, Inc. (ESI) developed a customized economic impact model using the IMPLAN input/output modeling system. IMPLAN represents an industry standard approach to assess the economic and job creation impacts of economic development projects, the creation of new businesses, and public policy changes.[2]

These economic impacts in turn produce one-time or ongoing increases in various tax bases, which yield temporary or permanent increases in various tax revenues. Thus, even though universities are non-profit institutions and are thus generally exempt from some local tax types, the economic activity and employment generated by them produces increases across a number of tax bases and therefore generates tax revenues for the jurisdictions within which they are located.

To estimate these increases, ESI has created a custom fiscal impact model to translate total economic impacts into their commensurate tax revenue gains for the City and Commonwealth. Output from the IMPLAN model determines its impact on the relevant tax types and tax bases associated with the jurisdictions in which revenue impacts reside. These include income, sales, and business taxes at both the City and Commonwealth level.

Gross and Net Impact Analysis

Broadly, economic impact reports can estimate the magnitude of either the total gross impact of an institution (or project, policy, etc.) or its net impact. In a gross impact analysis, overall impact amounts are determined for an institution's activities with no regard to what impacts might have occurred in a geography absent that institution. A net impact analysis, which sometimes takes the form of a cost-benefit analysis, develops a "counterfactual" that overall impact amounts are netted against impact levels that might have occurred anyway in place of that institution's existence and operations.

[2] IMPLAN is one of several popular choices for regional input-output modeling. Each system has its own nuances in establishing proper location coefficients. IMPLAN uses a location quotient to determine its regional purchase coefficient (RPC). This represents the proportion of demand for a good that is filled locally; this assessment helps determine the multiplier for the localized region. Additionally, IMPLAN also accounts for inter-institutional transfers (e.g. firms to households, households to the government) through its Social Account Matrix (SAM) multipliers. IMPLAN takes the multipliers and divides them into 440 industry categories in accordance to the North American Industrial Classification System (NAICS) codes.

This analysis, like most standard economic impact analyses, broadly utilizes a gross impact approach. This methodology is appropriate in part because alternative development paths are largely speculative. For example, simulating alternative uses for the CMU's campus or the alternative development of Pittsburgh's regional economy over the more than a century since the founding of Carnegie Mellon would produce a wide range of results that could not be reliably compared to the known activity level of CMU.

Notably, however, the nature of Carnegie Mellon's activities and impact suggest that its impact is largely "net new" to the Pittsburgh region, and that its activity would not be easily replaced within the regional economy. CMU is a significant importer for the region, attracting the bulk of its students, researchers and research dollars from outside of the region. This knowledge activity is highly mobile, and absent CMU would likely take place at other knowledge centers nationally or internationally rather than simply shifting internally to other Pittsburgh institutions. As described in Section 2.3, the total economic impact quantified in this report is confined to the footprint of activity directly attributable the university, and the spillover activity it generates. This aggregate amount largely excludes CMU's central role in attracting high-tech firms and indeed entire industries to the Pittsburgh region, which has been vital in re-orienting the region's economy in the post-industrial era. As discussed in Section 8, strong evidence indicates that significant private employment and economic activity within the region's knowledge industry sectors would not take place in the region absent CMU. Thus, a comprehensive "net" analysis of CMU's impact that accounted for the alternative development path of the regional economy over decades absent its leading research institution would be is likely to yield a number far larger than the gross amount calculated in this report.[3]

2.3 SCOPE OF ECONOMIC IMPACT ANALYSIS

The purpose of this report is to articulate and quantify the current economic impact of CMU within various defined geographic areas. This section reviews the geographic and categorical definitions, as well as the data sources utilized to undertake this analysis.

[3] In addition, this analysis compares Carnegie Mellon's activity level to a counterfactual in which Carnegie Mellon does not exist, rather than a scenario in which the identical activities are somehow transported to a different geography, or one in which other universities increase their activity levels by a commensurate amount to absorb this lost activity. Thus, the benefits to employees and students of CMU are not understood to be simply shifted in their geographic scope, but representative of an overall increase in level of activity in the educational sector due to the existence of Carnegie Mellon. Further, from a geographic standpoint, benefits are not confined to those residents that would have been within the geographic boundaries absent CMU, but rather reflects the role of the University in drawing activity into the region, which includes the importation of new students, faculty, administrators and researchers who would likely reside and work elsewhere absent Carnegie Mellon.

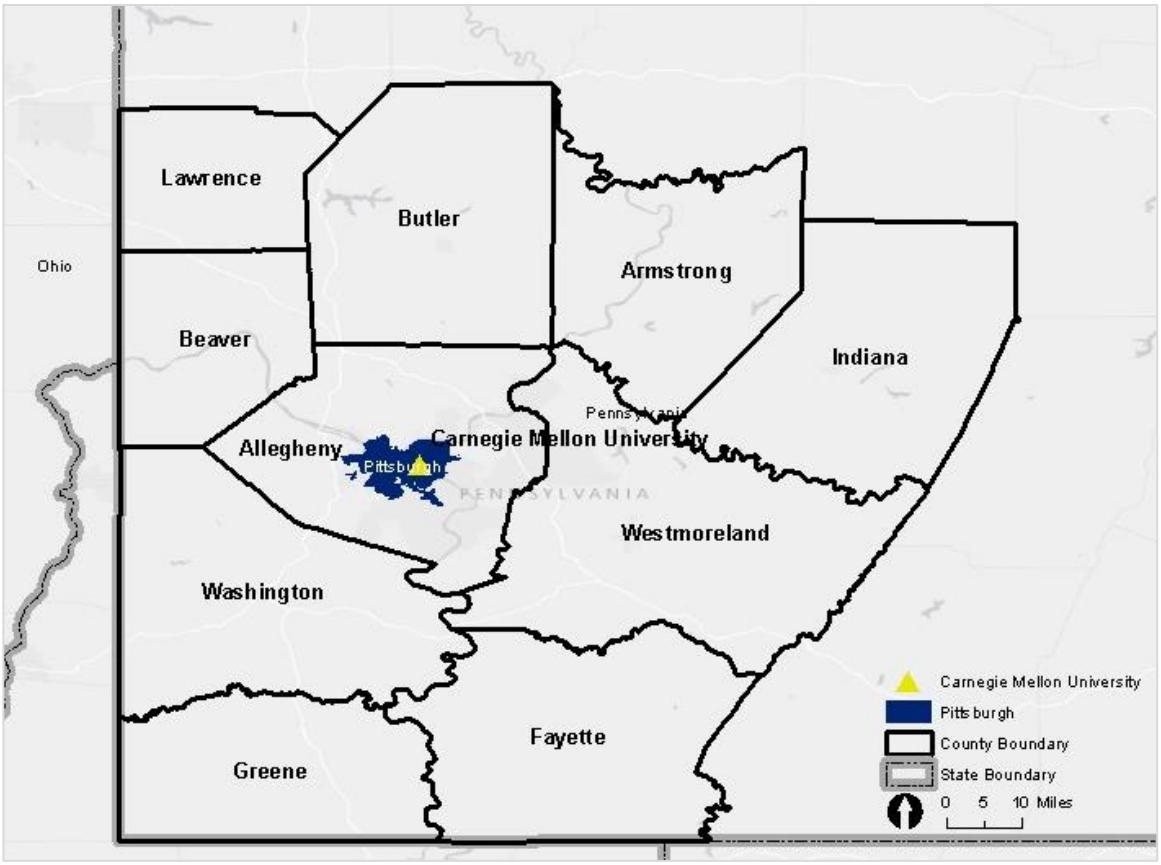
Geographies of Interest

The primary geographies of consideration of Carnegie Mellon's economic and tax revenue impact within this report are the City of Pittsburgh, the Pittsburgh region,[4] and the Commonwealth of Pennsylvania (see Figure 2.1), while tax revenue impacts are modeled for the City of Pittsburgh and Commonwealth of Pennsylvania.[5] While the bulk of CMU's operating footprint takes place within the City of Pittsburgh at its main campus, CMU has a global presence through a variety of academic partnerships, and through satellite campus locations in Silicon Valley and Qatar. Expenditures taking place within these geographies are excluded from the scope of this study since they do not yield direct quantifiable impacts within the local geographies. However, CMU's global presence and connections are an important part of its local impact through international students and visitors (and their spending) brought to the Pittsburgh region, and CMU's impact on the innovation economy.

FIGURE 2.1 – GEOGRAPHIES OF INTEREST

[4] The Pittsburgh region utilized in this report is comprised of ten counties in Pennsylvania as defined and served by the Allegheny Conference on Community Development. These counties are: Allegheny, Armstrong, Beaver, Butler, Fayette, Greene, Indiana, Lawrence, Washington and Westmoreland. This region is slightly larger than the official seven-county Pittsburgh Metropolitan Statistical Area (MSA), and is used because of CMU's active involvement in the Allegheny Conference and the regional efforts undertaken through that vehicle (as described in Section 8).

[5] CMU's economic impact also generates local tax revenues for other jurisdictions within the Commonwealth besides the City of Pittsburgh, which vary based on the nature and structure of local tax codes. Those amounts are excluded from this analysis.



It should also be noted that the economic impact amounts in the City of Pittsburgh are included in the economic impact amounts in the Pittsburgh region and Commonwealth of Pennsylvania, and the Pittsburgh region within the Commonwealth of Pennsylvania, since these localized economies are wholly contained within the larger economies. However, the tax generation amounts for Pittsburgh are separate from the tax generation amounts for Pennsylvania, because the City of Pittsburgh and the Commonwealth of Pennsylvania are separate and distinct government jurisdictions with separate and distinct tax bases.

Data Sources and Time Periods

This analysis seeks to quantify the current annual level of economic activity associated with Carnegie Mellon. To do so, it seeks to use the most appropriate and recent data available as of the end of calendar year 2016 for each component of the calculation. Where available and appropriate fiscal year 2016 data was utilized as it represents the most recently completed fiscal year. In some instances, however, multiple years of data are useful, either in establishing a more appropriate baseline for metrics that may fluctuate on an annual basis, or in illustrating a changing trend in the level of activity over time. Data utilized throughout this report are largely provided by Carnegie Mellon, and are verified against publicly reported sources. Operations and

capital investments represent categories of spending undertaken by Carnegie Mellon itself and can therefore be accounted for at a high level of precision using financial data provided by CMU. Ancillary spending and wage premium are by their nature less precise, and estimates are developed based on a combination of direct information provided by CMU and assumptions anchored by research.

Additive Impact Categories

While a variety of impacts associated with CMU's activities are analyzed and described within this report, care has been given to understanding which impacts are unique and therefore sum to the total economic and tax revenue impact figures documented in the conclusion of the report.

- Methodologies used to estimate impacts in Sections 3-6 (Operations, Capital Investments, Ancillary Spending and Wage Premium, respectively) are chosen to ensure that these impacts are mutually exclusive[6] and therefore additive.

- Impacts described in Sections 7-9 (Innovation, Regional Economic Contribution, and Local Engagement) largely stem from programs and efforts originating within CMU's operating budget. Therefore, these impacts cannot be added to impacts from operations calculated in Section 3 without some degree of double counting. These sections therefore focus on the implications of CMU's activity globally, regionally and locally. This includes CMU's contribution to advancing the body of knowledge on important technological and societal challenges (globally), drawing activity that could take place anywhere across the globe into Pennsylvania and taking a central role in economic development efforts (regionally), and by engaging with needs specific to the Pittsburgh community (locally).

[6] For example, Section 5 only includes spending by students and visitors that is "ancillary" (i.e. not accruing to CMU through categories like on campus room and board), and therefore reflected as part of the operations quantified in Section 3.

INTRODUCTION TO AGGREGATE ECONOMIC IMPACT ANALYSIS (SECTIONS 3-6)

Sections 3-6 represent the four discrete categories of economic impact that sum to the aggregate economic impact of direct, indirect and induced economic activity attributable to Carnegie Mellon. These impact categories are as follows:

- *Impact from Operations* (Section 3), which includes the broad base of employment, procurement, research and administration activities that comprise the daily activities of the institution, and represent its largest and most direct economic footprint.

- *Impact from Capital Investments* (Section 4), which includes the large scale investments made by the institution in the physical space (construction, renovation and maintenance), which create activity for local building trades and improve the built environment.

- *Impact from Ancillary Student and Visitor Spending* (Section 5), which reflects the spending footprint of students and visitors drawn by the university that takes place off campus, supporting the local hospitality, food and retail industries.

- *Impact from Wage Premium and Talent Attraction* (Section 6), which reflects the incremental earning power conveyed by the university to its graduates and the talent attraction impacts of CMU within the city, region and state, leading to increased local household spending across a variety of sectors.

These four categories, including their indirect and induced effects, represent the industry-standard aggregate impacts typically estimated for educational institutions. Inputs for each component are carefully segregated, and outputs are expressed in common categories (economic output, employment, earnings, and tax revenue) and time periods (the current annual level) to ensure that impacts can be appropriately summed to yield the total current annual impact of the institution.

3.0 IMPACT FROM OPERATIONS

3.1 SECTION OVERVIEW

As a comprehensive university with a high level of research activity, Carnegie Mellon is a significant economic contributor through its ongoing operations, research, and employment. With an annual operating budget of nearly $1.1 billion, CMU procures millions of dollars in goods and services from Pennsylvania vendors and employs more than 5,500 faculty and staff members. These expenditures go on to support additional activity that adds to the economic vitality of the City of Pittsburgh, Pittsburgh region, and Commonwealth of Pennsylvania. This activity also generates direct, indirect, and induced tax revenues which support public services provided by the city and Commonwealth.

3.2 DIRECT OPERATING EXPENDITURES BY CARNEGIE MELLON

Carnegie Mellon's annual operating activity has grown to its highest level in school history. In FY 2016, the CMU global operating budget totaled nearly $1.1 billion, supporting direct employment of more than 5,500, and enrollment of more than 13,600 (see Table 3.1).

TABLE 3.1 – GROWTH IN CARNEGIE MELLON OPERATING EXPENSES AND EMPLOYMENT FY 2011 - FY 2016

Category	FY 2016	FY 2011	% Change
Total Expenses ($M)	$1,089	$909	20%
Employees	5,575	5,089	10%
Student Enrollment	13,648	11,618	17%

Source: Carnegie Mellon (2011, 2016)

Each of these indicators of operating activity grew from FY 2011 to FY 2016. Total operating expenses were up by 20% over this five year period, reflecting increased enrollment (up 17%) and employment (up 10%). It is important to note that at a time when many institutions of higher education are accused of increasing overhead expenditures faster than enrollment,[7] CMU's employment head count grew at a lower rate than enrollment over this period, and operating expenditure growth per student was effectively flat when inflation is accounted for.

[7] For example, according to Department of Education data, administrative positions at colleges and universities grew by 60 percent from 1993 to 2009. "The Real Reason College Tuition Costs So Much", *The New York Times,* April 2015 <http://www.nytimes.com/2015/04/05/opinion/sunday/the-real-reason-college-tuition-costs-so-much.html>

Ongoing operations represent Carnegie Mellon's largest direct contribution to the local and state economy. The vast majority of CMU's operating expenditures and employment takes place at its Pittsburgh location (see Table 3.2).

TABLE 3.2 – CARNEGIE MELLON FY 2016 DIRECT EMPLOYMENT AND OPERATING EXPENDITURES BY LOCATION

	Total	Pittsburgh Location	Other Locations[8]
Total Expenses ($M)	$1,089		
(Less Depreciation and Amortization) ($M)	($62)		
Operating Expenditures ($M)	**$1,027**	**$929**	**$98**
Compensation and Benefits Paid ($M)	$719	$658	$61
Other Operating Expenses ($M)	$308	$271	$37
Employees	**5,575**	**5,359**	**216**

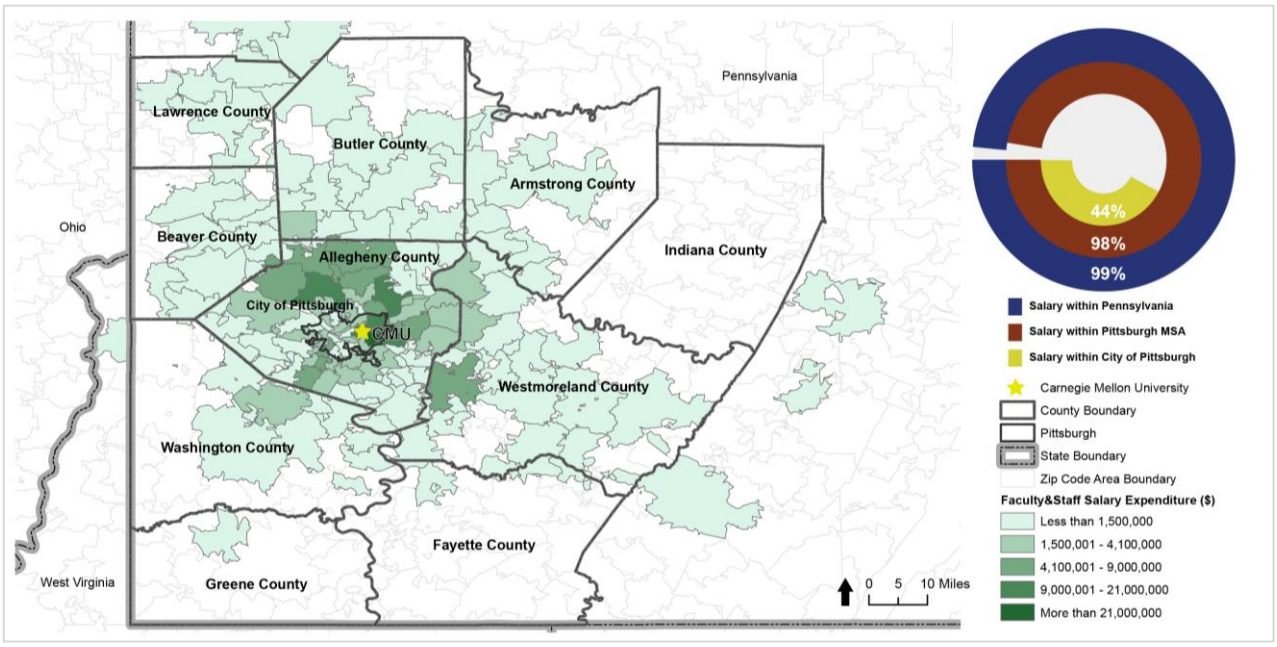
Source: Carnegie Mellon (2016), Econsult Solutions (2016)

Carnegie Mellon's large operating footprint means a significant number of jobs that are located in Pittsburgh and a large amount of spending on goods and services. Due in part to sheer proximity and in part to specific prioritizations by CMU, these economic opportunities are to the direct benefit of local residents who work for CMU and local vendors who do business with CMU.

Payroll represents the largest component of CMU's expenditures at its Pittsburgh location, with annual spending wages and benefits to employees totaling $658 million. A large portion of these wages are spent within the city, region, and commonwealth, generating induced economic impacts, and the City and Commonwealth also collect wage and income taxes on the salaries paid. Data on the residential locations of faculty and staff show virtually all CMU's payroll accrues to residents of the Pittsburgh region (98%) and Commonwealth of Pennsylvania (99%). Further, 44% of salary accrues to residents of the City of Pittsburgh (see Figure 3.1).

[8] Carnegie Mellon has additional academic and research facilities outside of Pittsburgh, most notably in the Silicon Valley and Qatar. Since this report is specific to CMU's contribution to the local, regional and commonwealth economies, CMU's footprint outside of the Commonwealth is excluded.

FIGURE 3.1 – CARNEGIE MELLON FACULTY AND STAFF PAYROLL BY EMPLOYEE ZIP CODES

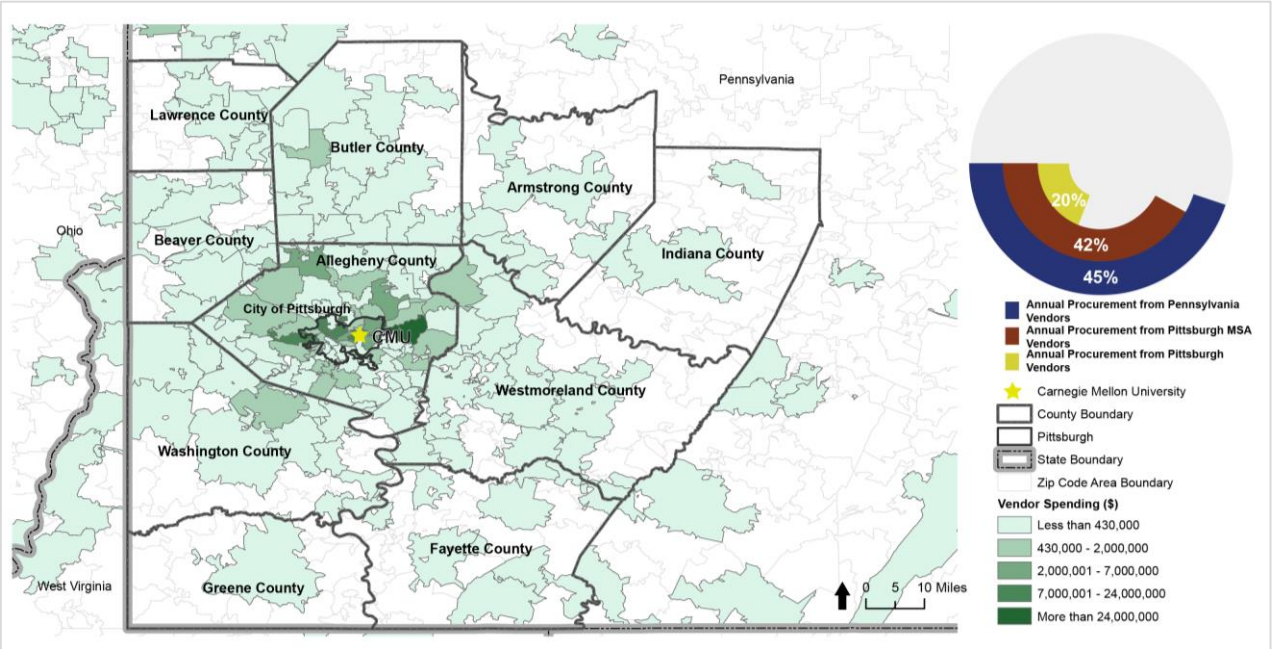


Source: Carnegie Mellon (2016)

Additionally, Carnegie Mellon spends more than $300 million annually on purchases of goods and services. A large percentage of these purchases go to vendors based in the city, region, and Commonwealth.

Data tracked and provided by Carnegie Mellon on the geographic distribution of its vendor spending shows a significant commitment to purchasing from locally-based businesses. Vendor data provided for Carnegie Mellon's operations in FY 2016 identified 45 percent of total expenditures as accruing to Pennsylvania-based businesses, with 42 percent going to Pittsburgh region-based businesses, 20 percent to Pittsburgh-based businesses (see Figure 3.2). These local suppliers span a variety of trades and services, including construction and manufacturing, health care, software and computing, professional services, etc. These vendors in turn also spend and hire within the local and state economies, which generate additional indirect economic impacts.

FIGURE 3.2 – CARNEGIE MELLON VENDOR PROCUREMENT BY ZIP CODE, FY2016



Source: Carnegie Mellon (2016)

Annual operating expenditures occurring within the geographies of interest can be identified by netting from the total operating budget depreciation and amortization, expenditures at other campus locations, and purchasing patterns. After accounting for these factors, annual operating expenditures associated with CMU's Pittsburgh location total $859 million within the City of Pittsburgh, $868 million within the Pittsburgh region and $874 million within the Commonwealth of Pennsylvania (see Table 3.3).

TABLE 3.3 – ANNUAL CMU OPERATING EXPENDITURES WITHIN THE CITY OF PITTSBURGH, PITTSBURGH REGION AND COMMONWEALTH OF PENNSYLVANIA

	City of Pittsburgh	Pittsburgh Region	Commonwealth of Pennsylvania
Total Expenditures ($M)	$1,089	$1,089	$1,089
(Less Depreciation and Amortization) ($M)	($62)	($62)	($62)
(Less Expenditures at Other Locations) ($M)	($98)	($98)	($98)
(Less Purchasing Outside of Geography) ($M)	($70)	($61)	($55)
Total Modeled Spend ($M)	**$859**	**$868**	**$874**

Source: Carnegie Mellon (2016), Econsult Solutions (2016)

3.3 ECONOMIC IMPACT FROM DIRECT OPERATING EXPENDITURES

Carnegie Mellon's annual direct operating expenditures generate more than $850 million in direct output within the City of Pittsburgh, Pittsburgh region, and Commonwealth of Pennsylvania. These direct expenditures support additional indirect and induced jobs, as well as, stimulate and expand regional business activity. Direct, indirect and induced impact from ongoing operations generated significant annual impacts:

- $1.19 billion in total output, supporting 7,610 jobs and $726 million in earnings within the City of Pittsburgh;
- $1.88 billion in total output, supporting 12,410 jobs and $955 million in earnings within the Pittsburgh region; and
- $1.90 billion in total output, supporting 12,500 jobs and $959 million in earnings within the Commonwealth of Pennsylvania (see Table 3.4).[9]

TABLE 3.4 – ANNUAL ECONOMIC IMPACT OF CMU'S OPERATIONS WITHIN THE CITY OF PITTSBURGH, PITTSBURGH REGION, AND COMMONWEALTH OF PENNSYLVANIA

	City of Pittsburgh	Pittsburgh Region	Commonwealth of Pennsylvania
Direct Output ($M)	$859	$868	$874
Indirect and Induced Output ($M)	$331	$1,011	$1,029
Total Output ($M)	**$1,190**	**$1,879**	**$1,903**
Employment	**7,610**	**12,410**	**12,500**
Employee Compensation ($M)	**$726**	**$955**	**$959**

Source: Carnegie Mellon (2016), IMPLAN (2013), Econsult Solutions (2016)

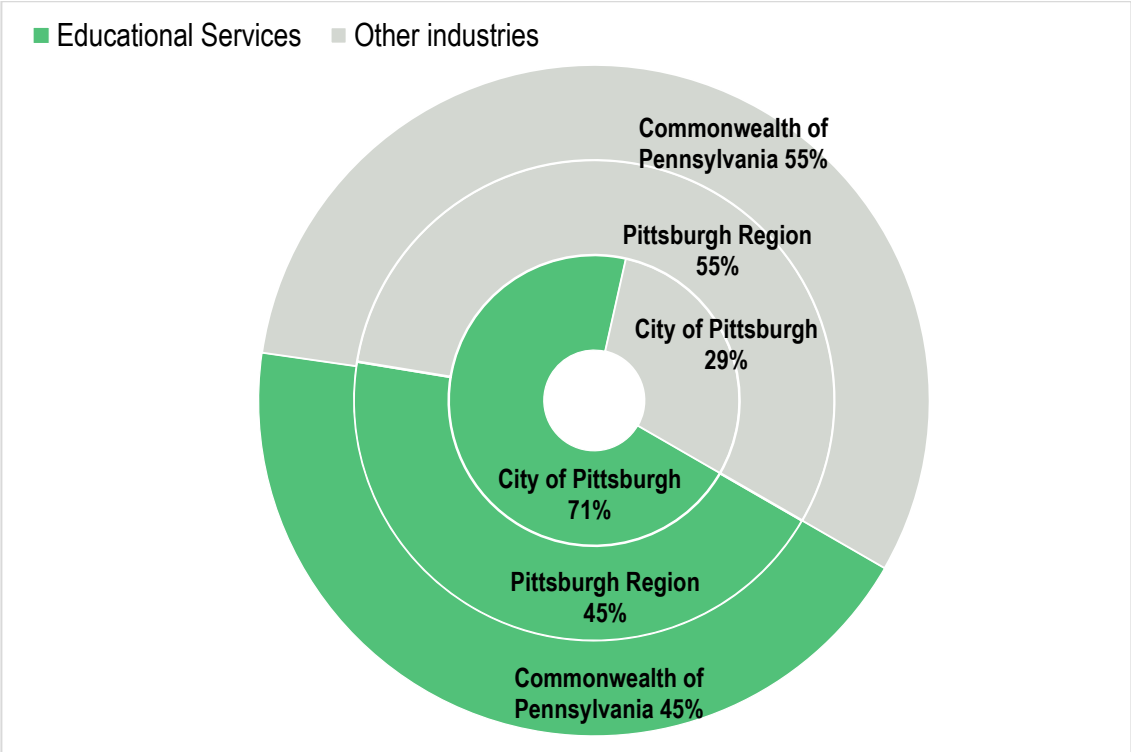
3.4 INDUSTRY DISTRIBUTION OF ECONOMIC IMPACT FROM DIRECT OPERATING EXPENDITURES

Carnegie Mellon's day-to-day operations affect a wide range of industries. Through the purchase of goods and services, and the spending of labor income it generates, CMU's activities have impacts throughout on a variety of sectors, including health care & social services, retail trade, accommodation & food services, and real estate & rental services. Overall, these top five industries capture 71 to 84 percent of the total jobs impact in the City of Pittsburgh, Pittsburgh region, and Commonwealth of Pennsylvania.

[9] Note that the City of Pittsburgh economy is fully contained within the Pittsburgh region economy, and the Pittsburgh region economy is fully contained within the Commonwealth of Pennsylvania economy

In total, educational services[10] represent 71 percent of the total employment impact from CMU's operations within Pittsburgh, but only 45 percent within the region and the state. Generally, in larger and more economically diverse geographies, spending within a single industry ripples through that economy into other sectors and is captured more broadly (see Figure 3.3).[11]

FIGURE 3.3 – INDUSTRY DISTRIBUTION OF EMPLOYMENT GENERATED BY CMU'S ONGOING OPERATIONS WITHIN THE CITY OF PITTSBURGH, PITTSBURGH REGION, AND COMMONWEALTH OF PENNSYLVANIA



Source: Carnegie Mellon (2016), IMPLAN (2013), Econsult Solutions (2016)

[10] As defined by the North American Industry Classification System (NAICS) used by the Bureau of Labor Statistics (BLS) and other federal statistical agencies, the "Educational Services" sector comprises establishments that provide instruction and training (whether publicly or privately owned, degree or non-degree granting, etc.). CMU's core educational functions fall within this category.

[11] See Appendix C for full detail on the industry distribution of employment generated by Carnegie Mellon's ongoing operations

CAMPUS CENTER "THE CUT" IN FALL

Source: Carnegie Mellon

3.5 REVENUE GENERATION FOR LOCAL AND STATE GOVERNMENT FROM DIRECT OPERATING EXPENDITURES

As a large regional employer and locus of economic activity, Carnegie Mellon generates significant tax revenues despite its non-profit status. Expenditures on wages and purchases on goods and services help spur on additional activity within the Pittsburgh region and Commonwealth of Pennsylvania. These activities combined generate income, sales, and business taxes to the City, County, and Commonwealth governments. In aggregate, annual ongoing operating activity by Carnegie Mellon generates approximately $9 million in City tax revenues and an additional $34 million in Commonwealth tax revenues (see Table 3.5).[12]

[12] Note that while City of Pittsburgh economy is wholly contained within the Commonwealth of Pennsylvania, the City and Commonwealth represent distinct government entities with distinct tax bases. Tax revenue impacts to the two jurisdictions are therefore additive.

TABLE 3.5 – ANNUAL TAX REVENUE GENERATION FROM CMU'S OPERATIONS WITHIN THE CITY OF PITTSBURGH AND COMMONWEALTH OF PENNSYLVANIA (IN $ MILLIONS)

Tax Type	City of Pittsburgh	Commonwealth of Pennsylvania
Personal Income Taxes ($M)	$8.61	$22.16
Sales and Use Taxes ($M)[13]	$0.28	$9.29
Business Taxes ($M)	$0.34	$2.22
Total ($M)	**$9.22**	**$33.66**

Source: Carnegie Mellon (2016), IMPLAN (2013), City of Pittsburgh (2014), Allegheny County (2014), Commonwealth of Pennsylvania (2014), Econsult Solutions (2016)

Notably, this figure doesn't capture any incremental property tax revenue attributable to the presence of the Carnegie Mellon. While property directly held by CMU for academic purposes is exempt from property taxes due to the University's non-profit status, CMU is a major contributor to nearby real estate demand, increasing property values for landholders and associated revenue collections for the city and school district. A report from Colliers International indicated that the office vacancy rate in the Oakland neighborhood surrounding CMU was just 2.2% in Q2 2016, lowest of any neighborhood in the city and more than three times lower than the regional average of 7.7%.[14] Residential rents in nearby neighborhoods such as Oakland, Squirrel Hill and Shadyside are around $1,000 for a one-bedroom as of March 2016, according to real estate site Abodo.com.[15] This demand and its positive impacts on property values supports the crucial city and school district property tax base, in addition to stimulating demand for additional construction.

3.6 IMPORTANCE OF IMPACTS FROM ANNUAL OPERATIONS

The sheer size of Carnegie Mellon's operating activity makes it an economic engine for the City and Commonwealth. Its spending on employment and purchases of goods and services supports a significant amount of economic activity and tax revenue generation throughout the commonwealth. The same could be said for any entity of CMU's size, however. The strategic importance of CMU's economic and tax revenue impacts from annual operations lies in how those impacts are generated. These themes will be elaborated on in the second half of this report but are touched on here to provide suitable context for the economic and tax revenue impact numbers that have been presented in this section.

The vast majority of operating dollars spent by CMU within the local economy originated outside of Pittsburgh and Pennsylvania. CMU attracts students (and their attendant tuition dollars) from all over the world and the bulk of its research dollars come from the federal government. This

[13] Local Sales and Use Taxes generated within the City Pittsburgh included in this figure are collected by Allegheny County

[14] "Research and Forecast Report: Pittsburgh Office: Continued Strength in Q2". *Colliers International*, Q2 2016

[15] "Pittsburgh Rent Report. *Abodo.com*, March 7, 2016.

dynamic makes CMU the modern-day analogue of the manufacturers that once dominated Pittsburgh's economy, supporting local employment and tax base from a global customer base.

Furthermore, CMU is one of the largest employers in Allegheny County, with more employees than nationally recognized companies (including US Steel, and PPG). CMU's operating activity also directly and indirectly supports a diversity of jobs at all skill levels, including not only academic and research positions but administrative and service sector employment both on campus and through spillover activity throughout the region and state. This diversity of job types is important for a regional economy, both because it affords employment on-ramps at many different levels for existing and new residents, and because both high-paying and lower-wage jobs create economic ripple effects in different ways (high-paying jobs because they represent more discretionary household spending opportunities, and lower-wage jobs because a larger proportion of these earnings tend to be spent immediately and locally, rather than saved or spent outside the region).

Additionally, a large proportion of its instructional and operational activity focuses on advanced technologies. Indeed, students and research dollars are coming to CMU precisely because of its important contributions to the global knowledge economy. This attraction power draws in resources, concentrates activity in ways that yield powerful and prolific results, and has proven to have an immense halo effect on Pittsburgh's own reputation and attraction efforts.

THE MALL AT CARNEGIE MELLON

Source: Carnegie Mellon

4.0 IMPACT FROM CAPITAL INVESTMENTS

4.1 SECTION OVERVIEW

Capital investments are another important way that Carnegie Mellon contributes to the local and state economy, as well as to the physical landscape of Pittsburgh. These investments, in addition to allowing CMU to retain and expand its core operating activities, also represent a significant amount of construction activity which supports construction-related jobs, creates demand for various goods and services, and generates tax revenues to the city and Commonwealth.

The growing volume of construction and facility renovation activity represents a significant annual investment in the City of Pittsburgh, impacting both its economy and its physical environs. These capital investments also serve to attract prospective students and faculty, as well as meet the demand created by CMU's growing enrollment and ever expanding research capabilities.

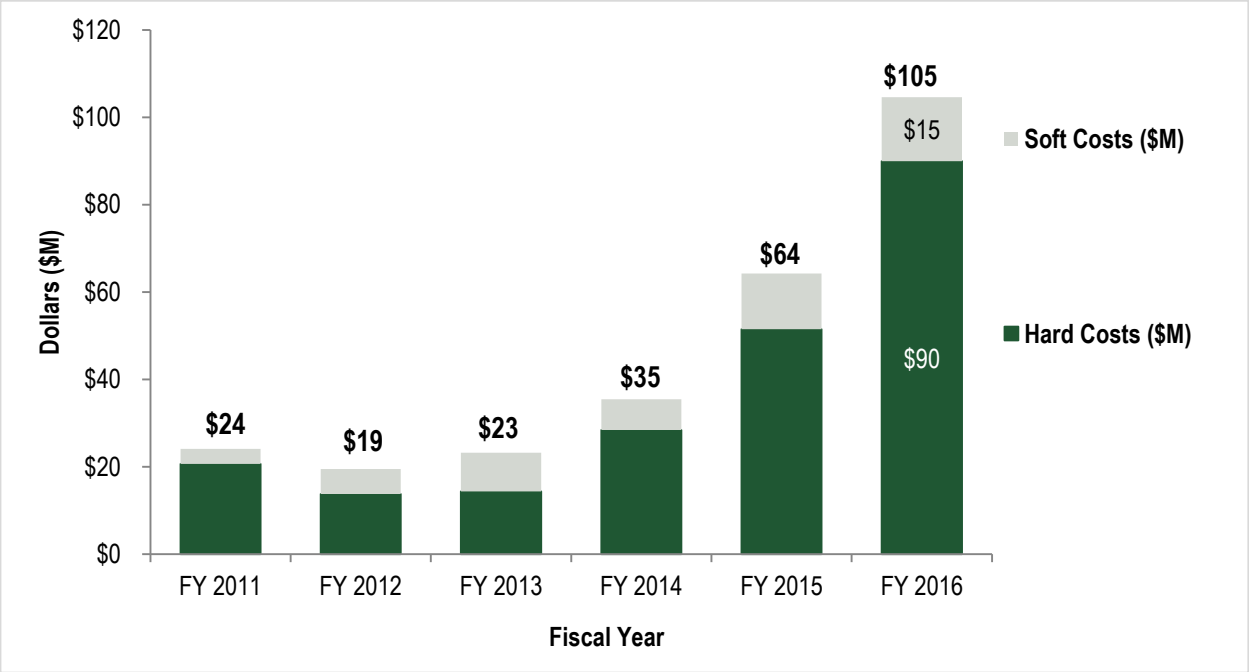
4.2 DIRECT CAPITAL INVESTMENTS

Carnegie Mellon has been a consistent source of major capital investments, which has provided a significant stimulus through an otherwise difficult time for the construction industry. These funds have also helped transform and refresh the campus's image with new modern facilities. Over the past six years, CMU's annual spending on investments in its Pittsburgh campus has increased from $24 million to nearly $105 million (See Figure 4.1).[16] Since FY 2011, CMU has spent about $271 million on capital investments, including $219 million in hard construction costs.[17]

[16] Within Pittsburgh, Carnegie Mellon's physical presence is largely concentrated in the Oakland neighborhood. However, Carnegie Mellon maintains other properties and investments outside of Pittsburgh, in Allegheny County, and beyond, including locations in include operating university facilities in the Silicon Valley of California and Qatar. Consistent with the parameters of this study, this analysis includes only capital investments taking placing on the Pittsburgh campus

[17] While capital expenditures are typically one-time expenditures, Carnegie Mellon's pipeline of current and future capital expenditures will support construction jobs within the Pittsburgh region for years to come.

FIGURE 4.1 – ANNUAL CMU CAPITAL INVESTMENTS AT ITS PITTSBURGH CAMPUS, FY 2011 - 2016 ($M)



Source: Carnegie Mellon (2016), Econsult Solutions (2016)

Current and Future Capital Investments

CMU is currently undertaking several large capital projects that will generate significant economic activity and upgrade the physical environment. These include significant investments in new academic and laboratory facilities. Most prominently, the David A. Tepper Quadrangle is a redevelopment of four and half acres of CMU's campus to include a 315,000 square foot building that will house the business school, visitor center, conference and dining spaces, and other university-wide needs, in addition to adding new greenspace to serve as a new campus gateway. By the end of 2018, these projects will have added over 550,000 square feet of academic space, and add $376 million to the local economy in construction expenditures (see Table 4.1). Most significantly, they will add to the capacity of the University to support research, instructional and entrepreneurship activity moving forward.

TABLE 4.1 – SELECTED ONGOING CAPITAL INVESTMENTS BY CARNEGIE MELLON ON ITS PITTSBURGH CAMPUS

	Total Budget ($M)	Square Footage	Start	Estimated Completion
University Center Addition	$26.8	56,700	12-Dec	May-16
Sherman and Joyce Bowie Scott Hall	$95.6	105,000	10-Sep	Oct-16
Tata Consultancy Services Building	$32.5	50,000	15-Aug	Jul-18
David A. Tepper Quadrangle	$201.0	315,000	13-Apr	Apr-18
ANSYS Simulation Building and Undergraduate Maker Center	$20.0	29,985	16-Apr	Dec-18

Source: Carnegie Mellon (2016), Econsult Solutions (2016)

Many of these projects are funded in part through partnerships with the private sector. These corporate investments represent a vote of confidence in the research activities of Carnegie Mellon, and extend the capital activity that the CMU is able to undertake.

Moving forward, Carnegie Mellon also anticipates at least $520 million in additional campus improvements and upgrades through the year 2022, or approximately $87 million per year. These planned investments indicate that CMU's activity will continue to generate significant spillover impacts in the local construction industry and for statewide suppliers and manufacturers for years to come. This activity also indicates CMU's commitment to providing its students and faculty with world class facilities, resources, and amenities which will help advance CMU's research and education mission and attract new students, faculty and researchers.

RENDERING OF DAVID A. TEPPER QUADRANGLE

Source: Carnegie Mellon

4.3 ECONOMIC IMPACT FROM DIRECT CAPITAL INVESTMENTS

Of the $105 million in capital investments in FY2016, $100 million generate an impact that can be modeled within the local economy.[18] These expenditures include physical construction costs, purchased supplies, and architectural, engineering, and other services related to construction. These direct construction expenditures generate significant economic activity on an annual basis:

- $132 million in total output, supporting 930 jobs and $57 million in earnings within the City of Pittsburgh;
- $196 million in total output, supporting 1,330 jobs and $80 million in earnings within the Pittsburgh region; and
- $202 million in total output, supporting 1,360 jobs and $81 million in earnings within the Commonwealth of Pennsylvania (see Table 4.2).

TABLE 4.2 – ANNUAL ECONOMIC IMPACT OF CMU'S CAPITAL INVESTMENTS WITHIN THE CITY OF PITTSBURGH, PITTSBURGH REGION, AND COMMONWEALTH OF PENNSYLVANIA

	City of Pittsburgh	Pittsburgh Region	Commonwealth of Pennsylvania
Direct Output ($M)	$100	$100	$100
Indirect and Induced Output ($M)	$32	$96	$102
Total Output ($M)	**$132**	**$196**	**$202**
Employment	**930**	**1,330**	**1,360**
Employee Compensation ($M)	**$57**	**$80**	**$81**

Source: Carnegie Mellon (2016), IMPLAN (2013), Econsult Solutions (2016)

[18] Supplies purchased only include the wholesale margin portion of the expense. Costs associated with the transportation and manufacturing of supplies are likely to occur outside of the Commonwealth and are therefore excluded from modeling.

SHERMAN AND JOYCE BOWIE SCOTT HALL

Source: Carnegie Mellon

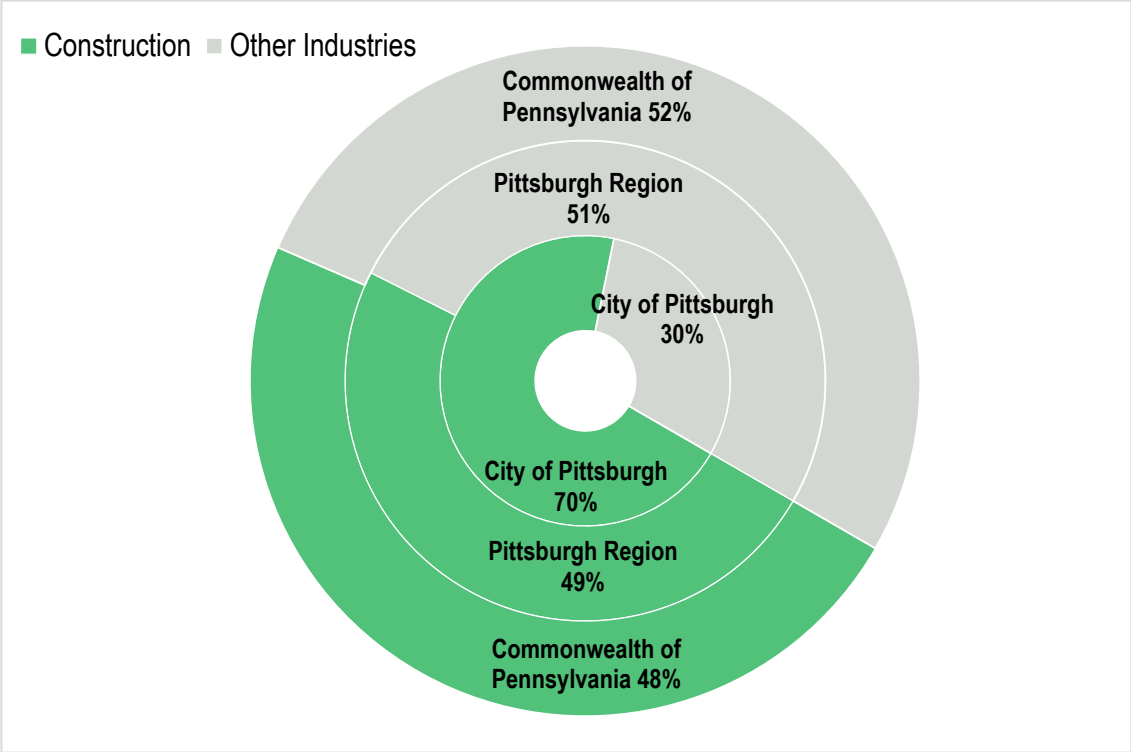
4.4 INDUSTRY DISTRIBUTION OF ECONOMIC IMPACTS FROM CAPITAL INVESTMENTS

The economic impacts associated with Carnegie Mellon's capital investments spread to industries far beyond the construction sector. While the construction industry is the largest individual beneficiary from these capital investments, other industries including professional, technical & scientific services, administrative & waste management, real estate, manufacturing, and retail trade also see significant benefits from the indirect (supply chain) and induced (labor income) impacts of the capital activity.

Figure 4.2 shows the proportion of the total employment impact associated with CMU's capital investments that accrues in and beyond the construction industry within the City, region, and Commonwealth. In the City of Pittsburgh, 70 percent of employment is generated within the

construction industry and 30 percent in other sectors. At larger geographies, more spillover activity is captured within other sectors of the economy. Thus, within the Pittsburgh region and Commonwealth economies, approximately half of the total employment associated with CMU's capital investments occurs within the construction sector, and with the remaining half in other sectors.[19]

FIGURE 4.2 – INDUSTRY DISTRIBUTION OF EMPLOYMENT GENERATED BY CMU'S CAPITAL INVESTMENTS WITHIN THE CITY OF PITTSBURGH, PITTSBURGH REGION, AND COMMONWEALTH OF PENNSYLVANIA



Source: Carnegie Mellon (2016), IMPLAN (2013), Econsult Solutions (2016)

[19] See Appendix C for additional detail on the industry distribution of employment generated by Carnegie Mellon's capital expenditures

4.5 REVENUE GENERATION FOR LOCAL AND STATE GOVERNMENT FROM DIRECT CAPITAL INVESTMENTS

Carnegie Mellon's capital activities are a significant revenue generator for the City of Pittsburgh and Commonwealth of Pennsylvania. These investments help create construction jobs, support local construction companies, and suppliers, all of which generate income, sales, and business taxes to the City and Commonwealth governments. In aggregate, direct capital investments by Carnegie Mellon in generate about $700,000 in City tax revenues and an additional $4.7 million in Commonwealth tax revenues on an annual basis (see Table 4.3).

TABLE 4.3 – ANNUAL TAX REVENUE GENERATION FROM CMU'S CAPITAL INVESTMENTS WITHIN THE CITY OF PITTSBURGH AND COMMONWEALTH OF PENNSYLVANIA (IN $ MILLIONS)

Tax Type	City of Pittsburgh	Commonwealth of Pennsylvania
Personal Income Taxes ($M)	$0.47	$2.42
Sales and Use Taxes ($M)[20]	$0.11	$1.82
Business Taxes ($M)	$0.14	$0.44
Total ($M)	**$0.72**	**$4.68**

Source: Carnegie Mellon (2016), IMPLAN (2013), City of Pittsburgh (2014), Allegheny County (2014), Commonwealth of Pennsylvania (2014), Econsult Solutions (2016)

4.6 IMPORTANCE OF IMPACTS FROM CAPITAL INVESTMENTS

The construction sector is notoriously cyclical, so steady investments by the education sector are an important way regions ride out recessions and minimize the disruptive effects of high unemployment. Carnegie Mellon's investment in its physical campus is large and growing, resulting in significant direct economic activity in the construction, and renovation trades, as well as yielding meaningful spillover effects into other industries and to City and Commonwealth tax bases.

The purpose of these capital projects by CMU is, of course, not the temporary stimulus they provide to the regional economy, although that stimulus is helpful and considerable. These expenditures represent an investment by Carnegie Mellon in a world-class campus and in high quality facilities befitting the quality and quantity of human capital and research activity that is being drawn into CMU. They are therefore an important part of CMU's ongoing ability to "export" intellectual and financial assets from all of the world into Pittsburgh and Pennsylvania.

[20] Local Sales and Use Taxes generated within the City Pittsburgh included in this figure are collected by Allegheny County

They are also representative of the changing landscape of where and how innovation takes place. The locus of innovation has shifted from stand-alone corporate research parks in suburban locations to urban settings with strong and fluid linkages between the corporate sector, startup communities, and research institutions. Especially when it comes to Carnegie Mellon's research and innovation specialties, CMU has attracted investment in facilities from private donors, publicly and privately held companies, and other public sources. These capital resources Carnegie Mellon is deploying in its buildings not only reflect an investment from CMU and third parties in a vibrant campus for the CMU community but to the broader innovation economy of the region. As discussed in Section 8, this ecosystem has significant implications for the overall reputation, competitive positioning, and entrepreneurship activity levels in the city, region and Commonwealth.

CLAIRE AND JOHN BERTUCCI NANOTECHNOLOGY LABORATORY

Source: Carnegie Mellon

5.0 IMPACT FROM ANCILLARY STUDENT AND VISITOR SPENDING

5.1 SECTION OVERVIEW

Over and above its own spending on operating activities and capital investments, Carnegie Mellon draws out-of-town spending from students and visitors that would likely not occur without CMU's presence in Pittsburgh. This spending would likely occur elsewhere if CMU did not exist. Of the two ancillary spending types, students by far represent the largest category, due to their volume and time spent in the city. Since the majority of these students are not Pennsylvania residents, their spending is net gain to City of Pittsburgh, Pittsburgh region and Commonwealth of Pennsylvania.

In addition to students, there are a significant number of visitors to CMU each year, which also brings spending into the region. These visitors come to Pittsburgh for a variety of reasons, including: prospective student campus visits, first year student move in, alumni events, conferences, special events, and commencement. While they visit, they spend money in the local economy on retail, food & beverage, lodging and transportation. Like students, these visitors would not likely visit the city, region or Commonwealth absent CMU. Therefore their spending can be considered net new to the city, region, and Commonwealth.[21]

Both students and visitors create demand in Pittsburgh for restaurants, retail establishments, hotels, and entertainment venues. As such their expenditures within the Pittsburgh region add to the overall health and vitality of the local and Commonwealth economy, which supports jobs and sustains businesses throughout the city and region.

5.2 A CAMPUS THAT DRAWS STUDENTS FROM AROUND THE WORLD

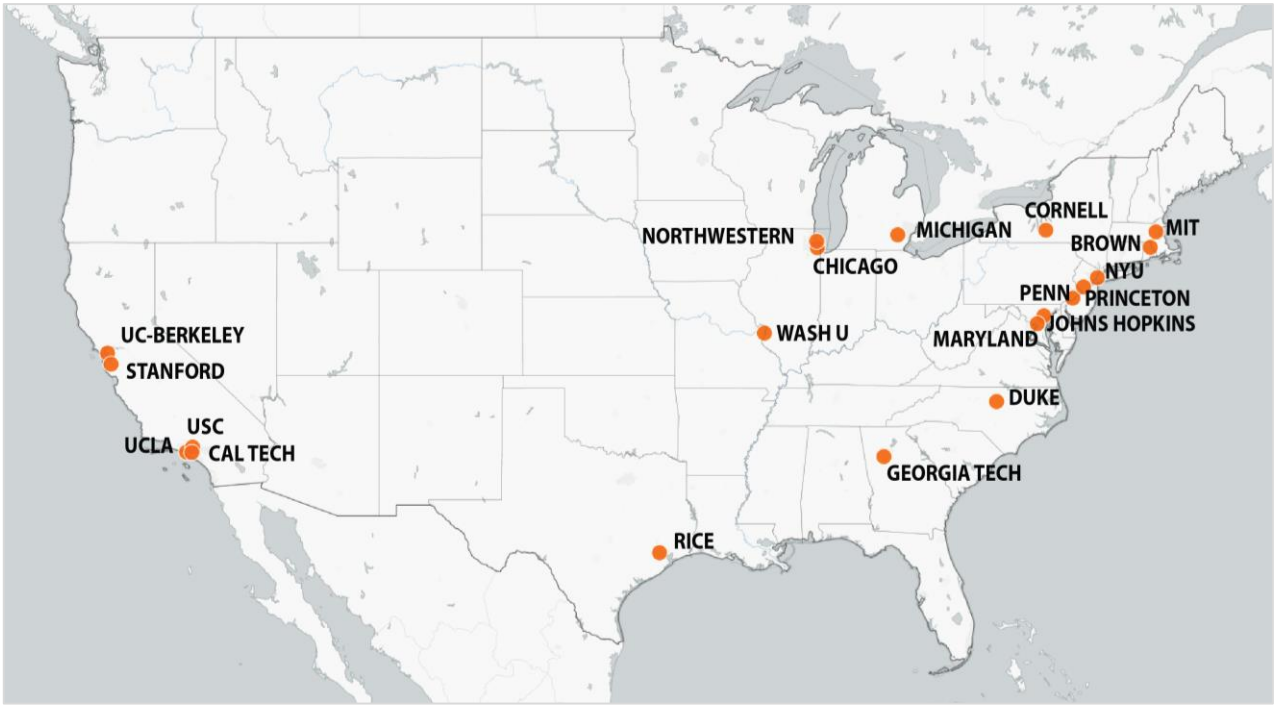
Carnegie Mellon's unique educational experience makes it a draw for students around the county and around the world. As a result, a high proportion of student spending associated with Carnegie Mellon is likely "net new" to the city, region and state based in part on the nature of CMU's student body. This key point is illustrated by both the geographic distribution of the student body, and the alternative schools that admitted students attend.

- Only four percent of all first-time degree seeking CMU students originate from Pittsburgh. Among all CMU students, 91 percent come from outside of the city, 86 percent from outside of the state, and 43 percent from outside of the country.

[21] See Appendix B for additional detail and supporting calculations on student and visitor spending associated with CMU.

- Students admitted to CMU who choose to enroll at a different institution rarely stay within the Pittsburgh region or within Pennsylvania. Among the top 20 alternative institutions chosen by admitted students, only one is within Pennsylvania (see Figure 5.1).

FIGURE 5.1 – TOP 20 INSTITUTIONS ATTENDED BY CMU ADMITTED STUDENTS WHO ENROLL ELSEWHERE, 2016



Source: Carnegie Mellon

The geographic composition and alternative choice set for the CMU student body clearly indicates that absent Carnegie Mellon, the vast majority of its students would not attend an institution in Pittsburgh or even in Pennsylvania. As a result, the significant living expenditures associated with the student body would likely to be taking place outside of these geographies absent CMU.

5.3 ANCILLARY SPENDING BY STUDENTS

University students not only pay tuition to Carnegie Mellon, they also spend on categories like transportation, room and board, supplies and books, and entertainment. Spending that takes place off-campus and does not accrue directly to CMU is considered "ancillary" for the purpose of this analysis (as it is separate from that which is already accounting for in CMU's operating budget and therefore in Section 3 of this report). A large proportion of this ancillary spending takes place within the City of Pittsburgh, where the vast majority of CMU students reside during the school year. An even larger sum is spent within the region and state. This spending is either "net new" to the city, region or state, in the case of students from outside those geographies, or is retained spending, in

that local students may well have attended a university outside those geographies (taking their spending power with them) in the absence of the CMU.

Using data provided by CMU's Office of Student Financial Services on projected total costs for students, ancillary spending profiles were developed by student type (on-campus or off-campus). Conservative estimates were then made for the proportion of ancillary spending not directly captured by CMU. This model is likely to underestimate the true impact of student ancillary spending owing to the fact that CMU's large international student body generally pays the full tuition rate, and therefore, they are likely to have a larger spending profile than what we have estimated here. For example, students who live in residence halls directly pay rent to CMU. That economic impact is therefore captured within CMU's operating budget and not included as ancillary spending. Further, the proportion of spending that takes place in the City of Pittsburgh, Pittsburgh region, and the Commonwealth of Pennsylvania was estimated for each spending category. This adjustment recognizes that not all spending takes place within the local geography, especially as consumer behavior has shifted, with millennials in particular increasingly shifting towards online shopping.

In total it is estimated that CMU's more than 12,000 students generate approximately $137 million in ancillary spending (net of that which is captured by CMU) each year. Of this spending:

- $100 million is estimated to be captured within the city of Pittsburgh; and
- $113 million is estimated to be within the Pittsburgh region and Commonwealth of Pennsylvania (see Table 5.1).[22]

TABLE 5.1 – ESTIMATED ANNUAL AGGREGATE ANCILLARY STUDENT SPENDING CAPTURED WITHIN THE CITY OF PITTSBURGH, PITTSBURGH REGION, AND THE COMMONWEALTH OF PENNSYLVANIA

Student Type	# of Students[23]	Per Student Ancillary Spending	Aggregate Ancillary Spending ($M)	Ancillary Spending in City of Pittsburgh ($M)	Ancillary Spending in Piit Region ($M)	Ancillary Spending in Pennsylvania ($M)
On-campus	3,517	$3,334	$11.7	$5.6	$6.4	$6.4
Off-campus	8,549	$14,388	$125.4	$94.8	$106.5	$106.5
Total	**12,066**	**$11,364**	**$137.1**	**$100.4**	**$112.8**	**$112.8**

Source: Carnegie Mellon (2016), Econsult Solutions (2016)

[22] Appendix B.1 details the data sources and assumptions utilized in this calculation.

[23] Includes undergraduate and graduate students of Carnegie Mellon's Pittsburgh campus only.

CMU STUDENTS ENJOY THE CRAIG STREET CRAWL BLOCK PARTY

Source: Carnegie Mellon

5.4 A CAMPUS THAT DRAWS VISITORS FROM AROUND THE WORLD

Throughout the academic year, Carnegie Mellon attracts thousands of visitors from all over the world to its Pittsburgh campus for a wide variety of events. These visitors include alumni, families, conference attendees, business leaders, foreign dignitaries, and distinguished guests that spend money on hotels, restaurants, retail establishments, and transportation within the city. This spending represents a gain to the Pittsburgh economy each year which helps support employment and generate tax revenues for the City and Commonwealth.

To accurately estimate aggregate visitor spending, it is necessary to develop spending profiles of the various types of visitors. Recognizing that not all visitors have the same economic footprint, spending profiles were constructed based on where the visitor originated from. These spending patterns approximate the average spending by local, out-of-town day trip visitors, and out-of-town overnight visitors. Given the large proportion of international students at Carnegie Mellon, it is likely that the overnight spending estimates employed within this analysis are conservative, since International travelers tend to stay longer and spend more than their domestic counterparts. The most prominent visitor-types to CMU for which annual visitation and spending profiles were estimated are:

- Prospective Undergraduate Students who visit CMU's Pittsburgh campus and the city with their family;
- First Year Student Move-in represents family and friends that assist CMU's incoming class move-in to on and off campus locations and help them get acquainted with Pittsburgh;
- Alumni Events including annual gatherings such as alumni weekend, spring carnival and family weekend;
- Conferences lectures and seminars sponsored by CMU's various schools and colleges;
- Special Events hosted by CMU which include business leaders, politicians, and academic guests; and
- Commencement at which friends, family members and loved ones gather to celebrate each graduating class.

5.5 ANCILLARY SPENDING BY VISITORS

Ancillary spending by visitors associated with Carnegie Mellon is estimated by combining estimates of attendance for the visitor types described in Section 5.3 with an appropriate spending profile by visitor type (reflecting, for example, that out of town visitors tend to spend more than local or regional visitors).[24] Attendance data were estimated using conservative assumptions in conjunction with data provided by CMU's alumni relations, student services, and facilities offices. These visitor estimates were calculated to include only outside attendance (non-CMU affiliated) at various events and attractions, since student spending is separately accounted for (Section 5.2).

These visitation estimates were then used to translate per visitor spending profiles into an aggregate annual ancillary visitor spending estimate. Projected spending within each category was detailed by industry, and conservative estimates were then made for the proportion of this ancillary spending taking place in the city, region and Commonwealth. As with the calculation of student spending, estimates reflect only ancillary spending not captured within CMU's operating budget.

In total, visitors associated with Carnegie Mellon are estimated to generate approximately $9 million in annual ancillary spending within the City of Pittsburgh, and approximately $10 million within the Pittsburgh region and Commonwealth of Pennsylvania (see Table 5.2).

[24]Appendix B.2 provides additional detail on these guests and their spending profiles, and reviews data sources and calculations for each individual visitation category.

TABLE 5.2 – ESTIMATED AGGREGATE ANNUAL ANCILLARY VISITOR SPENDING BY CMU VISITORS WITHIN THE CITY OF PITTSBURGH, PITTSBURGH REGION, AND COMMONWEALTH OF PENNSYLVANIA

Type of Visitor	Est. Visitors	Est. Annual Spending in Pittsburgh ($M)	Est. Annual Spending in Pittsburgh Region($M)	Est. Annual Spending in Pennsylvania ($M)
Prospective Students	39,600	$3.8	$4.2	$4.2
Move-in	3,900	$0.5	$0.6	$0.6
Alumni Events	6,000	$0.8	$0.8	$0.8
Conferences	10,000	$0.6	$0.7	$0.7
Special Events	1,900	$0.1	$0.1	$0.1
Commencement	10,500	$1.4	$1.6	$1.6
Total	**71,900**	**$7.2**	**$8.0**	**$8.0**

Source: Carnegie Mellon (2016), Pittsburgh Downtown Partnership (2016), US General Services Administration (2010), Econsult Solutions (2016)

CMU STUDENTS AND FAMILIES CELEBRATE THE GRADUATING CLASS AT COMMENCEMENT

Source: Carnegie Mellon

5.6 ECONOMIC IMPACT FROM ANCILLARY STUDENT AND VISITOR SPENDING

Local and regional spending by Carnegie Mellon students and visitors on categories like lodging, food & beverage, retail, and transportation adds up to an additional $95 million in spending within the city and an additional $106 million in spending within the region and state that will go on to support additional spending and jobs throughout the city, regional, and state economies.[25] This demand strengthens the local real estate market, stimulates the hospitality industry, and supports for local retailers who often operate in low-margin industries where foot traffic is crucial to sustaining their presence.

The direct, indirect and induced impact from student and visitor spending generates significant economic activity on an annual basis:

- $112 million in total output, supporting 1,030 jobs and $21 million in earnings within the City of Pittsburgh;
- $161 million in total output, supporting 1,400 jobs and $36 million in earnings within the Pittsburgh region; and
- $164 million in total output, supporting 1,450 jobs and $37 million in earnings within the Commonwealth of Pennsylvania (see Table 5.3).

TABLE 5.3 – ANNUAL ECONOMIC IMPACT OF ANCILLARY STUDENT AND VISITOR SPENDING WITHIN THE CITY OF PITTSBURGH, PITTSBURGH REGION, AND COMMONWEALTH OF PENNSYLVANIA

	City of Pittsburgh	Pittsburgh Region	Commonwealth of Pennsylvania
Direct Output ($M)	$95	$106	$106
Indirect and Induced Output ($M)	$17	$55	$58
Total Output ($M)	**$112**	**$161**	**$164**
Employment	**1,030**	**1,400**	**1,450**
Employee Compensation ($M)	**$21**	**$36**	**$37**

Source: Carnegie Mellon (2016), Pittsburgh Downtown Partnership (2016), US General Services Administration (2010), IMPLAN (2013),Econsult Solutions (2016)

[25] Note that a portion of the direct spending estimated in this category is excluded from the economic impact from ancillary spending because it is not likely to circulate through the local economy. Most notably, with respect to retail sales, many local stores originally buy goods from wholesalers and manufacturers outside of the region. In those instances, our model conservatively attributes only the "retail margin" (the difference between purchase price for the retailer and the sales price to the customer) as contributing to local economic activity.

5.7 REVENUE GENERATION FOR LOCAL AND STATE GOVERNMENT FROM ANCILLARY STUDENT AND VISITOR SPENDING

Spending by Carnegie Mellon students and visitors represents an influx of dollars to the region that would otherwise not occur. The economic activity generated by this spending grows various tax bases at the city and state level, increasing tax revenues for these jurisdictions. In aggregate, ancillary student and visitor spending activity generates an estimated $400,000 in City of Pittsburgh tax revenues and additional $3 million in Commonwealth of Pennsylvania tax revenues on an annual basis (see Table 5.4).

TABLE 5.4 – ANNUAL TAX REVENUE GENERATION FROM ANCILLARY SPENDING BY CMU STUDENTS AND VISITORS WITHIN THE CITY OF PITTSBURGH, PITTSBURGH REGION, AND COMMONWEALTH OF PENNSYLVANIA

Tax Type	City of Pittsburgh	Commonwealth of Pennsylvania
Personal Income Taxes ($M)	$0.18	$1.05
Sales and Use Taxes ($M)[26]	$0.10	$1.55
Business Taxes ($M)	$0.12	$0.38
Total ($M)	**$0.40**	**$2.98**

Source: Carnegie Mellon (2016), IMPLAN (2013), City of Pittsburgh (2014), Allegheny County (2014), Commonwealth of Pennsylvania (2014), Pittsburgh Downtown Partnership (2016), US General Services Administration (2010), Econsult Solutions (2016)

It is also important to note that because campus proximity matters to students, landlords who rent out properties near CMU's campus find that these properties are more valuable as they face higher demand from students. This in turn grows the value of these properties, and thereby generates additional tax revenues for the City, County and School District. Hence while CMU may not directly pay property tax due to its tax-exempt status, it is directly responsible for increasing the value and the associated tax revenue stream of nearby properties.

5.8 IMPORTANCE OF IMPACT FROM STUDENT AND VISITOR SPENDING

Cities and regions are rightly focusing more and more attention to new resident attraction and tourist attraction efforts. In both cases the gain to the regional economy is the injection of new spending power from outside the region which support local jobs and increase local, regional, and state tax bases. World-class universities are similarly important regional economic development assets, because they draw in students, visiting faculty, event participants, and other visitors (and their spending) from all over the world.

[26] Local Sales and Use Taxes generated within the City Pittsburgh included in this figure are collected by Allegheny County

CMU's student profile and its global reputation certainly mark it as an institution whose ancillary spending is significant, as is verified through the calculations in this section. Importantly, many of the key spending sectors represented by students and visitors contain low-margin businesses for whom the difference between survival and obsolescence is very narrow, so the infusion of spending power from CMU students and visitors can be particularly impactful in these categories and in locations near campus.

CMU STUDENTS CELEBRATE INDIAN HOLIDAY "HOLI"

Source: Carnegie Mellon

6.0 IMPACT FROM WAGE PREMIUM AND TALENT ATTRACTION

6.1 SECTION OVERVIEW

The previous three sections have accounted for expenditures made by directly Carnegie Mellon (Sections 3 and 4) or by students and visitors drawn into the local economy by CMU (Section 5). However, it is important to not lose sight of CMU's core mission, which is to educate students. This primary function, in addition to helping foster a more enlightened society, has meaningful and immediate gains for Carnegie Mellon graduates and for the regional economies they participate in after graduation by increasing the productivity and earning power of the local workforce.

The notion of a "wage premium" is commonplace to institutions of higher education, and it is well-established that higher levels of educational attainment (i.e. degree completion) are associated with higher average earnings. In addition to degree level, average wages for graduates based on a host of endogenous and exogenous factors including the prestige and quality of school attended, availability of educational resources, field of study, etc. This link is often conceptualized and calculated from the perspective of the student, who can compare the costs associated with various educational (or non-educational) options with the expected return.

This analysis extends this framework to local economy, recognizing that when CMU educates students who are retained within the city, region and Commonwealth, those graduates increase the educational attainment and earnings potential of the local workforce. The economic impact attributable to Carnegie Mellon is defined and calculated as the additional household spending taking place in these geographies as a result of higher earnings due to the wage premium associated with CMU. Appendix D provides a more detailed description and discussion of the underlying methodology and calculations reviewed in this section.

6.2 WHAT CARNEGIE MELLON MEANS FOR LOCAL AGGREGATE EARNING POTENTIAL

The presence of Carnegie Mellon has a significant impact on the composition, educational attainment and skill level of the local workforce. Post-graduation location decisions are impacted by educational experience, with a clear correlation between locations during and after schooling.[27] From a regional workforce standpoint, Carnegie Mellon alumni living and working within the city, region and Commonwealth are either imported to those geographies (in the case of students originating from around the nation and the world) or retained within those geographies

[27] See, for example: Groen, J. A. (2004). "The Effect of College Location on Migration of College-Educated Labor." *Journal of Econometrics*, *121*(1), 125-142.

(in the case of the students originating within those geographies who are retained due to the presence of CMU.[28] Alumni data provided by CMU shows that more than 20,000 alumni currently live within the Commonwealth of Pennsylvania. Notably, this data indicates that a greater proportion of alumni are located within these local geographies than the proportion of the entering student body originating from those areas.

The presence of these skilled graduates in the workforce has two quantifiable effects on earnings within the city, region and state:

1) CMU graduates increase the educational attainment level of the local workforce, which can be translated into increased earnings based on the established relationship between educational attainment and wages.

2) CMU graduates gain a specific wage premium associated with the knowledge and credentials they impart, above and beyond earning power associated with a particular degree level. Both the selectivity of the university (as manifested in the quality of the educational experience) and its areas of focus (which weigh heavily towards the STEM fields) yield a wage premium for its graduates over a typical degree.

Thus, from a regional economic standpoint, benefits accrue in the form of increased household spending by CMU alumni due both to the increased earnings of those alumni from degree attainment, and due to the enhanced selectivity premium associated with attraction and retention of highly talented students.

CMU INTEGRATED INNOVATION INSTITUTE STUDENTS

Source: Carnegie Mellon

[28] As noted in Section 5.2 and shown in Figure 5.1, none of the top 20 institutions chosen by students who were admitted by CMU but went elsewhere are in the Pittsburgh region, and only one is the Commonwealth of Pennsylvania.

6.3 IMPACT OF CARNEGIE MELLON ON EDUCATIONAL ATTAINMENT IN THE LOCAL WORKFORCE

The retention of Carnegie Mellon graduates within the city, region and Commonwealth increased the educational attainment of the workforce within each of these geographies, which in turn increases earnings potential. To estimate these impacts, it is necessary to understand the geographic distribution of CMU alumni, and educational attainment level and associated earnings by education within these geographies.

Geographic Distribution of CMU Alumni

Data provided by Carnegie Mellon yields the residential location of the approximately 94,000 active members of the alumni database including about 9,400 in Pittsburgh and 20,000 in Pennsylvania. Based on national averages, it is assumed that 72% of CMU graduates are currently employed (as opposed to retired, unemployed, or otherwise out of the workforce).[29] Applying this proportion evenly across geographies, it is estimated that approximately 68,000 CMU alumni are currently employed, of which 6,800 live in the City of Pittsburgh, 4,600 in the Pittsburgh region excluding Pittsburgh, and 3,100 in the remainder of Pennsylvania (see Table 6.1).[30]

TABLE 6.1 – GEOGRAPHIC DISTRIBUTION OF CMU ALUMNI ESTIMATED TO BE WITHIN THE WORKFORCE

	Est. Total Employed Alumni	City of Pittsburgh	Pittsburgh Region (non-city)	Commonwealth of Pennsylvania (non-Pitt region)
Est. Undergrad Working Alumni (000s)	34,900	3,500	2,300	1,600
Est. Graduate Working Alumni (000s)	33,300	3,300	2,200	1,500
Est. Total Working Alumni (000s)	**68,200**	**6,800**	**4,600**	**3,100**

Source: Carnegie Mellon (2016), Bureau of Labor Statistics (2016), Econsult Solutions (2016)

[29] This assumption is based on the employment to population ratio reported by the BLS for adults 25 or older with an advanced degree. This estimate is likely conservative in the case of Carnegie Mellon, both due to the highly qualified nature of CMU graduates and the fields in which they receive degrees, and to the fact that enrollment has increased significantly in recent years, meaning that CMU alumni are disproportionately of working age rather than retiree age relative to the national population of college graduates.

[30] To enhance the accuracy of the calculation in terms of its differentiation of different geographic levels, workers within the subsumed geographies are netted out of each successive calculation (i.e. Pittsburgh region reflects the remaining portion of the region outside of the city, and the Commonwealth reflects the remainder of the state outside of the Pittsburgh region). Full values for the Commonwealth will therefore be the sum of all three columns (city, region exclusive of city, and state exclusive of region).

Educational Attainment in the Local Workforce

The loss of these CMU degree recipients would have notable impacts on the educational attainment levels of the city, region and Commonwealth workforce. Absent CMU alumni, local employers would have access to fewer bachelor's and advanced degree holders. While any individual position currently held by a CMU graduate may be replaced by a graduate from another institution with the same degree level, the reduction in overall supply of skilled and credentialed workers is modeled to result in a "filtering down" of educational attainment, where jobs currently held by advanced degree holders are filled by bachelor's degree holders and jobs currently held by bachelor's degree holders are filled by associate's degree holders.[31] This process results in an overall reduction of the educational attainment level of the city, regional and state workforce (see Table 6.2).

TABLE 6.2 – ESTIMATED FILTERING OF REGIONAL EDUCATIONAL ATTAINMENT ABSENT CARNEGIE MELLON

Education Level	City of Pittsburgh	Pittsburgh Region (non-city)	Commonwealth of Pennsylvania (non-Pitt region)
Total Civilian Employed	112,500	819,100	3,946,800
Some College / Associates Degree	30,100	243,900	1,052,300
Bachelor's Degree (only)	28,400	196,100	836,200
Advanced Degree	26,600	118,200	532,800
Est. CMU Bachelor's Alumni	3,500	2,300	1,600
Est. CMU Advanced Alumni	3,300	2,200	1,500
Modeled Net Change by Degree Type absent CMU			
Associates Degree	3,500	2,300	1,600
Bachelor's Degree	(200)	(100)	(100)
Advanced Degree	(3,300)	(2,200)	(1,500)

Source: Carnegie Mellon (2016), American Community Survey (2010-2014), Econsult Solutions (2016)

Average Earnings by Educational Attainment

This reduction in educational attainment is significant not only due to its impact on the productivity of the workforce, but on its earnings potential. Median earnings vary significantly by education level, both nationally and within the local geographies of interest. Nationally, median earnings increase by approximately $16,000 for those that have completed a bachelor's degree (relative to an associate's degree or some college) and an additional $16,000 for those that have completed an advanced degree (relative to a bachelor's degree) (see Table 6.3).

[31] See Appendix D.3, D.4 and D.5 for a more complete discussion of this modeling approach.

TABLE 6.3 – MEDIAN ANNUAL EARNINGS BY EDUCATIONAL ATTAINMENT (ADULTS 25+)

Education Level	National	City of Pittsburgh	Pittsburgh Region (non-city)	Commonwealth of Pennsylvania (non-Pitt region)
Some College / Associates Degree	$34,000	$29,700	$34,400	$35,300
Bachelor's Degree (only)	$50,500	$40,800	$50,600	$50,100
Advanced Degree	$66,900	$52,300	$65,800	$67,600
Premium – Bachelor's vs. Associate's	$16,500	$11,100	$16,200	$14,800
Premium – Advanced vs. Bachelor's	$16,400	$11,500	$15,200	$17,500

Source: American Community Survey Five Year Estimates (2010-2014)

THE TECHNICAL OPPORTUNITIES CONFERENCE BRINGS MORE THAN 200 COMPANIES TO CAMPUS

Source: Carnegie Mellon

6.4 ENHANCED EARNING POTENTIAL FOR CARNEGIE MELLON GRADUATES

In addition to variation in earnings observed by degree level, earnings will vary within degree levels for graduates of different universities. This variance is due to a number of factors, including the selectivity of a university, the quality of the education experience, the fields of study in which it specializes, etc. From the perspective of the regional economy, it is not necessary to separate these causal factors, but it is important to recognize that the presence of a highly selective university like Carnegie Mellon brings additional earnings potential to the regional workforce above and beyond its effects on educational attainment levels.

Longitudinal data from the federal Department of Education confirms that Carnegie Mellon graduates earn a considerable premium above median earnings by education level. The latest "College Scorecard" released publicly by the Department of Education reports earnings by institution based unique tracking of tax filings ten years after entering school for students who applied for student loans. This comprehensive data source indicates that the median salary ten years after entering Carnegie Mellon is currently $76,200.[32] Comparing this figure to the median national earnings for bachelor's or advanced degree holders of $56,700 yields an estimate "wage premium" to CMU alumni of 34.4% relative to the average institution.[33]

No similar data source has been identified to calculate the incremental earnings potential associated with advanced degrees from specific institutions (with returns likely to vary significantly by program and selectivity). However, national data from the American Community Survey on median earnings for advanced degree holders in various fields indicates clear variation by area of study, with significantly higher earnings for degree holders in the STEM and business fields. Comparing the premiums by field to the distribution of degrees granted by CMU suggests a premium of 22.8% above and beyond a typical advanced degree (excluding any additional premium that may be associated with the selectivity and quality of CMU programs in these fields).[34]

To isolate the wage effects to the city, region and Commonwealth, these CMU-specific premiums are applied to the average earnings by degree level for residents of these geographies. This approach yields an estimated premium of $14,000 - $17,400 for CMU bachelor's degree holders $12,000 - $15,400 for CMU advanced degree holders relative to the average degree holder within these geographies (see Table 6.4).

[32] Note that this figure is likely conservative as to the average salary for a CMU alumnus for a number of reasons. First, it is calculated ten years after entering school and thus only a few years into the workforce for many graduates. These graduates are likely to see their wages increase over time as they stay in the workforce. Second, it includes only students who seek federal financial aid for school (since this forms one of the characteristics necessary for data collection). In doing so, it omits students from higher income families, a characteristic which may be correlated with higher earnings. Finally, it includes earnings of all attendees of the University ten years after entering CMU, regardless of whether they in fact graduated. An alternative analysis by the Brookings Institution utilizing data from Payscale.com estimates that the "median alumni mid-career salary" for Carnegie Mellon graduates is $110,700. However, this data source suffers from potential sources of bias as well, and the more conservative (and widely available) federal data source is preferred for comparison to average earnings as reported by the Census Bureau. Appendix D.6 includes a fuller discussion of these issues.

[33] Note that the figure of $56,700 represents a blended average of bachelor's and advanced degree holders, since CMU graduates in the College Scorecard data set may also hold additional advanced degrees.

[34] As shown in Table D.6 in Appendix D, 70% of CMU advanced degrees granted in FY 2015 were in the STEM or business fields.

TABLE 6.4- ESTIMATED ANNUAL WAGE PREMIUM FOR UNDERGRADUATE AND GRADUATE DEGREES CONFERRED BY CMU

	City of Pittsburgh	Pittsburgh Region (non-city)	Commonwealth of Pennsylvania (non-Pitt region)
Bachelor's Degree – Average Earnings	$40,800	$50,600	$50,100
CMU Bachelor's Degree Wage Premium (%)	34.4%	34.4%	34.4%
Est. CMU Bachelor's Degree Earnings	$54,800	$68,000	$67,400
CMU Bachelor's Degree Wage Premium ($)	**$14,000**	**$17,400**	**$17,300**
Advanced Degree – Average Earnings	$52,300	$65,800	$67,600
CMU Advanced Degree Wage Premium (%)	22.8%	22.8%	22.8%
Est. CMU Advanced Degree Earnings	$64,300	$80,700	$83,000
CMU Advanced Degree Wage Premium ($)	**$12,000**	**$14,900**	**$15,400**

Source: Carnegie Mellon University (2016), American Community Survey (2011, 2015), US Department of Education (2016), Econsult Solutions (2016)

6.5 AGGREGATE INCREASE IN EARNING POTENTIAL WITHIN THE CITY, REGION AND COMMONWEALTH

The aggregate increase in the earning potential within the city, region and Commonwealth can be estimated as a function of both the increases in educational attainment of the workforce (as calculated in Section 6.3) and the additional earnings potential for degree holders from Carnegie Mellon (as calculated in Section 6.4). The combined wage premiums attributable to both increased educational attainment within the workforce and CMU-specific premiums range from $25,100 - $33,600 for bachelor's degree holders and from $23,500 - $32,900 for advanced degree holders. Applying these premiums to the CMU degree holders estimated to be working within the respective geographies yields a wage premium of $165 million within City of Pittsburgh, $312 million within the Pittsburgh region, and $412 million within the Commonwealth of Pennsylvania (see Table 6.5).

TABLE 6.5 – AGGREGATE EARNINGS INCREASE ATTRIBUTABLE TO CARNEGIE MELLON FROM WAGE PREMIUM AND TALENT ATTRACTION

Premium	City of Pittsburgh	Pittsburgh Region (non-city)	Commonwealth of Pennsylvania (non-Pitt region)
CMU Employed Alumni – Bachelor's	3,500	2,300	1,600
Bachelor's – Educational Attainment Premium	$11,100	$16,200	$14,800
Bachelor's – CMU-Specific Premium	$14,000	$17,400	$17,200
Bachelor's Degree Premium	**$25,100**	**$33,600**	**$32,100**
CMU Employed Alumni – Advanced	3,300	2,200	1,500
Advanced – Educational Attainment Premium	$11,500	$15,200	$17,500
Advanced – CMU-Specific Premium	$11,900	$15,000	$15,400
Advanced Degree Premium	**$23,500**	**$30,100**	**$32,900**
Aggregate Earnings Increase	**$165.5 M**	**$146.2 M**	**$99.9 M**
City Total	**$165.5 M**		
Region Total (including City)		**$311.8 M**	
Commonwealth Total (including Region)			**$411.6 M**

Econsult Solutions (2016)

6.6 ECONOMIC IMPACT FROM WAGE PREMIUM AND TALENT ATTRACTION

This additional household income within the city, region and state in turn enriches these economies through increased spending, for the support of local merchants, local jobs, and the local tax base. Accounting for savings rates, tax withholdings, and spending outside of the city, the region and Commonwealth, total output captured within these geographies will be less than the direct increase in earnings from the wage premium, but are nonetheless significant. Direct, indirect and induced impact from the annual wage premium and talent retention gain generate significant economic impacts on an annual basis:

- $48 million in total output, supporting 340 jobs and $10 million in earnings within the City of Pittsburgh;
- $287 million in total output, supporting 2,110 jobs and $86 million in earnings within the Pittsburgh region; and
- $374 million in total output, supporting 2,680 jobs and $109 million in earnings within the Commonwealth of Pennsylvania (see Table 6.6).

TABLE 6.6 – ANNUAL ECONOMIC IMPACTS FROM THE WAGE PREMIUM ASSOCIATED WITH CMU ALUMNI WITHIN THE CITY OF PITTSBURGH, THE PITTSBURGH REGION, AND COMMONWEALTH OF PENNSYLVANIA[35]

	City of Pittsburgh	Pittsburgh region	Commonwealth of Pennsylvania
Direct Wage Premium ($M)	$166	$312	$412
Total Output ($M)	**$48**	**$287**	**$374**
Total Employment	**340**	**2,110**	**2,680**
Total Earnings ($M)	**$10**	**$86**	**$109**

Source: Carnegie Mellon (2016), Bureau of Labor Statistics (2015), IMPLAN (2013), The Economist (2015), Econsult Solutions (2016)

6.7 REVENUE GENERATION FOR LOCAL AND STATE GOVERNMENT FROM WAGE PREMIUM AND TALENT ATTRACTION

The economic activity associated with the wage premium attributable to CMU also generates additional tax revenue within the city and state. The increased earnings enjoyed by alumni result in direct gains in personal income tax, and the additional household spending that it engenders results in direct and indirect increases in income, sales and business taxes. These impacts generate additional revenue to support needed services at the local and state level without increasing the tax burden on other residents. Combined, the City of Pittsburgh gains about $1.5 million each year in tax revenues from the wage premium and talent attraction associated with Carnegie Mellon graduates, while the Commonwealth of Pennsylvania gains an additional $20 million (see Table 6.7).

TABLE 6.7 – ANNUAL TAX REVENUE GENERATION FROM THE WAGE PREMIUM ASSOCIATED WITH CARNEGIE MELLON WITHIN THE CITY OF PITTSBURGH AND COMMONWEALTH OF PENNSYLVANIA (IN $ MILLIONS)

Tax Type	City of Pittsburgh	Commonwealth of Pennsylvania
Personal Income Taxes ($M)	$1.45	$15.49
Sales and Use Taxes ($M)[36]	$0.04	$3.32
Business Taxes ($M)	$0.05	$0.81
Total ($M)	**$1.54**	**$19.62**

Source: Carnegie Mellon (2016), IPEDS (2015), Bureau of Labor Statistics (2015), The Economist (2015), IMPLAN (2013), City of Pittsburgh (2014), Allegheny County (2014), Commonwealth of Pennsylvania (2014), Econsult Solutions (2016)

[35]Accounting for savings rates, tax withholdings, and spending outside of the respective geographies, the annual economic impacts of the wage premium and talent attraction gains will be less than the total value of wage premium to alumni workers within those geographies. This is part of the spillover effect associated with labor income being spent within a particular geography (as opposed to the indirect impact, which accounts for the spillover effect of vendors being supplied by an entity's spending on various goods and services).

[36] Local Sales and Use Taxes generated within the City Pittsburgh included in this figure are collected by Allegheny County

6.8 IMPORTANCE OF IMPACT FROM DIRECT ANNUAL WAGE PREMIUM

The wage premium generated by Carnegie Mellon graduates is a testament of the value of the University's educational offerings and the credentials it confers. Coupled with CMU's connections to prominent employers, in the technology field specifically, Carnegie Mellon serves an important role in expanding the local and state knowledge base with Pennsylvania and non-Pennsylvania residents. As such, prominent technology-focused universities like Carnegie Mellon have helped Pennsylvania retain many of its most talented students, and import talented students from elsewhere.

The access to such a concentration of top-tier talent in one place also attracts businesses to the region, and fosters an environment friendly to startup companies. This further encourages investment in the region and state that otherwise might not have occurred absent Carnegie Mellon's presence. Said another way, CMU's role in educating and credentialing students creates a critical mass of human capital whose presence draws in additional academic, research, business, and entrepreneurship activity, and whose absence would likely result in the deployment of human and financial capital to other, non-Pittsburgh and non-Pennsylvania locations.

INTRODUCTION TO IMPLICATIONS OF IMPACT ANALYSIS (SECTIONS 7-9)

Sections 7-9 explore the implications of Carnegie Mellon's economic footprint and activity (as calculated in Sections 3-6) globally, regionally, and locally. That is, it is useful to understand how big CMU's impact is and where it derives from, but it is also useful to express why that impact matters. Impacts described within these sections generally originate from programs and efforts originating within CMU's operating budget, and therefore from a quantitative standpoint are illustrative of and not to be added to the impacts previously calculated. The sections proceed as follows:

- *The Reach and Impact of CMU's Innovation Diaspora* (Section 7) describes CMU's contribution to advancing the body of knowledge on important technological and societal challenges and therefore its global impact;

- *CMU's Essential Contribution to Regional Economic Transformation* (Section 8) describes CMU's historic and current role in drawing activity that could take place anywhere across the globe into the area and taking a central role in economic development efforts at the regional level;

- *Impact from Local Engagement* (Section 9) describes CMU's commitment to, engagement with and service to its host community, and engaging with needs specific to the Pittsburgh community, and therefore its impact at a very local level.

PRESIDENT OBAMA INSPECTS SENSABOT AT CMU'S NATIONAL ROBOTICS ENGINEERING CENTER (NREC)

Source: Superior Tire & Rubber Corp

President Barack Obama signs *Sensabot*, a battery powered remote-sensing machine developed by Carnegie Mellon University's National Robotics Engineering Center (NREC). President Obama visited the center in June 2011 where he also launched the Advanced Manufacturing Partnership, a national effort to create high-quality manufacturing jobs in emerging technologies, and the National Robotics Initiative, which provides funding for research and has accelerated the development and use of robots that work beside or cooperatively with people. *Sensabot* was the first resident mobile robot certified to work in difficult and hostile environments and was first deployed in September 2016 by Shell Global. In addition, NREC has helped to spawn a rejuvenation of the Lawrenceville neighborhood, with at least 14 robotics companies located within a mile radius of the Center, and new residential and commercial activity growing in support of this cluster.

7.0 THE REACH AND IMPACT OF CMU'S INNOVATION DIASPORA

7.1 SECTION OVERVIEW

The purpose of this section is to view Carnegie Mellon's impact in global terms. CMU is truly a global institution, drawing both human and financial capital from all over, and in turn its graduates, scientific discoveries, and commercial ventures have worldwide presence and influence. CMU is prolific at translating its academic and research infrastructure into intellectual property outcomes and strong commercialization partnerships, to the benefit of the world at large. In the process, this borderless approach has helped Pittsburgh, a city once synonymous with the nation's past industrial might, become a breeding ground for transformative technologies and a byword for innovation. This generates important impacts for the regional economy.

7.2 THE IMPORTANCE OF INNOVATION IN THE KNOWLEDGE ECONOMY

Much has been written about the decades-long transition to a global "knowledge economy" in which there is an ever greater reliance on knowledge activity rather than the physical inputs or natural resources which were the backbone of the industrial and agricultural economies of the past. These capabilities are hence the drivers of economic growth and increasing prosperity for individuals, regions, and nations.

A key component of the knowledge economy is a block of studies known as the STEM fields: science, technology, engineering, and mathematics. Workers in these positions command higher pay, experience less unemployment, and are projected to have more opportunities in the coming decades. [37] Recognition of this economic shift and of its strong connection to economic competitiveness led the Obama administration to launch a national STEM education initiative, which since its inception in 2009 has garnered over $700 million in public-private partnerships to broaden and deepen this country's capacity for producing effective STEM graduates and teachers.[38]

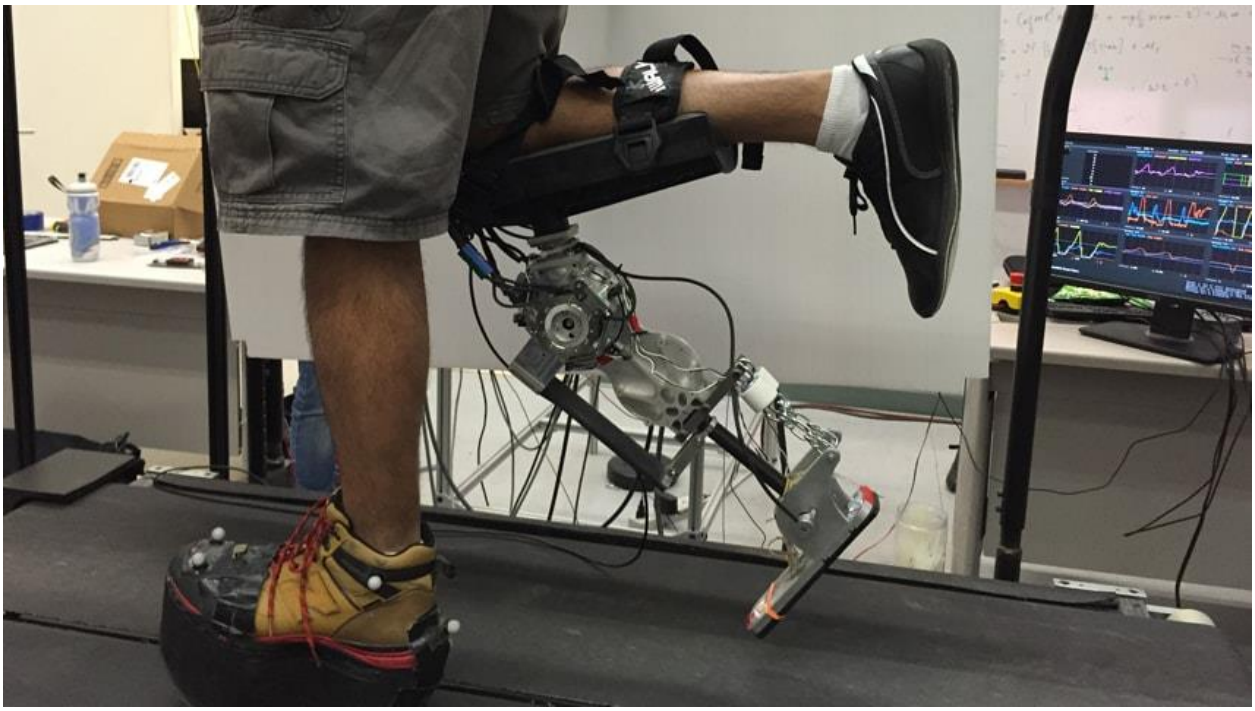
Universities are at the forefront of this shift to a knowledge economy, as they are the principal actors producing STEM graduates and performing the research breakthroughs which expand our country's aggregate knowledge stock. A confluence of contemporary trends has particularly advantaged universities with strong connections to the engineering and entrepreneurial sector. As a top-tier global research university with more than 100 research centers and institutes, Carnegie

[37] "STEM: Good Jobs Now and for the Future", *US Department of Commerce, July 2014* <http://www.esa.doc.gov/sites/default/files/stemfinalyjuly14_1.pdf>

[38] More information on President Obama's Educate to Innovate initiative and other initiatives promoting education in the STEM field can be found at <https://www.whitehouse.gov/issues/education/k-12/educate-innovate>

Mellon addresses real-world problems in innovative ways. Demonstrating its culture of innovation, CMU founded the world's first university robotics department, and has the #1 Computer Science, the #1 Information and Technology Management, and the #5 Engineering graduate programs in the nation.[39] Additionally, Carnegie Mellon is a crucial member of several corporate and institutional partnerships promoting innovative research in the Pittsburgh area. With its strong research curriculum and research programs, CMU works from its Pittsburgh home to better the world at large.

PROSTHETIC LEG BALANCE RECOVERY TECHNOLOGY



Source: Carnegie Mellon

7.3 RESEARCH FUNDING ATTRACTED BY CMU

Research dollars attracted by Carnegie Mellon not only generate important discoveries that advance the body of knowledge, but on a practical level bring significant economic activity to the Pittsburgh region that otherwise would likely be deployed elsewhere. CMU attracts more than $380 million annually in research funding, nearly all of which comes to the main campus and Pittsburgh region. This represents approximately 40% of CMU's local operating footprint, and astoundingly high proportion that speaks to its status as a premier research institution.

[39] Graduate Program Rankings from *US News and World Report*: Computer Science (2014), Information and Technology Management (2012), Engineering (2016)

From an economic standpoint, this activity is beneficial in large part due to its source. The vast majority of research funding (88% in fiscal year 2016) comes from federal source, including 100% of funding for the Software Engineering Institute (see Table 7.1). This share is significantly higher than the national average of 62%.[40] Federal research projects are highly competitive, and can easily be awarded anywhere in the country, meaning that absent CMU, these investments would likely take place outside of the region and the Commonwealth.

TABLE 7.1 – CMU RESEARCH SPONSORED REVENUE BY SOURCE, FISCAL YEAR 2016 ($M)

Research Sponsor Type	Funding ($M)	Proportion (%)
Federal	**$337**	**88%**
Software Engineering Institute	$146	38%
CMU	$191	50%
Non-Federal	$48	12%
Total	**$385**	

Source: Carnegie Mellon (2016)

Notably, 91% of CMU research expenditures are undertaken by its four STEM schools/institutes: the Carnegie Institute of Technology, the Mellon College of Science, the School of Computer Science, and the Software Engineering Institute (see Table 7.2). Given that the STEM field is so innovation-driven, these research costs serve to attract high-end STEM companies to the area which add a further value to diffusing research breakthroughs. Additionally, STEM jobs and the research that drives them have a very high multiplier effect as these positions are associated with a large amount of additional indirect economic activity (as discussed in more detail in Section 8).

Worthy of special mention is the single largest recipient of sponsored research costs at CMU, the Software Engineering Institute (SEI), one of only ten Federally Funded Research and Development Centers (FFRDC) sponsored by the Department of Defense. Founded in 1984 at Carnegie Mellon University, SEI researches complex software and cybersecurity problems, creates innovative technologies, and transitions these solutions to more widespread use.[41]

[40] "Women Are Almost Half of Carnegie Mellon's Incoming Computer Science Undergraduates", *Carnegie Mellon University School of Computer Science*, Sept 2016 <http://www.cs.cmu.edu/news/women-are-almost-half-carnegie-mellon-incoming-computer-science-undergraduates>

[41] In one high-profile case, a team from SEI assisted the U.S. Secret Service in collecting and analyzing evidence in one of the largest credit card fraud cases in history, involving more than 130 million credit and debit card numbers. Ultimately, their work led to the conviction of hacker Albert Gonzalez and his associates in 2010 see: <https://www.mitre.org/sites/default/files/publications/ffrdc-primer-april-2015.pdf>

TABLE 7.2 – FISCAL YEAR 2016 CMU SPONSORED RESEARCH EXPENDITURES BY SCHOOL/ENTITY (IN $M)

Entity	Expenditures ($M)	Proportion (%)
STEM Total	**$357**	**91%**
Software Engineering Institute	$151	39%
School of Computer Science	$95	24%
Carnegie Institute of Technology	$74	19%
Mellon College of Science	$37	9%
Non-STEM	$29	7%
Other	$6	2%
Total	**$392**	

Source: Carnegie Mellon (2016)

In short, CMU's leadership in the STEM fields, and its close ties to other research, corporate and entrepreneurship activities located in the Pittsburgh region draws human and financial capital into the region from all over the world.

CMU'S AERIAL ROBOT INFRASTRUCTURE ANALYSIS (ARIA) PROJECT

Source: Carnegie Mellon

7.4 BRINGING TECHNOLOGY TO THE MARKETPLACE

Of course, the benefits from Carnegie Mellon's research extend far beyond the realms of the University, the region, and its sponsors. CMU is specifically committed as an institution to the dissemination and commercialization of intellectual property, to ensure that technological breakthroughs are transferred into applications that fuel economic activity and address social challenges.

To that end, CMU founded the Center for Technology Transfer and Enterprise Creation (CTTEC) to facilitate the movement of research and technology out of the university and into the marketplace. While CMU receives dozens of patents and millions of dollars in licensing income annually from the research it sponsors, research at CMU directly benefits student inventors and the community at large. Over the past five years, CMU has directly or indirectly helped to foster 148 start-up companies, or 30 per year (see Table 7.3).

Carnegie Mellon offers a variety of services to promote entrepreneurship particularly within its Swartz Center for Entrepreneurship. The center runs several programs for entrepreneurs, a few noteworthy ones include: Project Olympus which provides start-up advice, micro-grants, and incubator space to cutting-edge, early-stage research; the Open Field Entrepreneurs Fund which provides $50,000 matching convertible notes to recent graduate entrepreneurs, and the Donald H. Jones Center for Entrepreneurship fosters students' abilities to innovate via an interdisciplinary academic approach coupled with experiential learning, leading Bloomberg to rank the Tepper School of Business at CMU as sixth in the nation for entrepreneurship.

TABLE 7.3 – CMU INTELLECTUAL PROPERTY AND TECH TRANSFER OUTCOMES, FISCAL YEAR 2012 - 2016

Metric	AVG	2016	2015	2014	2013	2012
Income from Licensing ($M)	**10.9**	16.0	6.3	6.8	5.3	19.9
Invention Disclosures	**280**	257	473	256	241	172
Inventors Served	**452**	458	513	438	432	417
Patents Filed	**216**	251	253	235	208	133
Patents Issued	**41**	54	52	46	35	20
Licenses, Options & Agreements	**174**	198	180	181	165	147
New Startups - Total	**30**	14	27	41	36	30
New Startups – Direct[42]	**10**	8	11	11	12	10
New Startups – Indirect	**19**	6	16	30	24	20

Source: CTTEC (2016)

[42] "Direct" startups represent those utilizing licensed technology through the CTTEC in a given fiscal year, while "Indirect" startups are those companies formed and assisted by CMU services such as the Swartz Center in a given fiscal year.

CMU intellectual property and tech transfer infrastructure has contributed to the commercialization of several technology-driven firms in recent years. These firms have attracted an infusion of venture capital and acquisition dollars, the vast majority of which accrues from outside of the region.

Using a combination of publicly available sources and internal knowledge of confidential transactions, CTTEC has tracked an influx in venture capital raised by firms that were direct or indirect CMU start-ups over the past few years. In total:

- CTTEC has identified $1.05 billion in venture capital funding raised by 42 firms since FY 2011; and
- $783 million (74%) of that funding is associated with 31 firms located in Pennsylvania

The breadth and scale of capital raised are a clear signifier of the intellectual quality and commercial potential of technologies being developed and commoditized at CMU, and translate into a significant importation of dollars from areas like Silicon Valley and New York City into the Pittsburgh region. They also serve as a residential attraction tool for the talented young knowledge workers that regions are competing for.

Some prominent recent products of CMU's tech transfer and commercialization infrastructure include:

Carnegie Mellon professor Luis von Ahn founded Duolingo, a free language learning software with more than 120 million users around the world learning 19 distinct language,[43] which placed its new headquarters in the East Liberty Neighborhood of Pittsburgh.[44] Additionally, von Ahn founded reCAPTCHA, Inc, the anti-spam software digitizing printed books which was a spin-off from his research project in Carnegie Mellon's CyLab, [45]

"CMU is an amazing hub of activity and smart people in computer science… we're proud to be a Pittsburgh-based company and to stick to our roots"
– Luis von Ahn

[43] For a more extensive list of Duolingo language courses and courses under development, see <https://www.duolingo.com/courses/all>

[44] "Duolingo moving to East Liberty, plans to add employees," *Pittsburgh Business Times*, Mar 2016 <http://www.bizjournals.com/pittsburgh/news/2016/03/23/duolingo-moving-to-east-liberty-plans-to-add.html>

[45] "Google Buys Service That Uses Humans to Digitize Books", *The New York Times,* Sept 2009 <http://bits.blogs.nytimes.com/2009/09/16/google-buys-service-that-uses-humans-to-digitize-books/?_r=0>

"(My) training as a PhD candidate in organizational behavior at Carnegie Mellon University enabled (me) with the ability to build and lead an impactful enterprise."
– Abilife Founder Courtney Williamson

Abililife was first conceived in 2013 and benefited from the Swartz Center for Entrepreneurship's resources which enabled the company to develop the only back brace specifically for Parkinson's patients.[46] The brace has garnered enough notoriety that several foundations have sponsored its production including the National Science Foundation and the Davis Phinney Foundation for Parkinson's, which lead Medicare and private insurance to now cover the brace.

CMU research professor John Bares formed Carnegie Robotics, LLC in 2010 within CMU's National Robotics Engineering Center (NREC), growing it to become a premier research and development organization in advanced field robotics. Since that time the company has expanded and has taken on multi-million dollar contracts from the U.S. Army and successfully completed a recent Critical Design Review with the U.S. Navy.[47]

"We believe NREC (CMU's National Robotics Engineering Center), Carnegie Robotics and western Pennsylvania are uniquely positioned to capitalize on… many mobile robot applications."
– John Bares

These are numeric and anecdotal examples of CMU's proficiency in translating incoming human and financial capital into meaningful intellectual property outcomes. These outcomes support large swaths of commercial activity and in some cases create entirely new product lines and unprecedented discoveries, whose beneficial implications reach the rest of the world, enhancing Carnegie Mellon's (and Pittsburgh's) reputation as an innovation hub.

7.5 ALUMNI ENTREUPRENEURSHIP IMPACTS

Of course, one of the fundamental reasons that universities exist is to provide benefits to their students long after graduation. In the case of a highly innovative university focused on research and technology like Carnegie Mellon University, the best way to note these positive externalities is to recognize the various ways in which CMU alumni have later contributed to the greater good via new companies and inventions. For example, CMU alumni have developed such important technologies as the Java computer programming language, Kevlar bulletproof vests, and the

[46] For more information on AbiliLife's mission, product information, and company history, see <http://www.abililife.com/about-us/>

[47] "Carnegie Robotics LLC Partners with Carnegie Mellon to Manufacture Robotic Components and Systems" *Carnegie Mellon University*, Aug 2010 <https://www.cmu.edu/news/archive/2010/August/aug30_roboticsstartupcompany.shtml>

Juicy Couture fashion line. Carnegie Mellon recently participated in an alumni survey that included information on involvement in start-up companies.[48] Impressive findings include:

- 21 percent of surveyed alumni have started their own company, creating more than 50,000 new jobs;
    - More than one-third of the oldest CMU cohort surveyed have started their own company;
- 15 percent of all alumni are currently employed by a start-up company;
- Recent CMU graduates are more likely to be currently employed at a start-up company than are graduates from Ivy League institutions or from the Top-25 non-Ivy League universities.

Clearly, CMU has helped inculcate in its students a spirit of innovation and entrepreneurship, drawing them from all over the world and then sending them forth back into the world to be agents of business formation, job creation and scientific discovery. The impact of CMU's diaspora in the worlds of innovation and entrepreneurship is not just its quality but also its quantity.

7.6 PHILANTHROPY AT WORK

On an annual basis, Carnegie Mellon University now receives more than $145 million in private philanthropic contributions which help fund current operations, strengthen the endowment, and improve facilities. These funds represent important transfers from households, corporations, and philanthropic organizations around the world to the Pittsburgh region. CMU directly spends these funds on both short-term operating expenditures, which generate increases in employment and local tax bases, as well as on long-term efforts to improve student accessibility to a Carnegie Mellon education via financial aid.

Carnegie Mellon's alumni network is spread throughout the country and around the world, but it retains a strong tie to the Pittsburgh region. Alumni are more likely to stay in or later return to Pittsburgh and Pennsylvania due to on-campus events, their familiarity with the region, connections formed while studying or working here, or because they have children who are now more likely to attend CMU. Their connections to the area will bring economic benefits over the long-term. Additionally, when these alumni experience success in their own fields and make a positive difference in their own communities, many also make contributions back to CMU to support its continued educational and research missions.

[48] Consortium on Financing Higher Education Alumni Survey, Spring 2013

CMU has been the recipient of several generous gifts in recognition of its outstanding work and enormous student potential. In 2011, philanthropist, former steel executive, and Pittsburgh-native William S. Dietrich II made the largest gift in CMU history with a $265 million donation to the university.[49] This was also the eight largest gift to higher education in the United States at the time. Notably, Mr. Dietrich never studied at CMU, but his experience serving on the university's board of trustees showed him that CMU is unlike any other university in its ability to connect technology and the arts. While Mr. Dietrich has supported many other universities, his gift to CMU was by far the largest.[50]

"Serving as a trustee of Carnegie Mellon convinced me that Carnegie Mellon is not only a great university, but that it is an important driver of the future success of this region and its citizens."
– William S. Dietrich II

CMU has renamed its College of Humanities and Social Sciences the "Marianna Brown Dietrich College of Humanities and Social Sciences" in honor of Mr. Dietrich's mother.

"CMU has a long history of providing the world with innovative thinkers, and the establishment of a true hub for entrepreneurship will help create the next generation of global leaders."
– David Tepper

Hedge fund manager and alumnus David Tepper has personally benefitted from CMU's strong academic programs as he received his master's degree in business from CMU. Mr. Tepper has given more than $125 million to CMU since 2003. His giving includes a $55 million gift to CMU in 2004, for which the university renamed its Graduate School of Industrial Administration to the Tepper School of Business, and a $67 million gift in 2013 to create the David A. Tepper Quadrangle and a new home for the Tepper School of Business.[51] A Pittsburgh native, Tepper's family and company are now based out of Miami Beach, Florida, meaning that these donations represent a significant inflow of dollars from outside of the Pittsburgh region.

"For us it was important to have a very strong university partnership . . . Carnegie Mellon is known for the best of education, the best of research."
– Natarajan Chandrasekaran, CEO of Tata Consultancy Services

In recent years, corporations have also given ever increasing amounts to CMU as they too recognize and appreciate that CMU is home to world-changing innovation. Evidencing CMU's global reach, the largest corporate gift to CMU came in 2015 from an Indian enterprise, Tata Consultancy Services (TCS). TCS' $35 million gift, the largest CMU has ever received from abroad, will construct a multi-story facility to promote education and cutting-edge research.[52]

[49] Schackner, B. "CMU gets $265 million gift from William S. Dietrich II". *Pittsburgh Post-Gazette*. September 7, 2011.

[50] Hill, R. "University of Pittsburgh to Receive Historic Gift From Alumnus, Trustee, and Former Board Chair William S. Dietrich II". *University of Pittsburgh News Services*. September 22, 2011.

[51] Lattman, P. "David Tepper Giving Carnegie Mellon a $67 Million Gift." *The New York Times*. November 14, 2013.

[52] Schackner, B. "Carnegie Mellon gets $35M donation". *Pittsburgh Post-Gazette*. August 26, 2015.

7.7 A GLOBAL DRAW TO AND A GLOBAL IMPACT FROM THE PITTSBURGH REGION

In the modern knowledge economy, intellectual capital is paramount. A region's viability and competitiveness depends on the quality of its research institutions, and the strength of those research institutions depends on their ability to attract the world's best talent. Carnegie Mellon not only cultivates this intellectual capital and helps to send it out into the world, but it is committed to ensuring accessibility to its academic and intellectual resources. CMU's student body is a diverse community on a number of dimensions. Students at Carnegie Mellon come across the country and from more than 60 nations across the globe, with 43 percent of CMU's student body hailing from outside of the United States.

All International undergraduate students at CMU pay full tuition, which in turn helps make possible educational opportunities for domestic students with financial needs. A wide variety of scholarship opportunities are available to admitted and enrolled students based on financial need and merit. In addition to loans and work study opportunities, Carnegie Mellon provides the option of need- and non-need-based scholarships and grants. Altogether, 99 percent of Carnegie Mellon's full time undergraduate students who have financial need receive some form of financial assistance. In addition to federally funded grants like the Federal Pell Grant, the Federal Supplemental Educational Opportunity Grant (SEOG), and state grants, which are recognized by Pennsylvania and several surrounding states, Carnegie Mellon offers unique grant sources, which comprise 88 percent of CMU's total scholarships and grants. Carnegie Mellon's grants are based on academic, art, leadership, minority status, music/drama, and state/district residency. Scholarships and grants awarded to students in 2015 totaled $85 million, and self-help financial aid awarded in 2015 totaled $16 million.

The composition of CMU's student body also reflects its commitment to overcome the historic underrepresentation of women in the STEM fields. 48 percent of incoming first-year undergraduate students in CMU's School of Computer Science and 43 percent of entering engineering students are women, significantly exceeding the nationally averages for those fields. Diversity of all dimensions enriches the learning experience for all students on campus, and allows CMU to access the most talented students and potential researchers regardless of traditional barriers.

In sum, CMU's commitment to technological innovation and its close ties to other related research, corporate, and entrepreneurship activities located in the Pittsburgh region, draws both human and financial capital into the region from all over the world. In turn, it sends forth graduates, innovations, and start-up companies throughout the globe, whose ties back to CMU provide the Pittsburgh region with both economic and reputational benefits.

8.0 CARNEGIE MELLON'S ESSENTIAL CONTRIBUTION TO REGIONAL ECONOMIC TRANSFORMATION

8.1 SECTION OVERVIEW

In a competitive economy, regional economies are in flux rather than static, growing and ebbing on the relative strength of the key industries, infrastructure, and talent of the region. The Pittsburgh region emerged in the late 19th and early 20th century as an economic powerhouse thanks largely to its mighty steel industry, which fueled a building boom in America's cities and equipped an army for two world wars. In the latter half of the twentieth century, the steel industry found itself transformed by foreign competition, and Pittsburgh (like the other manufacturing giants of the rust belt) saw its population and employment base fall. Fortunately, unlike many of the other cities to which a similar story applies, Pittsburgh actively re-oriented itself to undertake the painful shift away from a manufacturing-dominant economy. This effort has paid dividends, as the city and region have recently seen population and job losses stabilize, and has re-emerged as an exciting and appealing place to live and work.

Carnegie Mellon has been an essential ingredient in Pittsburgh's largely successful transformation from industrial giant to knowledge leader. CMU's contribution is apparent in its intellectual capital, which has been essential to cultivating technological and entrepreneurial talent and to attracting companies, research dollars, and private investment into the region. It is also apparent in CMU's historic recognition of its civic role in leading key economic development initiatives within the city and region. Each of these traditions is apparent in CMU's role in Pittsburgh's recent development as a center of tech activity. High profile companies like Google, Facebook, and Uber have set up shop on or near campus to capitalize on the talent and innovation activity emerging from Carnegie Mellon, and CMU has worked closely with the City of Pittsburgh to attract more companies and undertake partnerships in technological innovation that further cement Pittsburgh's status as a growing technology hub.

8.2 THE IMPORTANCE OF EXPORT AND INNOVATION TO REGIONAL ECONOMIC GROWTH

Export industries are an essential contributor to regional economic growth. While the internal circulation of dollars has definite economic benefits, economies truly through the ability to sell outside of their borders, drawing in dollars that are used to support the local employment and tax base. In our nation's history, first agriculture and then manufacturing represented the predominant export industry, and in both cases regional economies succeeded to the extent that they were able to produce and then sell to others. Pittsburgh was of course at the forefront of the manufacturing economy, as the center of the nation's large and vital steel industry.

In today's knowledge economy, universities are exporting intangible but no less valuable commodities, such as educational services and research prowess. Hence, as with agriculture and manufacturing before it, research universities are among a region's most prominent exporters, bringing in resources from the outside to support local employment and tax bases. This is definitely true at CMU, which draws students and research funding from across the country and around the world. These tuition and grant checks ultimately support operating and capital expenditures and employment within Pittsburgh and Pennsylvania.

More broadly, the importance of innovation and entrepreneurship activity to regional economic competitiveness is hard to overstate. Talent and financial capital are fundamentally mobile, and accordingly, regions rise and fall based on their ability to identify, grow, and retain entrepreneurial activity. In this environment, research universities, especially those with a commitment not only to research and discovery but also to development and incubation, play a particularly vital role in birthing, cultivating, and coordinating entrepreneurial activity. World-class research institutions are a fertile source of both scientific breakthroughs and entrepreneurial leaders, and business incubation facilities and programming provide the support framework for those ideas and people to succeed. They are particularly valuable when they embrace their role as civic and institutional leaders and as key components of regional economic development, as CMU has done throughout its history.

8.3 CARNEGIE MELLON'S HISTORICAL CONTRIBUTION TO PITTSBURGH'S POST-INDUSTRIAL TRANSFORMATION

Post-war Pittsburgh was an industrial powerhouse, with a dominant steel industry, large corporate and banking headquarters, and a population of nearly 700,000. While the pre-war surge in population and economic activity brought challenges in areas like pollution and infrastructure, it also brought prosperity and family-sustaining jobs to the region. For Pittsburgh, like the other industrial powers of the rust belt, the second half of the 20th century would bring a radical transformation, with foreign competition and structural problems rapidly felling the local steel, aluminum, and glass industries by the early 1980s.

While population and employment decline were inevitable, Pittsburgh was more proactive than many of its peers in developing a strategy to re-orient its regional economy towards the growth sectors of the knowledge economy. This strategy has borne fruit in recent years with the stabilization of Pittsburgh's population and job base and development of its technology, education and health sectors. While the transition has been painful, and recent gains are not shared equally across the region, Pittsburgh has come to be regarded internationally as a success story in achieving a post-industrial transformation that positions the city to grow and thrive moving forward.[53]

[53] For more context and insight on Pittsburgh's post-industrial transformation, and its status as an international model, see *Remaking Industrial Cities: Lessons from North America and Europe* (2016), Edited by Donald K. Carter, including *Chapter 6: Pittsburgh Case Study*.

Carnegie Mellon has been integral to this effort, both through its status as a core regional economic development asset, and through its consistent and active participation in key civic revitalization efforts. As a cultivator of talent and intellectual property, CMU has been foundational to the emergence of the technology sector in the Pittsburgh region, from the founding of the Software Engineering Institute in the 1980s to the recent openings of Google, Facebook, and Uber offices near campus. This innovation activity cannot replace the manufacturing sector in size and scope, but does generate export activity with considerable spin-off effects, and also is crucial to the region's ability to attract and retain young talent.

Further, CMU has embraced its role as not only an asset but a civic leader in regional revitalization efforts. CMU's leadership (stretching back to the time when Carnegie Tech and Mellon University were separate institutions) has embraced leadership roles in major economic development efforts over generations, including:

- The Allegheny Conference on Community Development was incorporated in 1944 as a "postwar planning committee" under the leadership of regional planning association president and business titan Richard King Mellon, Mayor David Lawrence, and Carnegie Tech President Robert Doherty.[54] The group focused on the region's serious air pollution challenges, helping to enact comprehensive standards for Allegheny County in 1949, as well as the development of Gateway Center and Point State Park.

- As the statewide manufacturing decline accelerated in the early 1980s, the Thornburgh administration initiated its "advanced technology agenda," with the Ben Franklin Technology Partners as its centerpiece. CMU and the University of Pittsburgh jointly hosted the Southwestern regional office, which connects research and industry to help drive growth in the innovation economy.

- Concurrently, CMU President Richard Cyert was one of the authors of "Strategy 21,"[55] a regional "economic development strategy to begin the 21st century" developed in 1985 that set forth "university advanced technology research" as one of five project areas selected to "take maximum advantage of the comparative strengths of the Pittsburgh/Allegheny Region." This strategy manifested itself in a profound way with the establishment of the Pittsburgh Supercomputing Center, a joint effort of CMU and the University of Pittsburgh supported by federal, state and private funding, and the awarding of the federal Software Engineering Institute (SEI) contract to CMU. The institute continues to be a leader in cutting edge cyber-security technology, and today accounts for approximately one-third of research dollars flowing through CMU.

[54] Conference History", *Allegheny Conference on Community Development,* 2015, <http://www.alleghenyconference.org/ConferenceHistory.php>

[55] "Pittsburgh/Allegheny Economic Development Strategy to Begin the 21st Century" *The City of Pittsburgh, The County of Allegheny Board of Commissioners, The University of Pittsburgh, Carnegie Mellon University,* June 1985 <http://www.briem.com/files/strategy21.pdf>

- CMU President Robert Mehrabian (with the assistance of CMU professor Richard Florida) produced a benchmarking report in the early 1990s detailing the continued challenges in the Pittsburgh economy, and subsequently led a regional planning effort resulting in a 1994 regional economic development strategy, "Working Together to Compete Globally."

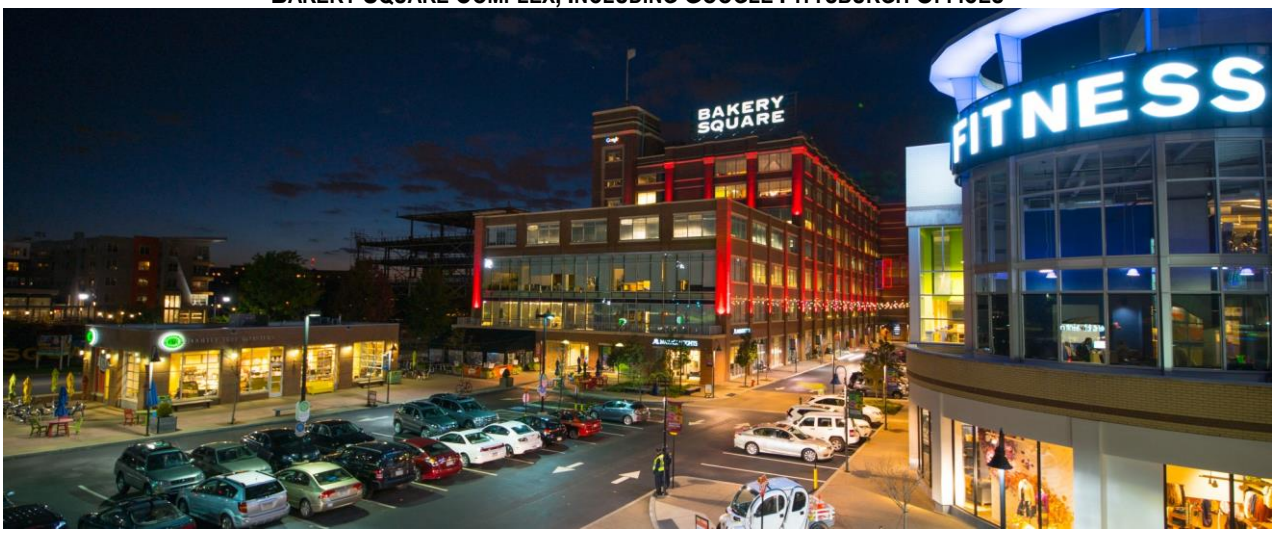
- CMU President Jared Cohon (1997-2013) continued this tradition of active engagement in economic development in southwest Pennsylvania. His tenure included the founding, in partnership with the University of Pittsburgh, University of Pittsburgh Medical Center, and Commonwealth of Pennsylvania, of the Pittsburgh Life Sciences Greenhouse, a collaborative that invests in emerging life sciences entrepreneurs and ventures.

- CMU continues to be engaged with the Allegheny Conference on Community Development and collaborates closely with Pittsburgh Mayor Bill Peduto and Allegheny County Chief Executive Rich Fitzgerald on business attraction and innovative planning and technology efforts (described in more detail below).

8.4 PITTSBURGH'S TRANSFORMATION INTO A KNOWLEDGE CENTER

The success of these efforts is borne out in Pittsburgh's current trajectory relative to the long-term challenges that it has faced. The city's population exodus has halted, with population levels stable at around 300,000 residents from 2010 to 2015, in part due to the city's improved ability to attract and retain young, talented workers. Regionally, employment has grown over the past two decades, as growth in knowledge sectors has offset the decline in manufacturing.

BAKERY SQUARE COMPLEX, INCLUDING GOOGLE PITTSBURGH OFFICES



Source: Walnut Capital

Figure 8.1 shows net job change within the Pittsburgh region between 1990 and 2015. Total employment increased by 122,000 over this time period, or 12%, from 1.04 million in 1990 to 1.16 million in 2015. This growth was primarily driven by two sectors:

- Education and Medicine jobs grew by 79,000, or 50%, from 160,000 in 1990 to nearly 240,000 in 2015. This sector now represents the region's largest concentration of employment, at 21% of all jobs.

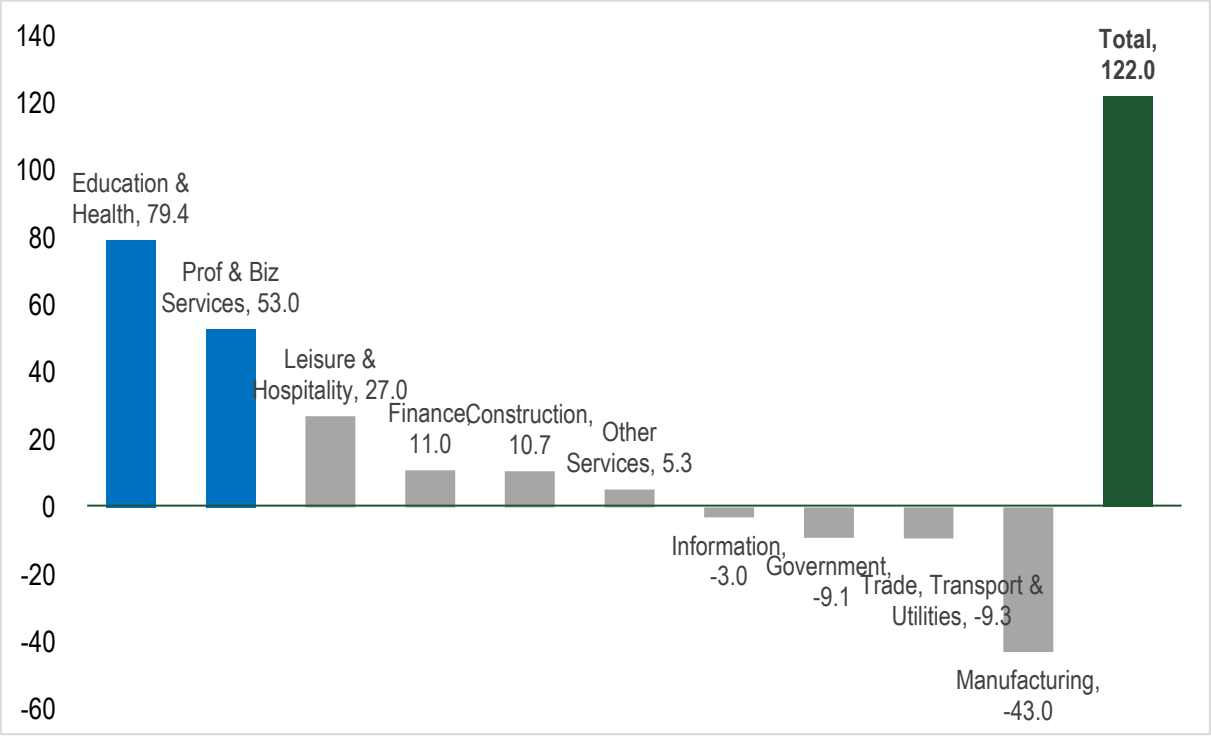
- Professional and Business Services jobs grew by 53,000, or 42%, from 127,000 in 1990 to 180,000 in 2015. This sector, which includes the "Professional, Scientific and Technical Services" sector that includes the bulk of the region's technology-focused companies, now represents 15% of all regional jobs.

Figure 8.2 illustrates the shift over this time period from a reliance on industrial sector jobs (defined as Trade, Transport & Utilities, Manufacturing, and Construction) to knowledge sector jobs (defined as Education & Health, Professional and Business Services, and Information).

- In 1990, the Trade and Manufacturing sectors represented the largest and third largest sectors of the regional economy, respectively, and the three industrial sectors represented 38% of regional employment, compared to 29% for the three knowledge industry sectors.

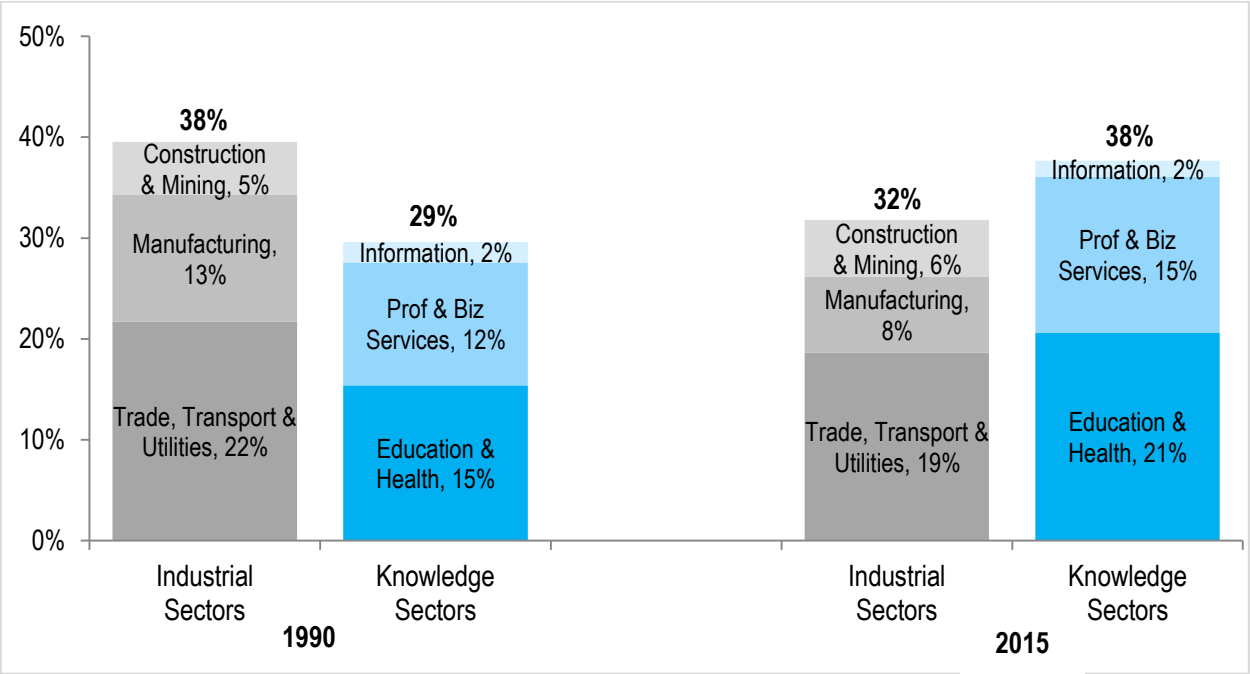
- By 2015, Education & Medicine and Professional and Business Services had jumped to represent the largest and third largest sectors (with Trade, Transport & Utilities second), and collectively the three knowledge sectors represented 38% of regional employment, compared to 32% for the three industrial sectors.

FIGURE 8.1 – NET JOB CHANGE BY SECTOR, PITTSBURGH MSA, 1990-2015 (IN 000S)



Source: Bureau of Labor Statistics (2016)

FIGURE 8.2 – PROPORTION OF PITTSBURGH MSA EMPLOYMENT, 1990-2015



Source: Bureau of Labor Statistics (2016)

The relevance of an industry to regional competitiveness is of course not dictated simply by its size. As discussed in Section 8.2, export industries which attract dollars from outside of the region are crucial to fostering economic growth by importing new dollars that then circulate through the regional economy. While manufacturing goods for sale around the world is a classic example of this phenomenon, educational and technology services are the export analogs of the modern economy. The high-paying jobs generated by this industry not only attract and retain talented workers, but they have a disproportionate spillover effect on the remainder of the economy. A comparative study of metropolitan economies by economist Enrico Moretti found, for example, that "for each new high-tech job in a metropolitan area, five additional local jobs are created outside of high tech in the long run."[56] Moretti goes on to define the diverse set of industries impacted by this activity, concluding that these spin-off including a relatively even mix of professional and service sector jobs.

Further, it is important to understand education and innovation activity within the context of the larger ecosystem of young and creative workers it attracts and supports. Quality of life amenities that appeal to these industries are symbiotic with arts and culture, as young artists attracted to the energy (and reasonable cost of living) in the region can support themselves through part-time service sector occupations.

This virtuous cycle is particularly important to the long-term trajectory of Pittsburgh given the dynamics of the city and regional population. Among a comparison set of 15 comparably sized metro areas, Pittsburgh has the oldest population and the lowest proportion of foreign born residents (less than 4 percent in 2014).[57] There are recent signs that these demographic trends, which bode poorly for the region's future growth prospects, appear to be changing. CMU's global footprint, development and nurturing of young talent, and contributions to the innovation ecosystem are clearly important contributors to these trends.

- A 2012 report by *Pittsburgh Today* found that the region's age 20-34 population increased by 7 percent from 2005-2010 and was anticipated to grow another 8 percent by 2020. This young population was also identified as having one of the highest education rates nationally.[58]

- Census data aggregated by *Pittsburgh Today* indicates that 25 percent of Pittsburgh's foreign-born population in 2014 had arrived in the US in 2010 or later, higher than any competitive regions.[59] Further, Pittsburgh's foreign-born population is small but highly skilled, with a 2011 Brookings Institution analysis of the nation's 100 largest metropolitan

[56] Enrico Moretti, *The New Geography of Jobs* (2013)

[57] This competitive set of metropolitan regions is identified by the *Pittsburgh Today* Key Indicators for Understanding our Region project, available at http://pittsburghtoday.org/

[58] *Pittsburgh Today*, "Young Adults Report" (2012).

[59] It should be noted that proportion is measured against Pittsburgh's low base of foreign born residents, and thus does not imply that immigration to Pittsburgh has exceeded all competitive regions since 2010. It does represent a first step, however, in reversing long-term trends.

areas identifying Pittsburgh as possessing the highest skilled immigrant population in the country, with "high-skilled immigrants outnumbering low-skilled immigrants by nearly 4 to 1."[60]

Without question, significant challenges remain for the Pittsburgh region. The age and lack of diversity of the region's population limit its current growth potential, and gains have not been shared equally across the region, from former steel towns still struggling to re-orient to continued pockets of urban poverty. But it is unfair to diminish the benefit of the high-tech, research and education sectors simply because they collectively do not rise to the sheer magnitude of the economic footprint once represented by the region's manufacturing sector.

It is important to consider the alternative outcomes realized by similarly situated rust belt industrial powerhouses like Detroit, Cleveland, Buffalo, and Cincinnati. Each of those cities has seen a similar drop in population and manufacturing might as Pittsburgh in the last 50 years, as automation increased productivity but lowered the labor intensity of the sector and once dominant American industries faced a sudden influx of competition in a rapidly globalizing economy. While these cities and their regions continue to see declines in population and employment, and face serious structural and governance issues as a consequence, Pittsburgh has successfully re-oriented its economy, attracted young residents, and laid the foundations for further growth. The names of many once mighty cities are now synonyms for obsolescence. Pittsburgh is not one of them; in fact it is now equated with cutting-edge technology and scientific innovation.

Carnegie Mellon, along with its educational peers, has been integral to this success. Pittsburgh's redevelopment strategy recognized explicitly and wisely that world-class research universities serve as building blocks and hubs of activity that are central to developing a regional strategy and a regional identity. While CMU is but one of many actors in Pittsburgh's post-industrial transformation, its presence and engagement were necessary conditions for the strategy that the region has been successfully pursuing. This central role continues today, which is something the U.S. government recognizes as President Obama has visited CMU five times and praised it and other Pittsburgh universities for their continuing efforts to transform the region.[61]

"Pittsburgh has been revitalizing itself through technology for a very long time. The Steel City is now home to groundbreaking medical research and world-class universities. It's the birthplace of some of the most advanced artificial intelligence and robotics systems the world has ever seen. And you (CMU) are investing in your young people with after-school STEM programs and maker fairs, and Girls of Steel robotics teams."
– President Barack Obama

[60] *Brookings Institution*, "The Geography of Immigrant Skills: Educational Profiles of Metropolitan Areas" (2011) (https://www.brookings.edu/wp-content/uploads/2016/06/06_immigrants_singer.pdf)

[61] "Obama, Leading Scientists Explore Frontiers at CMU". *Carnegie Mellon University News*. October 13, 2016.

8.5 CARNEGIE MELLON'S ROLE IN PITTSBURGH'S MODERN KNOWLEDGE ECONOMY

CMU's central role in Pittsburgh's economic re-orientation has crystalized in recent years with the attraction of several high profile technology giants to the city and region. Companies like Google, Facebook/Oculus, Uber, and General Electric have all opened significant research and development centers in the region, and have all cited proximity to CMU and its expertise in robotics and engineering as the driving factor in their location decisions. These organizations and CMU have in turn worked actively with the City of Pittsburgh to encourage an innovative atmosphere in which the city itself has become a laboratory for cutting edge experimentation in new technology with the potential to change the way we live, interact, and travel. This phenomenon, which continues to build, has helped to solidify Pittsburgh as an emerging technology hub. This status has meant not only direct and indirect jobs as a result of the footprint of these leading firms, but the development of an innovation ecosystem with reputational benefits that will continue to pay dividends for business and resident attraction and retention efforts moving forward, and gives the Pittsburgh region the ability to control its economic destiny.

The importance to the region of this confluence of research strength and commercial opportunity cannot be emphasized enough. In today's innovation-driven economy, nothing is static: there is either more activity begetting more activity, or the loss of activity to more vibrant regions producing further dislocation. The venture capital community, leading technology giants, and young knowledge workers all "vote with their feet" and have increasingly made massive investments dollars and effort in advanced-robotics technology with the potential to fundamentally change the way we live, experience the world, and move through it. CMU's reputation and talent in the fields of robotics and engineering in particular have made it an acknowledged magnet for such activity.

While recent high-profile technology partnerships have often been in the robotics and computing arenas, CMU has deep experience helping to drive innovation across a number of fields, notably including advanced manufacturing and energy. Over decades, CMU has developed relationships with major manufacturers like Caterpillar, General Electric, General Motors and most recently Boeing to research innovative manufacturing technologies. More recently, Carnegie Mellon launched the Wilton E. Scott Institute for Energy Innovation, building upon decades of energy research at CMU and the increasing importance of energy issues to the Pennsylvania economy. The Scott Institute brings together corporate and academy energy research, with a particular focus on improving energy efficiency and develop sustainable energy sources, and is directed by CMU President Emeritus Jared Cohon. In total, CMU has more than 350 corporate partners across a range of technology and innovation driven fields.

Companies seeking access to CMU's talent and expertise have pursued a variety of approaches. As described in Section 7, many organizations have embedded directly within CMU, including companies like Intel, Disney, Apple, and General Motors that have set up research facilities within CMU's Robert Mehrabian Collaborative Innovation Center (CIC) (see Table 8.1). Others firms, including Uber, have located off-campus but engaged CMU directly in collaborative research

projects, helping to spawn a robotics cluster of approximately 40 firms and 2,000 employees. Still others, including Google, Amazon, Delphi, Autodesk, and the Facebook-owned virtual reality firm Oculus have fully independent operations in the Pittsburgh area, capitalizing heavily on the talented faculty and students from CMU in staffing their operations.

TABLE 8.1 – SELECT CARNEGIE MELLON CORPORATE/INSTITUTIONAL PARTNERSHIPS

Select Corporate/Institutional Partnerships	Details
Robert Mehrabian Collaborative Innovation Center	A four-story, 136,000 SF dry-lab research facility and partnership providing office and lab space for technology companies to collaborate with CMU
General Motors-Carnegie Mellon Collaborative Research Labs	A joint research lab between GM and CMU to advance next-generation vehicle technologies, including driverless cars
Disney Research Lab	An R&D lab exploring the fields of computer animation, virtual reality, and computational cinematography, among others
Intel Research Pittsburgh	An interdisciplinary lab currently researching robotics, computer systems, cloud computing, and other microprocessing technology
Gates Center and Center for Computational Thinking	CMU's new home for computer science is made possible by a gift from the Bill & Melinda Gates Foundation. Microsoft Research also sponsors the Center for Computational thinking, which advances computing research.
Entertainment Technology Center	A project-based learning center focused bridging the gap between science and technology, with corporate sponsors including Disney, Electronic Arts, Microsoft and Intel
CyLab	A university-wide initiative which runs a partnership program with dozens of corporations at the crossroads of cyber security challenges and privacy concerns
Boeing/Carnegie Mellon Aerospace Data Analytics Lab	An academic research initiative seeking to find ways to use artificial intelligence and big data improve the design, contruction and operation of aircraft
Google	CMU serves as research partner and a living laboratory for Google-funded research to create the "Internet of Things"

Source: Carnegie Mellon (2016)

In each instance, proximity to CMU and its knowledge and talent base has been the clear and explicit driver of the location decision of these leading technology firms. As recently explained by the *New York Times,* "the university's expertise in computer science had attracted not only Uber but also General Motors, Google and Intel, some of which embedded at Carnegie Mellon. Google and Uber later opened research centers, hiring dozens of Carnegie Mellon professors and graduate students." [62] Figure 8.3 below illustrates just a few of the many examples of technology firms explaining the draw of locating research operations within or near Carnegie Mellon.

[62] *The New York Times*, "No Driver? Bring it On. How Pittsburgh Became Uber's Testing Ground. Celia Kang, September 10, 2016. http://www.nytimes.com/2016/09/11/technology/no-driver-bring-it-on-how-pittsburgh-became-ubers-testing-ground.html?_r=0

FIGURE 8.3 – HIGH-PROFILE COMPANIES DRAWN BY PROXIMITY TO CMU[63]

This cluster of high-tech activity attracted by and located near CMU has profound implications for Pittsburgh's positioning in the knowledge economy. Developments in fields like robotics, computer science, and virtual reality proceed rapidly, and the investments made in these fields strongly suggest that we are at the beginning, not the end, of the prominence of these industries. As new technology re-shapes the way we interact with and move about in the world, Pittsburgh is situated as a centerpiece of this activity which promises and continued and growing influx of human and financial capital into the region.

This status has important implications for the direct footprint of economic activity in the Pittsburgh region, as the continued growth in research operations is translated into local jobs, earnings, purchasing, and associated spin-off activity. It also has important implications for the reputational

[63] Quotes from (clockwise from top left):"Facebook-Owned Company Opening Research Office in Pittsburgh", *CBS Pittsburgh*, January 18, 2016
"Google Coming Because Local Talent Likes it Here" *Pittsburgh Post-Gazette*, December 16, 2005.
"Pittsburgh: GE Celebrates Grant Opening of $40 Million Center for Additive Technology Advancement (CATA), *3DPrint.com*, April 7, 2016.

status of the city and region. Interestingly, thanks in large part to the positive working relationships between CMU, its research partners, and the City of Pittsburgh, the city itself has become a laboratory for technology activity and in a very real sense a byword for innovation. A recent *New York Times* article described the city as the "testing ground" for Uber's fleet of driverless vehicles.[64] Similarly, CMU and Google announced in 2015 a project to turn Pittsburgh into a "living lab" for the "internet of things" (a term for products with Internet connectivity built into them) by installing millions of sensors around the city to begin collecting and reporting data.[65] This activity gives the Pittsburgh region a crucial "first mover" advantage in these new and emerging industries.

Pittsburgh's increasing involvement in technology activities that help shape the way people interact with each other and with the built environment will likely contribute to the image that people across the nation and around the world have of the region. For a younger generation and for decades to come, the dominant association of the region will likely not be forged in steel, but instead in sensors and pixels.

UBER ADVANCED TECHNOLOGY CENTER TESTS AN AUTONOMOUS CAR IN PITTSBURGH

Source: NBC News

[64] *The New York Times*, "No Driver? Bring it On. How Pittsburgh Became Uber's Testing Ground. Celia Kang, September 10, 2016. http://www.nytimes.com/2016/09/11/technology/no-driver-bring-it-on-how-pittsburgh-became-ubers-testing-ground.html?_r=0

[65] *GovTech*, "Pittsburgh to be Carnegie Mellon University's Guinea Pig in "Smart City" Experiment," Deborah Todd, July 9, 2015. http://www.govtech.com/fs/Pittsburgh-to-be-Carnegie-Mellon-Universitys-Guinea-Pig-in-Smart-City-Experiment.html

9.0 IMPACT FROM LOCAL ENGAGEMENT

9.1 SECTION OVERVIEW

Sections 3-6 articulated the many categorical ways Carnegie Mellon is a significant contributor to the local and state economy. Through its operations and capital investments, ancillary spending by students and visitors, and the increased earning potential of its graduates, CMU represents an economic engine generating significant economic activity, direct and indirect employment, and local and state tax revenues.

Sections 7 and 8 have served to explore the ways in which these impacts manifest themselves for the good of the world as a whole as well as to the gain of the region and state. But it is important to remember that all of the good work CMU does takes place in a place. And place matters, to universities seeking to draw students and staff and to private sector entities looking for talent-rich and amenity-rich locations to thrive. Universities are often referred to as "anchor institutions," and that commitment to a particular place can (although it does not always) engender a sense of shared destiny with and commitment to a community. The purpose of this section is to explore how CMU engages with, benefits from, and in turn benefits its immediate neighborhood.

9.2 CIVIC ENGAGEMENT

Universities depend on localities for important public services, and increasingly recruit students and faculty based not only on on-campus features but on the attractiveness of their host communities. In turn, localities benefit from the presence of universities, which represent job opportunities for local residents, purchasing power to support local merchants, and physical and programmatic resources for the community at large. This can yield a symbiotic relationship between university and municipality, for the benefit of both entities. The town/gown relationships in many cities are, unfortunately, transactional and even adversarial, with localities complaining of the cost burden that universities impose upon them and universities in turn declining opportunities to engage in and assist with issues of local concern.

By contrast, Carnegie Mellon has been integral to the region's transformation and development, both through its status as a core regional economic development asset and through its consistent and active participation in civic revitalization efforts as noted in Section 8. It has historically recognized its civic role in leading major economic development efforts in the generations since the postwar era, and continues to find ways to leverage its unique strengths into win/win partnerships for the city and the university. The sense of presence in and responsibility to a particular place extends down to its interface with its immediate surrounding community.

Heinz College and its school of Public Policy and Management are one key manifestation of CMU's commitment to engaging in public sector challenges. Heinz faculty and students are often

called on by city and regional leaders to serve as a think tank to help address public policy challenges. The Center for Economic Development (CED) at Heinz College, for example, has conducted applied research on economic, community and workforce development projects that have helped to enable significant impact for the Pittsburgh community. In addition, Heinz College reports that approximately 30% of its Public Policy and Management graduates end up staying in Pennsylvania after graduation, often passing up private sector opportunities to serve in government, non-profit and public service positions.

Heinz College has also been the locus of specific public-serving initiatives. In addition to economic development, Heinz College has historical been deeply engaged in regional transportation issues. In the 1970s, Heinz College faculty and alumni secured and utilized a grant from the Urban Mass Transportation Administration to design a paratransit service for Allegheny County in southwestern Pennsylvania, including the city of Pittsburgh. The program was adopted by the Port Authority and launched in 1979 as ACCESS. This door-to-door advance reservation, shared ride-transportation is still running today, and in 2015 yielded 1.9 million rides within Allegheny County. ACCESS serves primarily senior citizens and persons with disabilities, and has been a recognized and replicated model for the delivery of paratransit services in other cities. More recently, Heinz launched the Traffic21 initiative (now the Traffic 21 Institute), a multi-disciplinary research effort to design, test and implement communications technology-based solutions to address transportation issues. The city and region serve as a "learning lab" for cutting-edge (and replicable) approaches to transportation management. Concurrently, Carnegie Mellon has developed the Metro21 initiative, which supports the research, development and deployment of CMU projects that seek to solve problems in a broader variety of metro-related focus areas, channeling university resources to improve quality of life in the Pittsburgh region.

As a world-class innovation center, Carnegie Mellon has also been able to leverage its deep technological capabilities for public benefit. One such example is Speck, a personal Wi-Fi connected air pollution monitor. This device was developed at the CMU's Robotics Institute and is now marketed by Airviz Inc., a direct CMU spinoff company. Airviz Inc. ran a pilot program with the Squirrel Hill Library in Pittsburgh in which the library members could reserve one of six monitors for a three week timespan. The program proved popular, so Airviz expanded it first to nineteen area libraries, but eventually to more than 100 libraries nationwide.[66] The benefits from using Speck were so apparent that the Heinz Endowments and the Pittsburgh Foundation have since purchased 1,000 Specks that they made available to the public through libraries, schools, and citizen groups in the Pittsburgh region.[67]

It is also worth noting that as a large-scale institution, Carnegie Mellon's operating capacity allows it to provide for itself many services that are usually rendered by municipal government. In areas such as public safety, snow removal, storm water management, landscaping and sanitation,

[66] Templeton, D. "CMU Speck pollution monitors now available at Carnegie libraries". *Pittsburgh Post-Gazette.* March 21, 2016.

[67] Spice, B. "Carnegie Mellon Spinoff Introduces Speck, a Personal, Wi-Fi-Connected Air Quality Monitor". *Carnegie Mellon University News*. March 16, 2015.

Carnegie Mellon renders its own services, supplementing those provided by the city, thereby reducing its burden on city government. For example, Carnegie Mellon University Police provides Patrol Services 24 hours a day, seven days a week, 365 days a year in a primary patrol zone which includes all campus property, Off Campus Housing & Sites, and residential areas immediately in the vicinity of the CMU Main Campus. Thus, in terms of direct government service provision, CMU directly pays for many of its own service needs and even goes beyond that to provide essential quality-of-life services to its surrounding community immediately off campus.

9.3 EDUCATIONAL OPPORTUNITIES

Another way that CMU leverages its intellectual capital to benefit the community beyond its own student body is through the educational opportunities that it offers for local high school students. Many of these opportunities are STEM-focused, and serve as a portal for students to develop their skills and interests and explore a STEM career path even in advance of their higher education experience, whether they ultimately enroll at CMU or elsewhere. This activity benefits local students, by equipping them with the skills needed for the jobs of tomorrow, and in turn the local economy, which will benefit from the availability and depth of these skills locally.

These opportunities emanate from a variety of schools and initiatives within CMU. Notable examples include:

- The Pittsburgh Science and Technology Academy (*Sci-Tech)*, is a local high public high school for students interested in STEM which focuses on life sciences, computer science, environmental science, and engineering. It originated as a student system project led by a Heinz College student, Sam Franklin, who went on to design and launch the school for Pittsburgh Public Schools in 2009.
    - The school graduated its first class of 56 students in 2013 and now serves over 550 students, 47% of whom are African American. The school has a waiting list due to its popularity, standardized tests scores above the city and state average, and nearly all of its graduates continue their education at a post-secondary institution.[68]
    - Sci-Tech is one of five Pittsburgh schools participation in the Microsoft-initiated Technology Education and Literacy in Schools (TEALS) initiative which seeks to increase access to computer science and engineering skills at the high school level. This effort and Sci-Tech's curriculum are geared towards equipping Pittsburgh's students with the type of skills that are increasingly in demand in the economy of the future.

[68] See: Morrow, C. "Pittsburgh Science & Technology Academy…More than 90 Percent College Bound." *Pittsburgh Courier*, June 3, 2014, and Horn, B. and Gideon, G, "First Class Graduating Tonight at Pittsburgh Science and Technology Academy 6-12." *Pittsburgh Post-Gazette*, June 8, 2013.

- The *Girls of Steel* robotics team (founded in 2010) is comprised of more than 60 middle school and high school girls from nearby schools who design robots for the prestigious FIRST Robotics Competitions. The team has won numerous awards and participated in the FIRST World Championship several times; most importantly though, it has empowered many girls to pursue a career in the STEM fields. The program was commended by President Obama in his recent visit to campus for the White House Frontiers Conference.[69]

- CMU's College of Engineering sponsors and designs numerous programs for local elementary, middle, and high school students, including:

    - Science days such as the annual *Moving 4th into Engineering* day of science activities for 4th grade students.
    - Workshops including *SPARK* Saturdays, which introduces high schoolers to electrical and computer engineering concepts and their career fields.
    - A *Green Design Apprenticeship Program* that exposes high school students to the field of engineering and its connections to environmental and social issues.

- The College of Engineering also runs various programs that specifically promote women's entrance into STEM fields where they have been historically underrepresented.

    - The *Strong Women, Strong Girls* program pairs CMU undergraduate women with elementary school girls to promote positive self-esteem and life success skills.
    - The *Summer Engineering Experience for Girls* is a two week program during the summer for 8th and 9th grade girls where they get to learn about the different fields of engineering.
    - The *Society of Women Engineers High School Day and Middle School Day* is an annual event for 250 girls to visit CMU's campus and participate in engineering activities.

- CMU's School of Computer Science (SCS) also offers a variety of educational opportunities.

    - *Leap@CMU* is a summer enrichment program for local high school students to interact with leading computer scientists and explore the future of computer science.
    - Undergraduate and graduate members of SCS bring the *Outreach Roadshow* presentation to local schools where they introduce students to computational thinking.
    - SCS sponsors the *Linguistics Olympiad*, a contest for high-school students to solve linguistic puzzles.

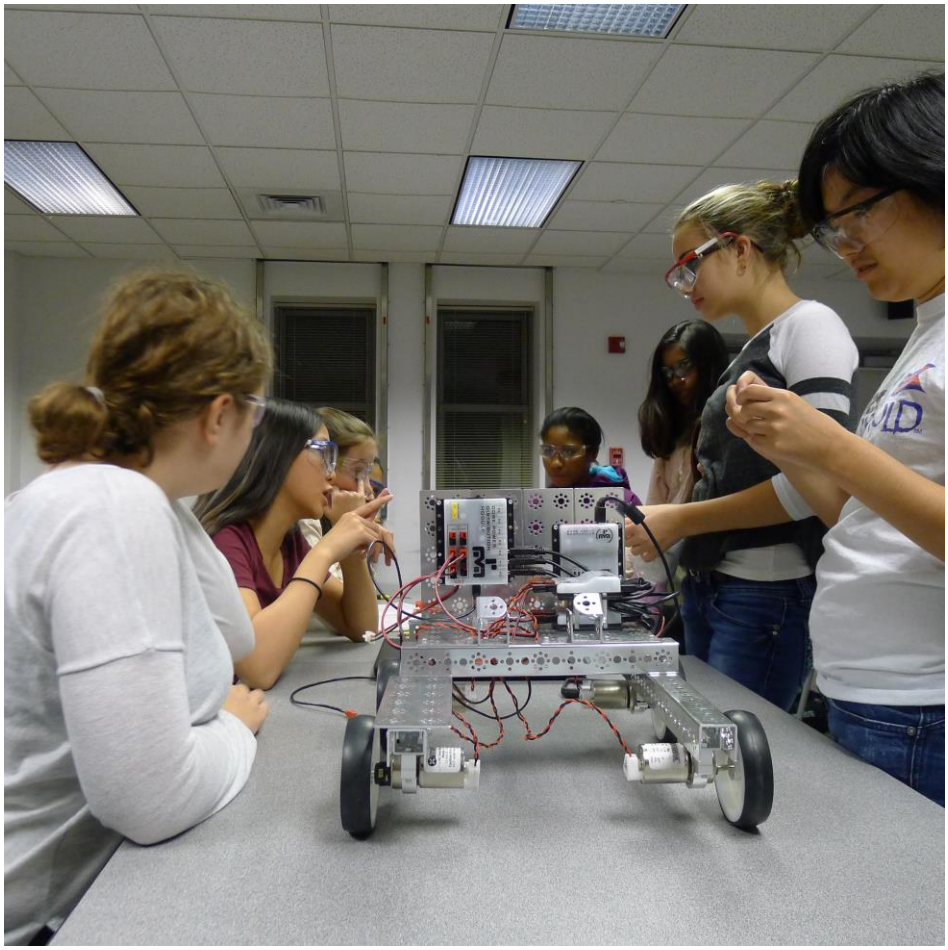
[69] Rao, K. "President Barack Obama headlines Frontiers Conference at Carnegie Mellon". *The Tartan*. October 16, 2016.

- The School of Architecture runs the *UDream* program which diversifies the field of urban design by offering a five-week program of academic courses and studio work and a 12-week internship for minority architects.

- The Mellon College of Science runs *TutorNet*, a volunteer organization that combines classroom and online tutoring for Pittsburgh students in various science classes.

Notably, Carnegie Mellon has also developed partnerships outside of the Pittsburgh area to extend its footprint in secondary-level STEM education. With support from a National Science Foundation (NSF) grant, robotics kits developed by CMU have been integrated into middle school curriculums in rural Mingo County, West Virginia as well as suburban Pittsburgh to help identify and nurture students with STEM abilities. In October 2016, CMU announced a partnership with Southern Utah University on a CREATE (Community Robotics, Education and Technology Empowerment) Lab satellite. The Lab program will empower students with technology at young ages, offering opportunities for young learners and student volunteers.

CMU'S "GIRLS OF STEEL" ROBOTICS TEAM PREPARES FOR THE 2016-2017 SEASON



Source: Carnegie Mellon

9.4 COMMUNITY SERVICE

Carnegie Mellon also recognizes its role as an anchor institution by deploying its most valuable resource, its students, in formal and informal community service activities. These take the form of academic courses with an integrated service learning component, student organizations that operate through student activities or through academic departments, and federal community service work study employment. CMU reported that during the 2014-2015 academic year:

- Twenty-seven officially recognized student organizations are categorized as service-focused;
- More than 5,000 CMU students engaged in community service; and
- These students provided more than 216,000 total service hours in total[70]

Carnegie Mellon offers approximately 30 "Service Learning" courses for students to work with non-profit, civic, and other agencies to aid the community while also gaining educational experiences. The Leonard Gelfand Center for Service Learning and Outreach offers more than 85 opportunities to help educate teachers and students in southwestern Pennsylvania. K-12 Teachers provided over 7,500 professional development hours at Carnegie Mellon in 2007, More than 10,000 children participate in Carnegie Mellon educational outreach programs each year. Osher Lifelong Learning Institute in Pittsburgh provided 396 individual courses from 2015 to 2016 for the community to increase the members' knowledge, sharpen their skills, foster interaction, and engender aesthetic and cultural awareness.

CMU's Heinz College also plays an important role in developing and implementing programs that provide local community service:

- Heinz alums Andrew Butcher and Chris Koch founded *G-Tech Strategies* in 2006, an organization that work with local communities to improve the social, economic and environmental health of the whole community, especially focused on the reclamation of vacant lots. Since 2006, *G-Tech Strategies* had worked with 55 partners, collaborated with 33 communities, cleaned up 56 acres of vacant land and installed 23 permanent projects on vacant land.
- *Grow Pittsburgh* was started in 2005 with the aim of educate the general public about the importance of gardening and agriculture as part of a vibrant, healthy community. The initiative includes variety of educational programs for all age ranges and provides education, planning resources, and technical assistance for existing and newly developing community vegetable gardens in low-to-moderate income communities.

[70] According to *The Independent Sector*, volunteer time can be conservatively valued at $20 an hour or more. Hence, CMU students are responsible for volunteer contributions of time valued at over $4 million per year. See: "The Value of Volunteer Time", *The Independent Sector*, 2016 <https://www.independentsector.org/volunteer_time>

- Since 2005, *Grow Pittsburgh* has started 17 community gardens, seven within the city and ten in the county; taught more than 1,400 K-12 students food based lessons with the Edible School Yard Program; grown more than 14 tons of food a year through farm and garden programs; and expanded community garden growing area at new and existing gardens by more than 12,000 square feet.

MEMBERS OF THE HEINZ HEALTH CARE CLUB PACK MEDICAL SUPPLIES

Source: Carnegie Mellon

9.5 ARTS AND CULTURE CONTRIBUTIONS

Arts and culture is another area in which Carnegie Mellon is a significant contributor to the region's quality of life. Arts and culture amenities are frequently cited as a strength of the Pittsburgh region as a place to live, work and visit, as well as a large economic driver. Young artists are crucial to the recent increases in young population within the city, contributing to the vitality of the city. CMU and its highly regarded College of Fine Arts are contributors to this ecosystem through programming on campus, participation in the local arts scene, and the fine arts graduates who stay in the area and become contributors and leaders.

As the Pittsburgh region transitions to a post-industrial economy, it relies increasingly not only on its high-tech and education/medicine sectors, but also on its arts and culture and entertainment community. These amenities and associated activities are economic drivers in and of themselves, generated nearly $1.2 billion in total economic impact in Allegheny County, according to the Greater Pittsburgh Arts Council.[71] They are also a crucial contributor to the attractiveness and vitality of the region, which has broad economic implications. Pittsburgh's arts and culture amenities are attractive to a potential workforce, and therefore make the region a more attractive place to locate businesses, which often follow talent rather than the other way around. Further, combined with the reasonable cost of living, a dynamic arts scene makes the region attractive to the often-young artists looking for a community in which to develop and show their craft. This dynamic has been an important driver in the demographic change that is revitalizing many urban centers, and has contributed to the influx of a younger population into Pittsburgh in recent years.

Carnegie Mellon is interwoven into the local arts scene and local arts economy in several ways:

- CMU is itself a producer and host of arts and culture events, which are open to the general public.
    - For example, the CMU School of Drama program produces approximately 25 events a year, ranging from fully mounted, mainstage productions to staged readings. Programs are hosted at four venues including Chosky Theater, with a capacity of 450. Total attendance for the 2015-2016 Mainstage season was more than 11,600, with ticket sales revenue of more than $146,000.
    - The School of Drama also runs Studio 201, a flexible media lab in an open warehouse environment in Pittsburgh's North Point Breeze neighborhood, which offers the opportunity for experimental artistic productions off-campus.

- CMU also encourages its students, faculty and staff to engage in Pittsburgh's arts and culture scene through its discount program with events in the Cultural District.
    - The program allows the CMU community discounted admission to participating organizations including the Pittsburgh Ballet Theater, Pittsburgh Opera, Pittsburgh Symphony Orchestra, Pittsburgh Public Theater and Pittsburgh Cultural Trust.

- CMU is a leader in research and conversation around arts and culture through its Center for Arts in Society (CAS) and Frank-Ratchye STUDIO for Creative Inquiry.
    - CAS is the midst of the three-year (2014-2017) "Performance Initiative," which explores artistic performances in an expansive way, including the relationship between audience and actor, constructions of political protest, and social rituals. Previous multi-year themes have included "Media" (2011-2014) and "Public Art" (2008-2011)

[71] "Arts, Culture & Economic Prosperity in Allegheny County, PA." *Greater Pittsburgh Arts Council,* 2013.

- CMU produces the next generation of artists and arts leaders through its highly regarded College of Fine Arts and other programs.
    - Students at the Schools of Art, Drama, and Music help to fuel the local arts scene both during and after graduation
    - CMU offers Arts and Entertainment Management programs, which train the next generation of leaders in the arts community.

In sum, Carnegie Mellon not only supports the thriving local arts and culture scene through its direct programming, but encourages the participation of its community, and attracts and trains talented artists and arts and culture leaders.

SET OF THE GLASS MENAGERIE AT STUDIO 201

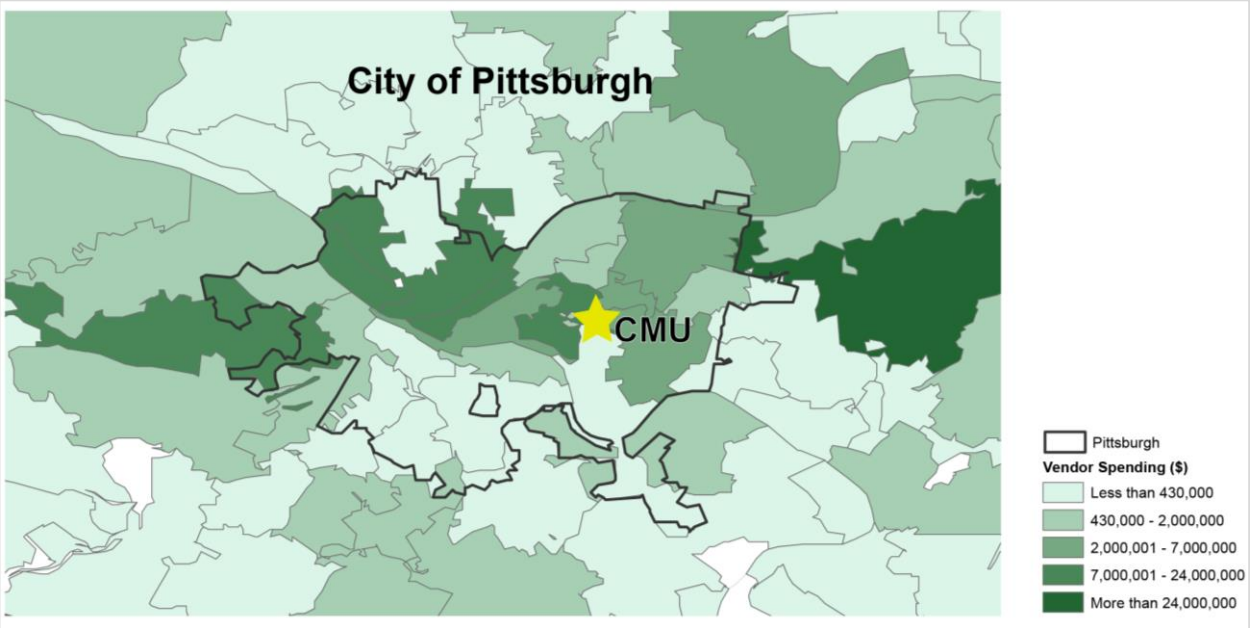
Source: Joey Sarno Designs

9.6 LOCAL PROCUREMENT AND HIRING

Finally, Carnegie Mellon's large operating footprint means a significant number of jobs that are located in Pittsburgh and a large amount of spending on goods and services. Due in part to sheer proximity and in part to specific prioritizations by CMU, these economic opportunities are to the direct benefit of local residents who work for CMU and local vendors who do business with CMU.

As noted in Section 3, Carnegie Mellon tracks the distribution of its vendor spending and has measured how much of that spending goes towards local businesses. In Fiscal Year 2016, 20% of vendor (i.e. non-payroll) spending went to City of Pittsburgh-based businesses, and 42% to businesses based in the Pittsburgh region. Figure 9.1 below shows the breakdown of that local spending by zip code. Within the City of Pittsburgh, a high volume procurement activity accrues in the nearby Oakland neighborhood, as well as the neighborhoods east of the campus. CMU also has a significant procurement footprint with businesses based in northwest Pittsburgh. In addition, vendors located outside of the city limits are significant beneficiaries of Carnegie Mellon procurement activity.

FIGURE 9.1 – CARNEGIE MELLON VENDOR PROCUREMENT BY ZIP CODE, FY2016



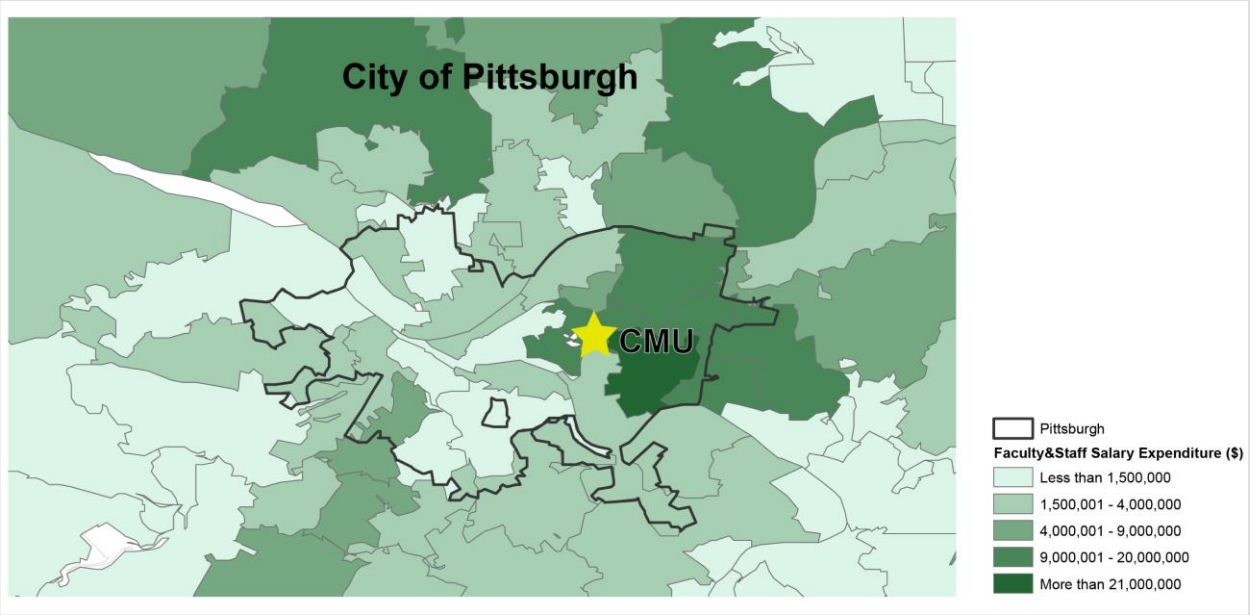
Source: Carnegie Mellon

In addition to procurement activity, CMU's payroll expenditures to local residents also stimulate the local economy and drive demand for local business. As noted in Section 3, 44% of CMU's payroll accrues to residents of the City of Pittsburgh, and 98% accrues to residents of the Pittsburgh region. Figure 9.2 below shows the distribution of CMU payroll expenditures by zip code within the city and nearby surroundings. CMU staff and faculty are densely clustered in the neighborhoods around of

campus (including Squirrel Hill, Shadyside, Point Breeze and Oakland) as well as in pockets of north, northwest and southwest Pittsburgh. This demand supports the local real estate market, supporting strong rents and property values in neighborhoods proximate to campus (as noted in Section 3.5).

In addition, a significant volume of CMU employees live in proximate neighborhoods outside of the city. The household spending generated by these faculty and staff not only supports their local communities, but in part back to the City, where they commute each workday.

FIGURE 9.2 – CARNEGIE MELLON FACULTY AND STAFF PAYROLL BY EMPLOYEE ZIP CODE



Source: Carnegie Mellon (2016)

10.0 CONCLUSION

Carnegie Mellon University is a world-class research university with an enrollment of over 13,000 students. It directly employs more than 5,000 people and has an annual operating budget of more than one billion. It is therefore not surprising that its direct, indirect and induced economic footprint within the city, region and state economy is significant. However, it is important to understand the composition and scale of that impact, and to explore how that impact was achieved and why that impact matters.

Carnegie Mellon's aggregate annual impact amounts derive from four mutually-exclusive categories for which CMU can take direct credit. These impact categories begin to convey and define the broader importance of CMU to the City of Pittsburgh, Pittsburgh region, and Commonwealth of Pennsylvania.

1. Annual operating activities, the vast majority of which are supported by non-local revenue sources (tuition payments by out-of-town students, federal research grants) (Section 3);

2. Capital investments, which not only provide temporary stimulus to the local construction sector but also position the campus and the city as a whole as a vital part of Greater Pittsburgh's increasingly competitive innovation economy (Section 4);

3. Spending by students and visitors, whose injection of purchasing power from outside the region keeps local businesses open, supports local jobs, and generates local tax revenues for the provision of a variety of essential local public services (Section 5); and

4. The additional household spending amounts located in the region from the wage premium residents have gained from their CMU degree and from the net new gain in residents drawn in by CMU (Section 6).

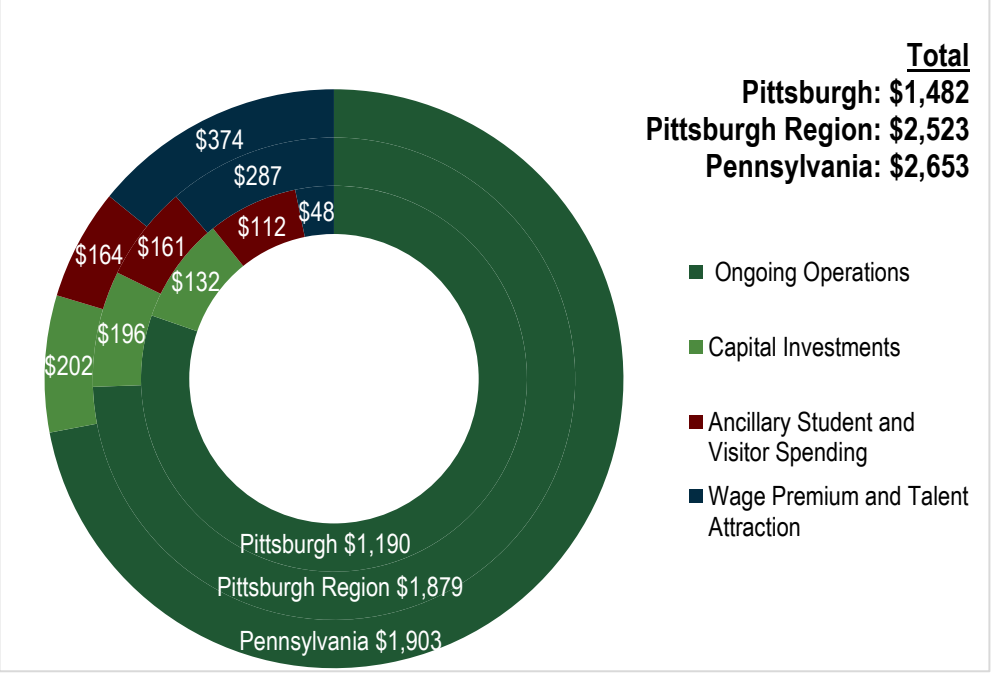
Carnegie Mellon's annual economic contribution to the city, region, and state economy is substantial, representing nearly $2.7 billion of economic activity and supporting 18,000 jobs throughout the Commonwealth. Within the City of Pittsburgh, annual impacts total $1.5 billion, supporting nearly 10,000 jobs (see Table 10.1 and Figures 10.1 and 10.2).

TABLE 10.1 – SUMMARY OF ANNUAL CMU ECONOMIC IMPACTS WITHIN THE CITY OF PITTSBURGH, PITTSBURGH REGION, AND COMMONWEALTH OF PENNSYLVANIA

City of Pittsburgh	Ongoing Operations	Capital Investments	Ancillary Student and Visitor Spending	Wage Premium and Talent Attraction	Annual Total
Total Output ($M)	$1,190	$132	$112	$48	**$1,482**
Employment (jobs)	7,610	930	1,030	340	**9,910**
Earnings ($M)	$726	$57	$21	$10	**$814**
Pittsburgh Region	**Ongoing Operations**	**Capital Investments**	**Ancillary Student and Visitor Spending**	**Wage Premium and Talent Attraction**	**Annual Total**
Total Output ($M)	$1,879	$196	$161	$287	**$2,523**
Employment (jobs)	12,410	1,330	1,400	2,110	**17,250**
Earnings ($M)	$955	$80	$36	$86	**$1,157**
Commonwealth of Pennsylvania	**Ongoing Operations**	**Capital Investments**	**Ancillary Student and Visitor Spending**	**Wage Premium and Talent Attraction**	**Annual Total**
Total Output ($M)	$1,903	$202	$164	$374	**$2,653**
Employment (jobs)	12,500	1,360	1,450	2,680	**17,990**
Earnings ($M)	$959	$81	$36	$109	**$1,185**

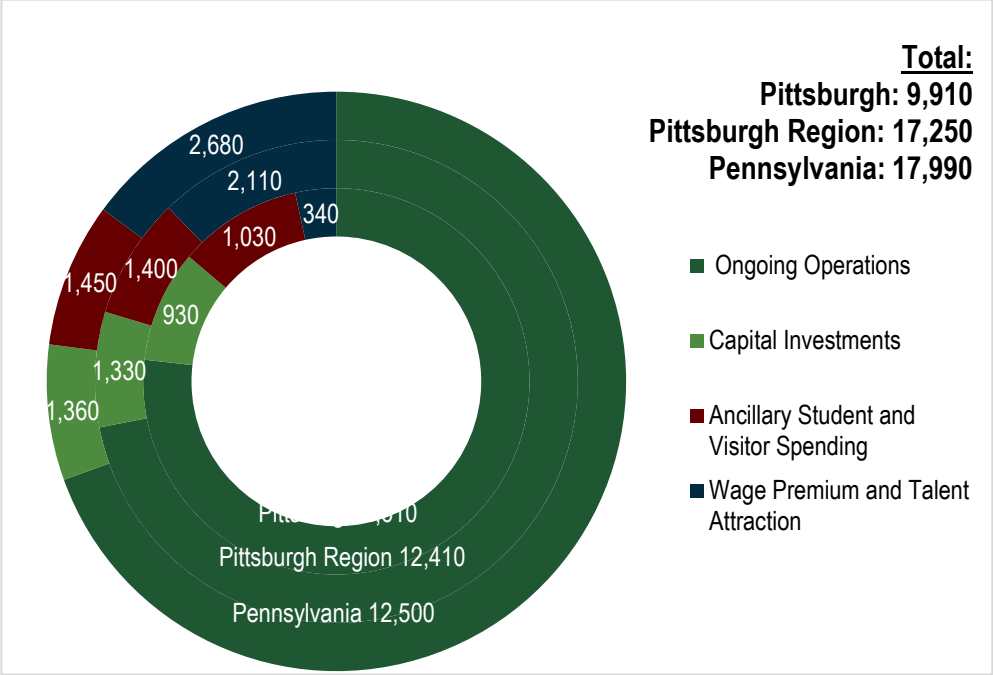
Source: Carnegie Mellon (2016), IMPLAN (2013), Econsult Solutions (2016)

FIGURE 10.1 – CARNEGIE MELLON ANNUAL OUTPUT BY IMPACT TYPE AND GEOGRAPHY ($M)



Source: Carnegie Mellon (2016), IMPLAN (2013), Econsult Solutions (2016)

FIGURE 10.2 – CARNEGIE MELLON ANNUAL EMPLOYMENT SUPPORTED BY IMPACT TYPE AND GEOGRAPHY



Source: Carnegie Mellon (2016), IMPLAN (2013), Econsult Solutions (2016)

Importantly for the City of Pittsburgh and Commonwealth of Pennsylvania governments, CMU is not only a major economic engine in the region but also a significant generator of local and state tax revenues. All of the economic activity represented by the impact categories described above creates in turn temporary or permanent expansions in various local and state tax bases, thus producing tax revenues for City and Commonwealth. It is estimated that the annual tax revenue generation is around $12 million in City of Pittsburgh and Allegheny County revenues and an additional $61 million in Commonwealth revenues (see Table 10.2). In other words, even though it itself is a not-for-profit institution and as such is exempt from most taxes, CMU is among the largest producers of tax revenues for the City and Commonwealth.

TABLE 10.2 – SUMMARY OF ANNUAL TAX REVENUE GENERATION ATTRIBUTABLE TO CMU WITHIN THE CITY OF PITTSBURGH AND COMMONWEALTH OF PENNSYLVANIA

Jurisdiction	Ongoing Operations	Capital Invest-ments	Ancillary Student and Visitor Spending	Wage Premium and Talent Attraction	Annual Total
City of Pittsburgh	$9.2	$0.7	$0.4	$1.5	**$11.8**
Commonwealth of Pennsylvania	$33.7	$4.7	$3.0	$19.6	**$61.0**

Source: Carnegie Mellon (2016), IMPLAN (2013), Econsult Solutions (2016)

The true economic story of Carnegie Mellon, however, goes well beyond these economic and fiscal impact totals. First, it is important to reiterate that these impacts largely represent a transfer from non-local sources, such as out-of-town students, federal research grants, and alumni donations from around the world, to the benefit of local jobs and local tax bases. This also means that, absent CMU's presence in Pittsburgh and Pennsylvania, the vast majority of those dollars would likely be deployed elsewhere, to no benefit to Pittsburgh or Pennsylvania.

It is also important to reiterate that the nature of CMU's core work is having a very direct, immediate, and transformative effect on the Pittsburgh region's global competitive position. CMU is, quite literally, good for the world, as its intellectual capital is deployed all over the map and its research discoveries support commercial and human development across the globe. All of this good work starts with and is centered on the concentration of scientific and technological activity located on the CMU campus, which serves as a figurative magnet for all manner of knowledge workers, research dollars, corporate presence, and entrepreneurial activity. The economic value of this intellectual property is in part reflected in the $1.05 billion in identified venture capital raised by start-ups associated with CMU since FY 2011.

With a particular reputation and expertise in the kind of robotics work that is seen as potentially transforming the way people get around, CMU is making Pittsburgh an irresistible destination for cutting-edge technologies and in the process fundamentally remaking Pittsburgh's brand in the global marketplace. Recent investments in Pittsburgh by the likes of Google and Uber have been directly tied to the presence and participation of CMU and in turn have turned Pittsburgh into a byword for innovation and cutting-edge technologies. This gives Pittsburgh a "first mover" advantage in these emerging industries, which has incredibly meaningful and long-lasting implications for Pittsburgh's competitive position and creates a virtuous cycle of drawing in more knowledge activity and in turn creating an even more compelling case for still others to be drawn in.

CMU's role in bolstering the local economy on the global stage is a long-standing one. Notably, Pittsburgh's long, painful, but largely successful transition from a manufacturing giant to a knowledge leader was aided greatly by its securing in the 1980's of the federal grants which led to the Software Engineering Institute, a high-tech initiative that continues to attract both federal dollars and international attention. CMU has nurtured that link through more than 350 corporate partnerships, which put its intellectual capital to use solving private sector research challenges. Today, the city has become a byword for innovation, as firms like Uber, Google, and Facebook are finding proximity to CMU to be the desirable place to invest, experiment and expand. Looking ahead, Pittsburgh is well-positioned to compete as an innovation hub against other world-class locations because of the concentration of intellectual capital and entrepreneurship activity represented by CMU. In this regard, the headline economic impact numbers arrived at in this report represent both the present aggregation of that important role in the regional economy and the path by which that the region will continue to thrive.

APPENDIX A – DETAILED ECONOMIC AND TAX REVENUE IMPACT METHODOLOGY

A.1 OVERVIEW

Economic impact estimates are generated by utilizing **input-output models** to translate an initial amount of direct economic activity into the total amount of economic activity that it supports, which includes multiple waves of spillover impacts generated by spending on goods and services and by spending of labor income by employees. This section summarizes the methodologies and tools used to construct, use, and interpret the input-output models needed to estimate this project's economic impact.

A.2 INPUT-OUTPUT MODEL THEORY

In an inter-connected economy, every dollar spent generates two spillover impacts:

- First, some amount of the proportion of that expenditure that goes to the purchase of goods and services gets circulated back into an economy when those goods and services are purchased from local vendors. This represents what is called the **"indirect effect,"** and reflects the fact that local purchases of goods and services support local vendors, who in turn require additional purchasing with their own set of vendors.

- Second, some amount of the proportion of that expenditure that goes to labor income gets circulated back into an economy when those employees spend some of their earnings on various goods and services. This represents what is called the "**induced effect**," and reflects the fact that some of those goods and services will be purchased from local vendors, further stimulating a local economy.

The role of input-output models is to determine the linkages across industries in order to model out the magnitude and composition of spillover impact to all industries of a dollar spent in any one industry. Thus, the total economic impact is the sum of its own direct economic footprint plus the indirect and induced effects generated by that direct footprint.

A.3 INPUT-OUTPUT MODEL MECHANICS

To model the impacts resulting from the direct expenditures Econsult Solutions, Inc. developed a customized economic impact model using the **IMPLAN** input/output modeling system. IMPLAN represents an industry standard approach to assess the economic and job creation impacts of economic development projects, the creation of new businesses, and public policy changes within a county its surrounding area

IMPLAN has developed a social accounting matrix (SAM) that accounts for the flow of commodities through economics. From this matrix, IMPLAN also determines the regional purchase coefficient (RPC), the proportion of local supply that satisfies local demand. These values not only establish the types of goods and services supported by an industry or institution, but also the level in which they are acquired locally. This assessment determines the multiplier basis for the local and regional models created in the IMPLAN modeling system. IMPLAN takes the multipliers and divides them into 440 industry categories in accordance to the North American Industrial Classification System (NAICS) codes.

The IMPLAN modeling system also allows for customization of its inputs which alters multiplier outputs. Where necessary, certain institutions may have different levels of demand for commodities. When this occurs, an "analysis-by-parts" (ABP) approach is taken. This allows the user to model the impacts of direct economic activity related to and institution or industry with greater accuracy. Where inputs are unknown, IMPLAN is able to estimate other inputs based on the level of employment, earnings, or output by an industry or institution. In the case of Carnegie Mellon, an ABP approach was implemented to account for the unique operating footprint that CMU has within the city, region and state.

A.4 EMPLOYMENT AND WAGES SUPPORTED

IMPLAN generates job estimates based on the term "job-years", or how many jobs will be supported each year. For instance, if a construction project takes two years, and IMPLAN estimates there are 100 employees, or more correctly "job-years" supported, over two years, that represents 50 annual jobs. Additionally, these can be a mix of a full and part-time employment. Consequently, job creation could feature more part-time jobs than fulltime jobs. To account for this, IMPLAN has a multiplier to covert annual jobs to full-time equivalent jobs.

Income to direct, indirect, and induced jobs is calculated as employee compensation. This includes wage and salary, all benefits (e.g., health, retirement) and payroll taxes (both sides of social security, unemployment taxes, etc.). Therefore, IMPLAN's measure of income estimates gross pay opposed to just strictly wages.

A.5 TAX REVENUE IMPACT

The economic impacts in turn produce one-time or ongoing increases in various tax bases, which yield temporary or permanent increases in various tax revenues. To estimate these increases, Econsult Solutions, Inc. created a **tax revenue impact model** to translate total economic impacts into their commensurate tax revenue gains. These tax revenue gains only account for a subset of the total tax revenue generation that an institution or industry may have on the economy. Furthermore, where institutions are tax exempt, only the tax revenue generation from supported indirect and induced industries is accounted for.

APPENDIX B – DETAILED STUDENT/VISITOR SPENDING METHODOLOGY

B.1 ANCILLARY STUDENT SPENDING

The first step to calculate ancillary student spending is to define total annual student spending by category. Base data comes from Carnegie Mellon's Office of Student Financial Services, which lists an approximate annual student budget for room, board, expenses, and transportation costs totaling $15,702 (see Table B.1).

It is necessary, however, to account for the proportion of this spending that is captured by CMU itself. Since the revenue generated by the institution is ultimately reflected in the University's operating budget, impacts from this spending are represented in the calculations of CMU's annual operating impact detailed in Section 3 of this report. This spending must therefore be excluded from student spending estimates, which reflect only ancillary spending not captured by the University, and may therefore be added to the operating impacts from Section 3. Room and board expenses for on-campus students are assumed to primarily accrue to CMU, as is a portion of other expenses by on-campus and off-campus students to reflect the CMU-operated retail options like the CMU bookstore and dining facilities. As such, we have made conservative estimates for ancillary student spending by on-campus and off-campus students which we then apply to the student financial aid office's academic year budget to produce annual ancillary spending estimates for on-campus and off-campus students (see Table B.1).

TABLE B.1 – ANNUAL ANCILLARY SPENDING ESTIMATES FOR ON-CAMPUS AND OFF-CAMPUS STUDENTS

Spending Category	Student Spending per academic year	On-campus Students		Off-campus Students[72]	
		% Spent within CMU	Average amount Spent Outside CMU	% Spent within CMU	Average amount Spent Outside CMU
Housing	$7,520	100%	$0	0%	$7,520
Food	$5,310	80%	$1,062	15%	$4,514
Other retail	$2,400	25%	$1,800	10%	$2,160
Transportation	$472	0%	$472	0%	$472
Total per student	**$15,702**		**$3,334**		**$14,666**

Source: Carnegie Mellon (2016), Econsult Solutions (2016)

Next, we have estimated the proportion of that ancillary spending which takes place within the city of Pittsburgh as well as within the 10-county region by expenditure category. We first take the proportion of total students who are on-campus (41.1%) and apply that to the total number of students at the Pittsburgh location (12,066) so as to narrow the scope of our analysis to this region. We then have made adjustments to the amounts captured within Pittsburgh and the 10-county region to reflect several realities. First, research indicates that around one-third of retail shopping by millennials occurs online and thus is not captured locally (except a certain amount spent at the campus online store).[73] Additionally, a portion of transportation spending is likely to take place outside of the local geography as students visit friends and family in other locations, in particular CMU's large international student body (approximately 43%) may have a large transportation spend outside of the city, region and state. These proportions can be applied to the category specific spending estimates developed in Table B.1, and the known distribution of on-campus and off-campus students that attend CMU's Pittsburgh campus. To produce an estimate of aggregate ancillary spending captured within the City of Pittsburgh and the Pittsburgh region, the annual ancillary student spending is multiplied by the number of students and percentage of expenditures uncaptured by CMU. As a result, ancillary student spending not captured by CMU is $100 million in Pittsburgh, and $113 million with in the Pittsburgh region and in Pennsylvania (see Table B.2).

[72] Off-campus students includes commuter students which are estimated to be a very small subset of Carnegie Mellon's student body. These students are likely have much lower room expenses, but higher transportation costs. While it is possible that the overall housing expenditures for off-campus students are overstated; the transportation costs are also equally likely to be understated. Combined with the small amount of commuter students, that that impact of commuter students is likely to be negligible.

[73] "Who are the Millennial Shoppers? And What do they Really Want?" *Accenture Outlook*. <https://www.accenture.com/us-en/insight-outlook-who-are-millennial-shoppers-what-do-they-really-want-retail>

TABLE B.2 – ESTIMATED ANCILLARY STUDENT SPENDING CAPTURED WITHIN THE CITY OF PITTSBURGH, PITTSBURGH REGION, AND COMMONWEALTH OF PENNSYLVANIA

City of Pittsburgh	Avg. Annual Ancillary Spending	# of Students	Housing	Food	Other Retail	Transport	Total Captured
On-campus students	$3,334	3,516	--	80%	20%	80%	**$5.6 M**
Off-campus students	$14,666	8,550	90%	60%	20%	80%	**$94.8** M
Total	**$11,364**	**12,066**	**$57.9 M**	**$33.9 M**	**$5.0 M**	**$3.7 M**	**$100.4 M**
Pittsburgh Region and Commonwealth of Pennsylvania	**Avg. Annual Ancillary Spending**	**# of students**	**Housing**	**Food**	**Other Retail**	**Transport**	**Total Captured**
On-campus students	$3,334	3,516	--	85%	30%	85%	**$6.4 M**
Off-campus students	$14,666	8,550	100%	65%	30%	90%	**$106.4 M**
Total	**$11,364**	**12,066**	**$64.3 M**	**$38.1 M**	**$6.2 M**	**$4.2 M**	**$112.8 M**

Source: Carnegie Mellon (2016), Econsult Solutions (2016)

B.2 ANCILLARY VISITOR SPENDING

Carnegie Mellon also attracts visitors to its campus from outside of the region from a variety of campus events. Throughout the year, Carnegie Mellon hosts family, alumni, and academic oriented events that bring in visitors that spend money on hotels, food & beverage, retail, and transportation within the City of Pittsburgh. The level of these expenditures varies on the location of where the visitor originates from. Local visitors are assumed to originate from the Pittsburgh region, out-of-town day trip visitors are assumed to come from the Pennsylvania, Ohio, West Virginia, Maryland quad-state area, and out of town overnight visitors are assumed to originate from outside of the quad-state region. Using student and alumni locations, as well as conservative assumptions, spending for local visitors is estimated at $25 per day, $68 per day for out-of-town day trip visitors, and $230 per day for out-of-town overnight visitors (see Table B.3).

TABLE B.3 – ESTIMATE OF PER DAY SPENDING BY CAMPUS VISITORS OF CARNEGIE MELLON

Expenditure Type	Local	Out of Town-Day Trip	Out of Town-Overnight	Source
Hotel Rate[74]			$162	Pittsburgh Downtown Partnership, 2015
Food	$15	$35	$35	US General Services Administration, 2015
Other Retail		$10	$10	US General Services Administration, 2010
Transportation	$10	$23	$23	US General Services Administration, 2010
Daily Spending	**$25**	**$68**	**$230**	

Source: Carnegie Mellon (2016), Pittsburgh Downtown Partnership (2016), US General Services Administration (2010), ESI (2016)

The vast majority of visitors to Carnegie Mellon's campus come from six types of events: prospective student, first-time student move-in, alumni events, conferences, special events, and commencement. The single largest visitation type is from prospective students with roughly half of total campus visits generated by Carnegie Mellon. The university also generates a significant amount of visitors from non-student oriented events (special events and conferences). These events include academic conferences, and visits to the campus from foreign dignitaries, business and thought leaders, as well as notable politicians. These visitation types were sorted into spending categories based on location of origin of Carnegie Mellon's student body, the location of active alumni, and conservative estimates for conferences and special events (see Table B.4)

TABLE B.4 – ESTIMATED QUANTITY OF ANNUAL VISITORS TO CARNEGIE MELLON BY TYPE

	Base	Visitors per Guest	Total Visitors (rounded)	Percent Local	Percent Out of Town - Day Trip	Percent Out of Town - Overnight
Prospective Students	15,830	2.5	39,600	4%	12%	84%
Move-in	1,550	2.5	3,900	4%	12%	84%
Alumni Events	5,973	1	6,000	10%	18%	72%
Conferences	10,038	1	10,000	25%	65%	10%
Special Events	1,775	1	1,800	25%	65%	10%
Commencement	1,500	7	10,500	9%	9%	82%
Total	**36,666**	**1.7**	**71,800**	**11%**	**28%**	**61%**

Source: Carnegie Mellon (2016), Econsult Solutions (2016)

[74] The hotel rate is subsequently divided by 1.5 to account for room sharing

Once the visitor categories are split into the local, out-of-town day trip, and out-of-town overnight categories they are applied to the spending categories in Table B.3. As a result, visitor spending from local visitors to Carnegie Mellon's campus is about $240,000 per year, out-of-town day trip visitors spend about $2 million and out-of-town overnight visitors generate $5.8 million per year. In aggregate, these visitor types add about $8 million each year to the Pittsburgh economy. Without Carnegie Mellon's presence in Pittsburgh, these expenditures would not take place within the city, region and state economies (see Table B.5, B.6, and B.7).

TABLE B.5 – ESTIMATED ANNUAL SPENDING FROM LOCAL VISITORS OF CARNEGIE MELLON

Type of Visitor	Count	Food and Beverage ($M)	Lodging ($M)	Other Retail ($M)	Transport ($M)	Total ($M)
Prospective Students	4,800	$0.07			$0.05	$0.12
Move-in	300	$0.00			$0.00	$0.01
Alumni Events	600	$0.01			$0.01	$0.02
Conferences	2,500	$0.04			$0.03	$0.06
Special Events	500	$0.01			$0.01	$0.01
Commencement	900	$0.01			$0.01	$0.02
Total	**9,600**	**$0.14**	**$0.00**	**$0.00**	**$0.10**	**$0.24**

Source: Carnegie Mellon (2016), Pittsburgh Downtown Sponsorship (2016), US General Services Administration (2010), Econsult Solutions (2016)

TABLE B.6 – ESTIMATED ANNUAL SPENDING FROM OUT-OF-TOWN DAY TRIP VISITORS OF CARNEGIE MELLON

Type of Visitor	Count	Food and Beverage ($M)	Lodging ($M)	Other Retail ($M)	Transportation ($M)	Total ($M)
Prospective Students	19,000	$0.67		$0.19	$0.44	$1.29
Move-in	600	$0.02		$0.01	$0.01	$0.04
Alumni Events	1,100	$0.04		$0.01	$0.03	$0.07
Conferences	6,500	$0.23		$0.07	$0.15	$0.44
Special Events	1,200	$0.04		$0.01	$0.03	$0.08
Commencement	1,000	$0.04		$0.01	$0.02	$0.07
Total	**29,400**	**$1.03**	**$0.00**	**$0.29**	**$0.68**	**$2.00**

Source: Carnegie Mellon (2016), Pittsburgh Downtown Sponsorship (2016), US General Services Administration (2010), Econsult Solutions (2016)

TABLE B.7 – ESTIMATED ANNUAL SPENDING FROM OUT-OF-TOWN OVERNIGHT VISITORS OF CARNEGIE MELLON

Type of Visitor	Count	Food and Beverage ($M)	Lodging ($M)	Other Retail ($M)	Transportation ($M)	Total ($M)
Prospective Students	15,800	$0.55	$1.71	$0.16	$0.36	$2.78
Move-in	3,000	$0.11	$0.32	$0.03	$0.07	$0.53
Alumni Events	4,300	$0.15	$0.46	$0.04	$0.10	$0.76
Conferences	1,000	$0.04	$0.11	$0.01	$0.02	$0.18
Special Events	200	$0.01	$0.02	$0.00	$0.00	$0.04
Commencement	8,600	$0.30	$0.93	$0.09	$0.20	$1.51
Total	**32,900**	**$1.15**	**$3.55**	**$0.33**	**$0.76**	**$5.79**

Source: Carnegie Mellon (2016), Pittsburgh Downtown Sponsorship (2016), US General Services Administration (2010), Econsult Solutions (2016)

APPENDIX C – ADDITIONAL DETAIL ON INDUSTRY SECTORS IMPACTED BY CARNEGIE MELLON'S ONGOING OPERATIONS AND CAPITAL EXPENDITURES

TABLE C.1 – DETAILED INDUSTRY DISTRIBUTION OF EMPLOYMENT GENERATED BY CARNEGIE MELLON'S OPERATIONS WITHIN THE CITY OF PITTSBURGH, PITTSBURGH REGION, AND COMMONWEALTH OF PENNSYLVANIA

Industry	Pittsburgh Jobs Count	Pittsburgh %	Pittsburgh Region Jobs Count	Pittsburgh Region %	Pennsylvania Jobs Count	Pennsylvania %
Educational Services	5,389	71%	5,586	45%	5,588	45%
Health & social services	351	5%	1,157	9%	1,163	9%
Retail trade	291	4%	1,002	8%	1,007	8%
Accommodation & Food Services	244	3%	739	6%	744	6%
Administrative & Waste Services	232	3%	619	5%	626	5%
Professional, Technical, and Scientific Services	237	3%	583	5%	590	5%
Other Services	149	2%	520	4%	524	4%
Finance & insurance	182	2%	487	4%	497	4%
Real Estate and Rental Services	167	2%	381	3%	386	3%
Transportation & Warehousing	63	1%	211	2%	217	2%
Wholesale Trade	56	1%	202	2%	204	2%
Arts, Entertainment & Recreation	57	1%	192	2%	193	2%
Construction	48	1%	176	1%	178	1%
Government	44	1%	147	1%	149	1%
Information	50	1%	129	1%	131	1%
Manufacturing	11	0%	75	1%	90	1%
Agriculture, Forestry, Fish & Hunting	3	0%	66	1%	75	1%
Utilities	15	0%	62	1%	63	1%
Management	13	0%	44	0%	45	0%
Mining	7	0%	34	0%	35	0%
Total	**7,609**		**12,411**		**12,503**	

Source: Carnegie Mellon University (2016), IMPLAN (2013), Econsult Solutions (2016)

TABLE C.2 – DETAILED INDUSTRY DISTRIBUTION OF EMPLOYMENT GENERATED BY CARNEGIE MELLON'S CAPITAL INVESTMENTS WITHIN THE CITY OF PITTSBURGH, PITTSBURGH REGION, AND COMMONWEALTH OF PENNSYLVANIA

Industry	Pittsburgh Jobs Count	Pittsburgh %	Pittsburgh Region Jobs Count	Pittsburgh Region %	Pennsylvania Jobs Count	Pennsylvania %
Construction	648	70%	654	49%	654	48%
Professional, Technical, and Scientific Services	87	9%	134	10%	136	10%
Retail trade	35	4%	93	7%	95	7%
Health & social services	35	4%	93	7%	95	7%
Accommodation & Food Services	22	2%	60	4%	61	4%
Finance & insurance	18	2%	48	4%	50	4%
Administrative & Waste Services	17	2%	46	3%	48	4%
Other Services	16	2%	44	3%	46	3%
Manufacturing	2	0%	23	2%	30	2%
Real Estate and Rental Services	10	1%	26	2%	27	2%
Wholesale Trade	11	1%	23	2%	24	2%
Transportation & Warehousing	6	1%	21	2%	22	2%
Educational Services	8	1%	21	2%	22	2%
Arts, Entertainment & Recreation	6	1%	15	1%	15	1%
Information	3	0%	9	1%	10	1%
Mining	1	0%	8	1%	8	1%
Government	2	0%	6	0%	7	0%
Management	1	0%	5	0%	5	0%
Agriculture, Forestry, Fish & Hunting	0	0%	2	0%	2	0%
Utilities	1	0%	2	0%	2	0%
Total	**928**		**1,331**		**1,357**	

Source: Carnegie Mellon University (2016), IMPLAN (2013), Econsult Solutions (2016)

APPENDIX D – DETAILED WAGE PREMIUM AND TALENT ATTRACTION METHODOLOGY

D.1 OVERVIEW

While anchor institutions of higher education such as Carnegie Mellon have significant economic footprints through their direct expenditures and through students and visitors they draw into the local economy, it is important not to lose sight of the core mission of these institutions in educating its students. This primary function, in addition to helping foster a more enlightened society, has a significant economic component as well, increasing the productivity and earning power of the local workforce.

The link between educational attainment and earnings power is well-established, and a "wage premium" associated with additional education is often conceptualized and calculated from the perspective of the student, who can compare the costs associated with various educational (or non-educational) options with the expected return. This analysis utilizes this framework to estimate the gain not to the student, but rather to the local geographies (City of Pittsburgh, Pittsburgh region, and the Commonwealth of Pennsylvania) in which Carnegie Mellon is located. Additional earnings attributable to CMU within these geographies are estimated, and translated into additional spending power within the local economy, which supports local employment and earnings.

Central to this exercise is the link between workforce location and location of employment. While the proportion of college graduates retained within a local workforce varies based on the particulars of the institution, its student body, and the geographies in question, institutions of higher education typically supply a significant volume of skilled workers into the local economy through their presence. This talent attraction impact is clear from alumni data supplied by Carnegie Mellon, which indicates that more than 20,000 CMU graduates currently live within the Commonwealth of Pennsylvania and would be living and working elsewhere absent CMU. The presence of these skilled graduates in the workforce has two quantifiable effects on earnings with a given geography:

1) A university increases the educational attainment level of the local workforce, which can be translated into increased earnings based on the established relationship between educational attainment and wages.

2) Universities may have a specific wage premium associated with the knowledge and credentials they impart, above and beyond earning power associated with a particular degree level. For Carnegie Mellon, both the selectivity of the university (as manifested in the quality of the educational experience) and its areas of focus (which weigh heavily towards the STEM fields) yield a wage premium for its graduates over a typical degree.

The section that follows details the data, assumptions and calculations utilized to estimate the impact of CMU on household spending within the City of Pittsburgh, Pittsburgh region and Commonwealth of Pennsylvania via additional earning power within those geographies.

D.2 CARNEGIE MELLON CONTRIBUTIONS TO THE EARNING POTENTIAL OF THE LOCAL WORKFORCE

The presence of Carnegie Mellon has a significant impact on the composition, educational attainment and skill level of the local workforce. Post-graduation location decisions are impacted by educational experience, with a clear correlation between locations during and after schooling.[75] From a regional workforce standpoint, Carnegie Mellon alumni living and working within the city, region and Commonwealth are either imported to those geographies (in the case of students originating from around the nation and the world) or retained within those geographies (in the case of the students originating within those geographies who are retained due to the presence of CMU.[76] Notably, alumni data provided by Carnegie Mellon indicates that a greater proportion of alumni are located within these local geographies than the proportion of the entering student body originating from those areas.

Graduates retained within the local workforce enhance local earnings potential in multiple ways. First, academic research and government data indicate a clear return to educational attainment in the form of advanced earnings potential. Census Bureau data documents a linear relationship between median wages and educational attainment, with each additional level of schooling yielding increased average earnings. Academic studies have explored this phenomenon from the perspective of an individual student evaluating the returns to investments in additional schooling in terms of their expected lifetime financial position.[77] However, these educational attainment gains accrue not only to the student, but to the region in which they are employed. Increased earnings enjoyed as a result of schooling are a market-based representation of the additional productivity associated with those workers, and ultimately result in additional household spending within the local economy on other goods and services.

Returns to education are also impacted by the specific university that a student attends, due to variance in both institutional quality and programs and degrees offered. Wage premiums vary by level of degree, but also by field of study, with graduates holding STEM degrees, for example, earning notably higher wages than the average graduate.[78] Thus, institutions like Carnegie Mellon

[75] See, for example: Groen, J. A. (2004). "The Effect of College Location on Migration of College-Educated Labor."*Journal of Econometrics*, *121*(1), 125-142.

[76] As noted in Section 5.2 and shown in Figure 5.1, none of the top 20 institutions chosen by students who were admitted by CMU but went elsewhere are in the Pittsburgh region, and only one is the Commonwealth of Pennsylvania.

[77] For an overview of research in this field, see: Barrow, L and Malamud, O (2015). "Is College a Worthwhile Investment?"*Annual Review of Economics. 2015, 7:5* 19-55

[78] For a detailed overview of anticipated lifetime earnings by degree type, see Webber, D (2014). "The Lifetime Earnings Premia of Different Majors: Correcting for Selection Based on Cognitive, non-Cognitive, and Unobserved Factors." *Labour Economics*, Volume 28, June 2014, 14-23.

which produce a disproportionate number of graduates in high-earning fields not only add to the educational attainment by members of the regional workforce (as reflected in the level of degrees achieved), but have additional additive effects on regional earning potential through the specialized skills they engender.

In addition to variance by degree type, institutions vary in selectivity, curricular rigor and reputation. These qualitative factors are also reflected in the earnings potential of graduates above and beyond the level of degree they attain. Academic research has demonstrated a clear correlation between the selectivity of higher education institutions and the earnings of its graduates, which again reflects a market-based valuation of enhanced productivity.[79] From the perspective of regional economy, the presence of a selective university like Carnegie Mellon therefore has additional additive effects on the earnings potential of the local workforce as well.[80]

D.3 MODELING INCREASED EARNINGS WITHIN A GEOGRAPHY

The modeling approach undertaken in this calculation conforms to the gross impact approach set forth in Section 2.2 and utilized throughout the report. Since a gross analysis does not include a counterfactual in which impacts are replaced through market forces in the absence of the institution, the alumni attracted and retained within the geography are all considered additive to the region. However, the level of local employment is also considered to be fixed even in the absence of the university. The benefit to the region is therefore not the full salary of those workers, but the productivity and wages associated with their additional educational attainment and skills/knowledge premium. A portion of these additional earnings (after accounting for taxes, savings, etc.) results in additional household spending which circulates through the local economy, generating indirect and induced impact and supporting employment and earnings.

As with other impact categories, a net rather than gross impact approach would require a speculative projection of broad labor market impacts within various geographies in the absence of CMU. In practice, it is likely that if CMU graduates were removed from a labor force with a fixed pool of jobs, some importation of similarly credentialed graduates from outside of the labor force would likely occur. However, it is equally true that absent CMU, it is unlikely that the local economy would retain the same level of jobs currently held by Carnegie Mellon alumni. Academic research has demonstrated a clear link between the presence of high-level research universities like Carnegie Mellon and regional job growth, which is credited in large part of the agglomeration

[79] See for example: Hoxby, C. (2015). "Computing the Value-Added of American Postsecondary Institutions."*Internal Revenue Service Statistics of Income Division Working Paper*, July 2015; and Monks, J. (2000)."The Returns of Individual and College Characteristics: Evidence from the National Longitudinal Survey of Youth."*Economics of Education Review, 19,* 279-289.

[80] Note that evidence is mixed on the extent to which selective universities are causally responsible for the observed increase in wages, and the extent to which the underlying characteristics of the student body they admit would lead to students achieving some or all of that premia at a less selective university. From the perspective of a regional workforce, however, this causality question is irrelevant, since the students that are attracted to the region by the selective institution and enjoy the associated wage gains would not otherwise be in the region absent the institution.

and spillover benefits associated with knowledge activity,[81] and as a general matter, business location decisions are increasingly understood to follow talent rather than the other way around. Specifically in the case of CMU, as discussed in Section 8.5 of this report, several high tech employers have explicitly chosen to locate in Pittsburgh due to the presence of Carnegie Mellon. Accordingly, it is likely that a non-trivial proportion of the jobs held by CMU graduates in the local economy may not exist at all in Pittsburgh absent CMU. The gross impact approach utilized in this analysis assumes these jobs to exist with our without the university, and estimates only the effects of the existence of CMU on the education and skill level of the local workforce and its attendant impact on wages.

D.4 GEOGRAPHIC DISTRIBUTION OF CARNEGIE MELLON ALUMNI

Understanding the impacts of Carnegie Mellon on the earnings potential of the local workforce begins with understanding the current distribution of CMU alumni within the city, region and state economies. Data provided by Carnegie Mellon yields the residential location of the approximately 94,000 active members of the alumni database. 10% of active alumni are currently living in Pittsburgh (or 9,400 alumni), while 17% are living within the Pittsburgh region (inclusive of the 10% living in the city) and 21% are living within the Commonwealth of Pennsylvania (inclusive of the 17% living within the region) (see Table D.1).

TABLE D.1 – ACTIVE CARNEGIE MELLON ALUMNI BY GEOGRAPHIC LOCATION

	Total	City of Pittsburgh	Pittsburgh Region	Commonwealth of Pennsylvania	United States
Alumni	94,400	9,400	15,800	20,000	83,100
% of Total Alumni	--	10.0%	16.6%	21.2%	88.0%

Source: Carnegie Mellon University (2016), Econsult Solutions (2016)

Next, it is necessary to estimate the proportion of alumni within each geography that are actively employed (and therefore generate an annual wage premium), and to divide those alumni by education attainment. The proportion of CMU alumni in the workforce within each geography is estimated based employment to population ratio for adults 25 and older with a bachelor's or advanced degree nationally, which is currently 72.2% according to the Bureau of Labor Statistics.[82] The distribution of educational attainment is drawn from the CMU alumni database, which indicates that 51% have achieved a bachelor's degree from CMU, while 49% have

[81] See, for example: Glaeser, E, Ponzetto G, and Tobio, K (2011). "Cities, Skills and Regional Change."*National Bureau of Economic Research Working Paper*, April 2011; and Moretti, E. (2003)."Human Capital Externalities in Cities."*National Bureau of Economic Research Working Paper*, April 2003.

[82] Note this estimate is likely conservative in the case of Carnegie Mellon, both due to the selective nature of CMU graduates and the fields in which they receive degrees, and to the fact that enrollment has increased significantly in recent years, meaning that CMU alumni are disproportionately of working age rather than retiree age relative to the national population of college graduates.

achieved an advanced degree or bachelor's and advanced degree.[83] Applying these proportions across all three geographies of interest yields an estimated distribution of CMU alumni currently employed within these geographies by degree level (see Table B.2).

TABLE D.2 – ESTIMATED CMU ALUMNI WITHIN THE WORKFORCE BY EDUCATIONAL ATTAINMENT AND GEOGRAPHY

Metric	Total Alumni	City of Pittsburgh	Pittsburgh Region	Commonwealth of Pennsylvania
Total Alumni	94,400	9,400	15,800	20,000
(x) Est. Proportion within Workforce	72.2%	72.2%	72.2%	72.2%
(=) Est Employed Alumni	**68,200**	**6,800**	**11,400**	**14,500**
Est. Employed Alumni	68,200	6,800	11,400	14,500
(x) Est. Bachelor's Degree Proportion	51.2%	51.2%	51.2%	51.2%
(=) Est. Employed Bachelor's Alumni	**34,900**	**3,500**	**5,800**	**7,400**
Est. Employed Alumni	68,200	6,800	11,400	14,500
(x) Est. Advanced Degree Proportion	48.8%	48.8%	48.8%	48.8%
(=) Est. Employed Graduate Alumni	**33,300**	**3,300**	**5,600**	**7,100**

Source: Carnegie Mellon University (2016), Bureau of Labor Statistics (2016) Econsult Solutions (2016)

American Community Survey data can be used to understand the overall educational attainment of the workforce within each of these geographies. Table D.3 below shows the highest level of educational attainment for the civilian workforce ages 25-64 within each geographic level.[84] CMU graduates represent a significant portion of the labor force with bachelor's or advanced degrees within the city of Pittsburgh.[85]

[83] Alumni who have received both an undergraduate and advanced degree from CMU are treated as graduate degree recipients for the purposes of this analysis, since the highest level of educational attainment is understood to be consequent in terms of post-graduate workforce location decisions.

[84] To enhance the accuracy of the calculation in terms of its differentiation of different geographic levels, workers within the subsumed geographies are netted out of each successive calculation (i.e. Pittsburgh region reflects the remaining portion of the region outside of the city, and the Commonwealth reflects the remainder of the state outside of the Pittsburgh region). Full values for the Commonwealth will therefore be the sum of all three columns (city, region exclusive of city, and state exclusive of region).

[85] Note that the analysis in Tables D.2 and D.3 utilize available information on the residential population as a proxy for the workforce in each geographic region. Due to commute patterns, the educational attainment of a residential population is not necessarily equivalent to the educational attainment of workers employed within this geography. This mismatch is generally larger at smaller geographic levels like a city, and less consequential for a region or state. For the City of Pittsburgh, data from the Longitudinal Employer-Household Dynamics (LEHD) program produced by the U.S. Census Bureau indicates a significant net inflow of workers into the city (i.e. more commuters live outside of and work inside of the city than live inside but work outside), suggesting that residential data utilized in this analysis is likely understates the impacts of CMU alumni on the educational attainment of the city's workforce.

TABLE D.3 – EDUCATIONAL ATTAINMENT OF LOCAL CIVILIAN WORKFORCE (AGES 25-64)

Education Level	City of Pittsburgh	Pittsburgh Region (non-city)	Commonwealth of Pennsylvania (non-Pitt region)
Total Civilian Employed	112,500	819,100	3,946,800
Some College / Associates Degree	30,100	243,900	1,052,300
Bachelor's Degree (only)	28,400	196,100	836,200
Advanced Degree	26,600	118,200	532,800
% Some College / Associates	26.7%	29.8%	26.7%
% Bachelor's	25.3%	23.9%	21.2%
% Advanced	23.7%	14.4%	13.5%
Est. CMU Bachelor's Alumni	3,500	2,300	1,600
Est. CMU Advanced Alumni	3,300	2,200	1,500

Source: American Community Survey Five Year Estimates (2010-2014), Econsult Solutions (2016)

D.5 IMPACT OF CARNEGIE MELLON ON EDUCATIONAL ATTAINMENT IN THE LOCAL WORKFORCE

Next, the impact of removing Carnegie Mellon graduates on the overall educational attainment of the workforce is estimated at each geographic level. As described in Section D.5 above, this analysis assumes that the volume of jobs within each geography remains fixed when CMU alumni are removed, and that the supply of graduates from alternative four-year higher education institutions remains fixed as well. The loss of CMU alumni therefore represents a substantial loss in the educational attainment level of the local workforce. In order to absorb this loss, while maintaining a fixed employment level, jobs held by Carnegie Mellon alumni with bachelor's degrees are assumed to "filter down" to employees with associates degrees,[86] while jobs held by Carnegie Mellon alumni with advanced degrees are assumed to "filter down" to employees with bachelor's degrees.[87]

This process generates a new modeled distribution of the local workforce absent Carnegie Mellon (see Table D.4). Net changes in educational attainment are shown for each geography, as well as the net change in the percentage of the workforce at each geographic level estimated to be within

[86] Note that the open enrollment practices of many Community Colleges or non-selective four year institutions suggest that the supply of these workers is likely relatively unconstrained. It is alternatively possible that positions would be filled by workers with High School degrees or less, which would yield an even larger wage premium.

[87] Note that the "filtering" process many in practice involve a long sequence of steps, where a highly skilled position held by an alumnus with an advanced degree is first replaced with a slightly less skilled advanced degree holder, whose position is then replaced by a slightly less skilled advanced degree holder, until a position currently held by a worker with an advanced degree is replaced by a worker with a bachelor's degree. This sequential process is mathematically equivalent to, and more easily conceptualized as, the replacement of one advanced degree worker with one bachelor's degree worker.

each level of attainment. The net difference between the attainment levels of the workforce with and without Carnegie Mellon graduates represents the educational attainment impact attributable to CMU.

TABLE D.4 – ESTIMATED FILTERING OF REGIONAL EDUCATIONAL ATTAINMENT ABSENT CARNEGIE MELLON

Education Level	City of Pittsburgh	Pittsburgh Region (non-city)	Commonwealth of Pennsylvania (non-Pitt region)
Bachelor's Degree → Associates Degree	3,500	2,300	1,600
Advanced Degree → Bachelor's Degree	3,300	2,200	1,500
Net Change by Degree Type			
Associates Degree	3,500	2,300	1,600
Bachelor's Degree	(200)	(100)	(100)
Advanced Degree	(3,300)	(2,200)	(1,500)
Net Change in % Attainment of Workforce			
% Associates Degree	3.10%	0.29%	0.04%
% Bachelor's Degree	(0.15%)	(0.01%)	(0.00%)
% Advanced Degree	(2.95%)	(0.27%)	(0.04%)

Econsult Solutions (2016)

D.6 EARNING POTENTIAL FOR CARNEGIE MELLON GRADUATES

Next, it is necessary to estimate the incremental earnings associated with each level of educational attainment within each geography of interest, as well as the additional wage premium associated with Carnegie Mellon above and beyond an average degree. Data from the American Community Survey is used to define the median earnings by educational attainment for adults 25+ nationwide and within the geographies of interest. Median earnings for the city of Pittsburgh are below the national average for each educational level, while median earnings in the region and Commonwealth are similar to the national average (see Table D.5).[88]

[88] As previously noted, comprehensive data available for this analysis is based on the residential location, rather than work location, of employees. While the residential and workforce populations are largely interchangeable at the regional and state level, the city of Pittsburgh has a significant net inflow of workers from outside of the city. It is likely that median earnings for workers employed in Pittsburgh exceed the median earnings of workers living in Pittsburgh (shown in Table D.5). This understatement suggests that the wage premium attributed to CMU within the City of Pittsburgh is likely understated in dollar terms.

TABLE D.5 – MEDIAN EARNINGS BY EDUCATIONAL ATTAINMENT (ADULTS 25+)

Education Level	National	City of Pittsburgh	Pittsburgh Region (non-city)	Commonwealth of Pennsylvania (non-Pitt region)
Some College / Associates Degree	$34,000	$29,700	$34,400	$35,300
Bachelor's Degree (only)	$50,500	$40,800	$50,600	$50,100
Advanced Degree	$66,900	$52,300	$65,800	$67,600

Source: American Community Survey Five Year Estimates (2010-2014)

Longitudinal data from the federal Department of Education indicates that Carnegie Mellon graduates earn a considerable premium above median earnings by education level. The latest "College Scorecard" released publicly by the Department of Education reports earnings by institution based unique tracking of tax filings of students who applied for student loans ten years after they entered school. This comprehensive data source indicates that the median salary ten years after entering Carnegie Mellon is currently $76,200.

This figure is likely conservative relative to the true average earnings of CMU alumni currently in the workforce for a number of reasons. First, it is calculated ten years after entering school and thus only a few years into the workforce for many graduates. These graduates are likely to see their wages increase over time as they stay in the workforce. Second, it includes only students who seek federal financial aid for school (since this forms one of the characteristics necessary for data collection). In doing so, it omits students from higher income families, a characteristic which may be correlated with higher earnings. Finally, it includes earnings of all attendees of the University ten years after entering CMU, regardless of whether they in fact graduated.[89]

Despite this caveats, this figure can be compared to national earnings by degree type as reported in the ACS to estimate the differential between earnings for CMU alumni and the average degree holder (i.e. the CMU "wage premium"). Since students may have completed advanced studies within ten years after undergraduate enrollment, the $76,200 figure is most appropriately compared to a blended average of the median salaries for bachelors and advanced degree holders nationwide, which is $56,700. This differential indicates that an undergraduate degree from CMU is associated with a wage premium of 34.4% (see Table D.6).

[89] An alternative analysis by the Brookings Institution utilizing data from PayScale.com estimates that the "median alumni mid-career salary" for Carnegie Mellon is $110,700. (see: Rothwell, J and Kulkarni, S. (2015). "Beyond College Rankings: A Value Added Approach to Assessing Two- and Four-Year Schools." *Metropolitan Policy Program at Brookings.* This method analyzes salaries reported by graduates with at least ten years of experience who log on to PayScale.com and enter their salary information in exchange for a free "salary report" through the site. This approach yields a median mid-career earnings for graduates of four-year colleges of $76,916, well above the median observed in more comprehensive government data, suggesting that the reported salaries may be non-representative of the full cohort of college graduates in the workforce. Nonetheless, this approach suggests a premium of 45.8% for CMU alumni, in line with the premium calculated from College Scorecard and ACS data. It also affirms that, for the reasons described above, the methodology utilized in this analysis may well be conservative with respect to the both the premium and salary level enjoyed by CMU graduates.

While it is clear that graduate degrees are associated with significant incremental earnings potential relative to bachelor's degrees, rigorous studies of wage gains associated with graduate programs at a given university has not been identified. Returns are also likely to vary significantly by program and selectivity. However, national data from the American Community Survey is available on median earnings associated with advanced degrees in various fields compared to the average earnings for advanced degree holders nationwide. This data indicates that graduates degrees in the STEM and business fields are associated with significantly higher than average median earnings (a premium of 35% for STEM and 27% for Business).[90] This information can be combined with the distribution of advanced degrees awarded on an annual basis by CMU to estimate a wage premium associated with CMU advanced degrees. Approximately 70% of CMU advanced degrees are in STEM and Business, with the remainder in Humanities, yielding a blended premium of 22.8% over the average advanced degree (see Table D.6).[91]

TABLE D.6 – WAGE PREMIUM FOR CARNEGIE MELLON UNDERGRADUATE AND ADVANCED DEGREES RELATIVE TO NATIONAL AVERAGE

Education Level	Median Earnings	% Wage Premium	CMU Proportion
National – Bachelor's / Advanced Degree	$56,700		
CMU Alumni – 10 Years after entering school	$76,200		100%
CMU Undergrad % Wage Premium		**34.4%**	
National – Advanced Degree	$66,900		
National Advanced – STEM	$90,200	34.7%	58%
National Advanced – Business	$85,200	27.3%	12%
National Advanced – Humanities	$65,700	(1.9%)	30%
National Advanced – Education	$57,600	(13.9%)	0%
CMU Advanced Degree Blended % Wage Premium	**$82,200**	**22.8%**	

Source: American Community Survey Five Year Estimates (2010-2014, 2007-2011), Department of Education College Scorecard (2016), Econsult Solutions (2016)

Next, the percentage premiums calculated at the national level for CMU alumni are applied to the median wage by educational attainment within the geographies of interest to yield estimated earnings for CMU alumni by degree level within each geography (see Table D.7). This approach accounts for the fact that average earnings are lower within the city of Pittsburgh than elsewhere in the region and Commonwealth, and adjusts estimated CMU earnings and the resulting wage premium down accordingly (in dollar terms).

[90] Ryan, C (2012) "Field of Degree and Earnings by Selected Employment Characteristics: 2011."*American Community Survey Briefs*, Issued October 2012.

[91] Note that this calculation conservatively excludes additional value above and beyond the degree types that may be associated with CMU advanced degrees due to the selectivity of the institution and its graduate programs.

TABLE D.7 – ESTIMATED EARNINGS FOR CARNEGIE MELLON ALUMNI BY GEOGRAPHY AND DEGREE TYPE

	City of Pittsburgh	Pittsburgh Region (non-city)	Commonwealth of Pennsylvania (non-Pitt region)
Bachelor's Degree – Average Earnings	$40,800	$50,600	$50,100
CMU Bachelor's Degree Wage Premium	34.4%	34.4%	34.4%
Est. CMU Bachelor's Degree Earnings	**$54,800**	**$68,000**	**$67,400**
Advanced Degree – Average Earnings	$52,300	$65,800	$67,600
CMU Advanced Degree Wage Premium	22.8%	22.8%	22.8%
Est. CMU Advanced Degree Earnings	**$64,300**	**$80,700**	**$83,000**

Source: American Community Survey Five Year Estimates (2010-2014, 2007-2011), Department of Education College Scorecard (2016), Econsult Solutions (2016)

D.7 AGGREGATE EARNINGS IMPACT FROM WAGE PREMIUM

Finally, the effects of CMU on the educational attainment of the local workforce are combined with the wage premia associated with increased educational attainment in general and with CMU in particular to estimate the total annual wage premium attributable to Carnegie Mellon within the geographies of interest. Table D.8 below shows:

- The estimated number of employed CMU alumni within each geography by degree level (as calculated in Section D.4);
- The estimated premium in dollar terms associated with the increased educational attainment attributable and the additional CMU-specific premium for both graduate and undergraduate degree holders by geography (as calculated in Section D.6).[92]

Multiplying the number of alumni by the premium within each degree type and geography yields the total annual premium attributable to Carnegie Mellon within each geography of interest (see Table D.8).

- Within the City of Pittsburgh, the estimated annual wage premium attributable to CMU totals $166 million;
- Within the Pittsburgh region, the estimated annual wage premium attributable to CMU totals $312 million;[93] and

[92] Note that this method implicitly assumes that all non-CMU alumni earn the average salary for their degree level within their respective geographies.

[93] As previously noted, premiums are calculated separately for non-overlapping geographic areas, but the full wage premium for the Pittsburgh region is represented by the sum of the premiums in the City of Pittsburgh and the remainder of the region, and the full wage premium for the Commonwealth of Pennsylvania is the sum of the premiums for the Pittsburgh region and the remainder of the state.

- Within the Commonwealth of Pennsylvania, the estimated annual wage premium attributable to CMU totals $412 million.

TABLE D.8 – AGGREGATE EARNINGS INCREASE ATTRIBUTABLE TO CARNEGIE MELLON FROM WAGE PREMIUM AND TALENT ATTRACTION

Premium	City of Pittsburgh	Pittsburgh Region (non-city)	Commonwealth of Pennsylvania (non-Pitt region)
CMU Employed Alumni – Bachelor's	3,500	2,300	1,600
Bachelor's – Educational Attainment Premium	$11,100	$16,200	$14,800
Bachelor's – CMU-Specific Premium	$14,000	$17,400	$17,200
Bachelor's Degree Premium	**$25,100**	**$33,600**	**$32,100**
CMU Employed Alumni – Advanced	3,300	2,200	1,500
Advanced – Educational Attainment Premium	$11,500	$15,200	$17,500
Advanced – CMU-Specific Premium	$11,900	$15,000	$15,400
Advanced Degree Premium	**$23,500**	**$30,100**	**$32,900**
Aggregate Earnings Increase	**$165.5 M**	**$146.2 M**	**$99.9 M**
City Total	**$165.5 M**		
Region Total (including City)		**$311.8 M**	
Commonwealth Total (including Region)			**$411.6 M**

Econsult Solutions (2016)

APPENDIX E – ABOUT ECONSULT SOLUTIONS, INC.

This report was produced by Econsult Solutions, Inc. ("ESI"). ESI is a Philadelphia-based economic consulting firm that provides businesses and public policy makers with economic consulting services in urban economics, real estate economics, transportation, public infrastructure, development, public policy and finance, community and neighborhood development, planning, as well as expert witness services for litigation support. Its principals are nationally recognized experts in urban development, real estate, government and public policy, planning, transportation, non-profit management, business strategy and administration, as well as litigation and commercial damages. Staff members have outstanding professional and academic credentials, including active positions at the university level, wide experience at the highest levels of the public policy process and extensive consulting experience.