The Impact of Engineering and Engineering Education

Economic and Functional Impacts

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Innovation-led
Economic Development

- Economic Development and Targeted Industry Strategies
- Science and Technology Roadmaps
- Workforce Development and Talent Strategies
- Innovation Ecosystem, Incubators, Research Parks, and Place Making
- Program Management and Implementation

Advanced
Analytics

- Economic and Functional Impact Analysis
- Advanced Analytics and Modeling
- Core Technology Competencies, Market Research and Competitive Analytics

Public
Policy

- Science and Technology Futures
- Program and Policy Evaluation

Some Recent TEconomy Reports

Assessing Washington's Life Science and Global Health Workforce Dynamics: Enhancing Connections and Addressing the Skills Gaps to Ensure Future Growth

Prepared by: TEconomy Partners, LLC
Prepared for: The Washington State Department of Commerce

Oct

National Evaluation of Capacity Programs

Quantitative and Qualitative Review of NIFA Capacity Funding

Prepared by:
TEconomy Partners, LLC.
Authors: Simon Tripp, Martin Grueber, Dylan Yetter
Joseph Simkins & Alyssa Yetter

Prepared for:
National Institute of Food and Agriculture

Seizing a New Era of Medical Discovery:

How Policymakers Can Embrace Practical Ideas that Help Lead to New Treatments and Cures

Improving the Lives of Patients and Growing the Economy

January 2018

Assessment of Virginia's Research Assets:

Strategic Directions to Advance Innovation-Led Growth and High-Quality Job Creation across the Commonwealth

Prepared by: TEconomy Partners, LLC
Prepared for: State Council of Higher Education for Virginia
on behalf of the Virginia Research Investment Committee

A Quantitative and Qualitative Review of the Impacts of University of Missouri Extension

June 2017

The Impact of MU Extension in Missouri

Phase II Report:

Strategies and Actions for Iowa Bioscience Development. Crosscutting and Platform Specific Strategies and Actions.

Performed for: Iowa Economic Development Authority
Performed by: TEconomy Partners, LLC

January 2018

Cummings,
Martin Grueber,
Partners, LLC.

TEconomy Partners Impact Analysis Practice

- Projects for individual institutions, colleges and programs through to entire industries and sectors
 - **Universities:** e.g. University of Nebraska, Oklahoma State University, The Ohio State University, NC State, etc.
 - **Industries:** e.g. Biotechnology, Pharmaceuticals, Industrial Physics, Clinical Genomics, Agriculture, Medical Devices, Recreation, Healthcare
 - **Major Initiatives & Institutions:** e.g. Human Genome Project, USDA Research Funding, Mayo Clinic
- TEconomy Partners was previously the Battelle Technology Partnership Practice. Became independent in 2015.

University
locations for core
competency,
strategic
planning and
impact analysis
projects

What are the impacts of a
College of Engineering?

Recent research profiling the importance of research universities is directly relevant to our discussion today

- Explained university research in the context of the full-range of functions served by universities in modern society.
- Profiled the structure of modern university-based research, academic disciplines, and the increasing importance of transdisciplinary inquiry.
- Explored the impacts of research universities in terms of private and social returns and market and non-market returns.
- Discussed the changing environment for university research funding and structural changes taking place in academe resulting from technological, political, and societal trends.
- Worked towards developing a mutual understanding and appreciation of the importance of universities and university-based research in all its forms.

<https://www.cicpindiana.com/resources/importance-research-universities/>

The Functional Impacts of Research Universities.

Towards a shared understanding of the benefits that accrue through wide-ranging university functions.

Impact Returns

Social/Private & Market/Non-Market Dimensions of Research University Impacts

Some Functional Impact Areas of Academic Engineering

- **Fundamental knowledge advancement:** Innovating and developing the advanced instruments, sensors and tools that enable discovery. (Examples: Colliders, Sequencers, Imaging, High Performance Computing, Space Systems)
- **Applied research and innovations:** The heart of engineering
- **Solutions to challenges – from “grand” to “local”**
- **Piloting, scale-up and commercialization**
- **Specialized Infrastructure**
- **Consulting and Expertise**
- **Extension solutions**
- **Knowledge and business clustering effects**
- **Talent attraction and development/human capital**

Economic Development:

Colleges of engineering are crucial to a complete economic development ecosystem

Symbiotic relationship between university and industry R&D

Like notes building upon notes to build a song, research discoveries build upon research discoveries to create novel products and technologies. **The result, in this case = Smart Phone....**

Engineering Impacts: Background and Characteristics

Engineering Education and Academic Research in the U.S.

- 2015-16 Academic Year Degrees Awarded*:
 - Bachelors = 112,721 (90.4% U.S. permanent resident)
 - Masters = 62,596 (58.1%)
 - Doctoral = 11,654 (45.2%)
 - + Engineering Technology Degrees = 7,241 (94.2%)
- Engineering academic research expenditures = \$8.9 billion*
- Starting salaries**:
 - Bachelors range \$64k (Indl/Mfg Eng) to \$68k (Chem Eng)
 - Masters range \$75K (EE) to \$80k (Software Eng)

Engineering at the core of major academic research advancement.
The example of Indiana's research university ecosystem

Indiana University
IUPUI
Purdue University
University of Notre Dame

Publications cluster analysis
by TEconomy Partners.

Engineering & Computer Science 2nd Largest Cluster for New Journals.

Global Analysis of the
Speciation of New
Academic Journals
(2000-2013). Simon
Tripp & Martin
Grueber.

- 7,496 new journals.
- Average of 535 completely new journals “speciated” annually.
- Average of almost 1.5 completely new journal mastheads per day.

Engineering capabilities are at the heart of tackling most major global grand challenges.

Simon Tripp, analysis of global challenge domains and connectivity to technologies.

UK Study by Royal Academy of Engineering

- Created an Engineering Index (measuring strength in engineering across 9 variables for 99 countries) and compared to “GDP per Capita” and “Investment per Capita”. Found:
 - ***“A strong positive link between engineering strength and both economic indicators.”***
- U.S. rated 17th with Engineering Indicator score of 60%
- Highest was Sweden with 75%, followed by Denmark, The Netherlands, Germany and Japan.
- The Republic of Korea has highest R&D as a percent of GDP at 4%, vs U.S. at 2.7% (ranked 8th)

Major Innovation Frontiers and Disruptive Technologies.

Engineering is engaged in all.

Classification of Disruptive Technologies by TEconomy Partners.

Biological	Physical	Cyber/Digital
<ul style="list-style-type: none">a. Next-Gen Sequencingb. Gene Editingc. Synthetic Biologyd. Regenerative Medicine and Tissue Engineeringe. Metabolic Engineeringf. Nanomedicineg. Cyber-biological systems/implantables	<ul style="list-style-type: none">a. Additive Manufacturingb. Advanced Roboticsc. Autonomous Vehiclesd. Energy Storagee. Alternative and Renewable Energyf. Advanced Materialsg. Electric Vehiclesh. Alternative Mass Transit	<ul style="list-style-type: none">a. Artificial Intelligenceb. Virtual and Augmented Realityc. Cyber Securityd. Cloude. Big Data Analytics and Associative Intelligencef. Natural Language Processingg. Quantum Computingh. Information Validationi. Edge Computingj. Mobile Internetk. Internet-of-Thingsl. Cryptocurrencies and Blockchain Technology

The U.S. cannot compete and realize the true opportunity inherent in any of these without R&D contributions across a range of engineering disciplines, and without a steady output of qualified engineering graduates.

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Colleges of Engineering and the Critical Supply of our Future Workforce

- Recent analysis by Mark Muro et al at Brookings examined changes in the digital content of 545 occupations embracing 90% of the U.S. workforce since 2001. Among their findings:
 - Digitalization is associated with increased pay for many workers and reduced risk of automation
 - Digitalization is changing the skills needed to access economic opportunity
 - Changes have been striking. By 2016, the share of employment in occupations with high digital content...more than tripled, from 4.8 to 23 percent of employment
 - Employment in occupations with low digital scores...declined precipitously, from 55.7 to 29.5 percent.

Conducting an Economic and Functional Impact Analysis

Conducting an Economic and Functional Impact Study

- Difference between backward linkage (expenditure impacts) and forward linkage impacts (functional impacts).
- Input/output analysis for measuring direct, indirect and induced impacts on output, employment, value added, tax base.
- Multiple spatial scales possible
- Starts with mapping out impact domains associated with the college
- Will have multiple audiences, so must present easily understood and well rounded assessment, including case studies/examples
- TEConomy also examines opportunities to increase impacts and enhance regional development ecosystem
- Can be combined with core competency assessment, TBED platform identification, strategic planning etc.

Colleges of Engineering. Structure of Functional Impacts

Undertaking economic and functional impact analysis.

Starts with mapping out impact domains

Undertaking economic and functional impact analysis.

Starts with mapping out impact domains

University of Missouri Extension. Functional Impact Coverage.

Also important to discuss threats.

A series of challenges, or “tensions” are facing U.S. research universities and colleges of engineering.

Conclusions (1)

- Engineering is key to solving challenges, and realizing opportunities, at a global and local scale.
- Areas of distinct opportunity for the U.S. economy are rooted in engineering progress and innovation.
- The theme of transdisciplinarity makes engineers a crucial component of R&D teams across most frontier areas of science and technology.
- Disruptive changes are coming, and colleges of engineering are key to realizing these as areas of opportunity and competitive advantage for the U.S., rather than threats.
- Colleges of engineering have diverse impacts across social/private and market/non-market dimensions.

Conclusions (2)

- Colleges of engineering are a critical component for a complete technology-based economic development ecosystem.
- STEM education and engineering/digital skills are crucial for workforce preparedness and high paying future jobs in the U.S.
- Explaining the economic and functional impacts of colleges of engineering to multiple stakeholders is critically important. Different factors will hold appeal to different audiences.
- The U.S. is far from alone in developing world-class engineering education and R&D. Continued investment in both is required to sustain the competitiveness of the U.S. and create a bright economic future for U.S. workers and families.

Innovating Tomorrow's Economic Landscape

TEconomy Partners is a global leader in research, analysis and strategy for innovation-based economic development. Today we're helping nations, states, regions, universities, and industries blueprint their future and translate knowledge into prosperity.

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