The Hidden STEM Economy

The Surprising Diversity of Jobs Requiring Science, Technology, Engineering, and Math Knowledge

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Outline

1. STEM: The Conventional View
2. Redefining the STEM Workforce
3. The “hidden” STEM economy
4. The Las Vegas STEM Economy
5. Policies to boost STEM Demand and Supply

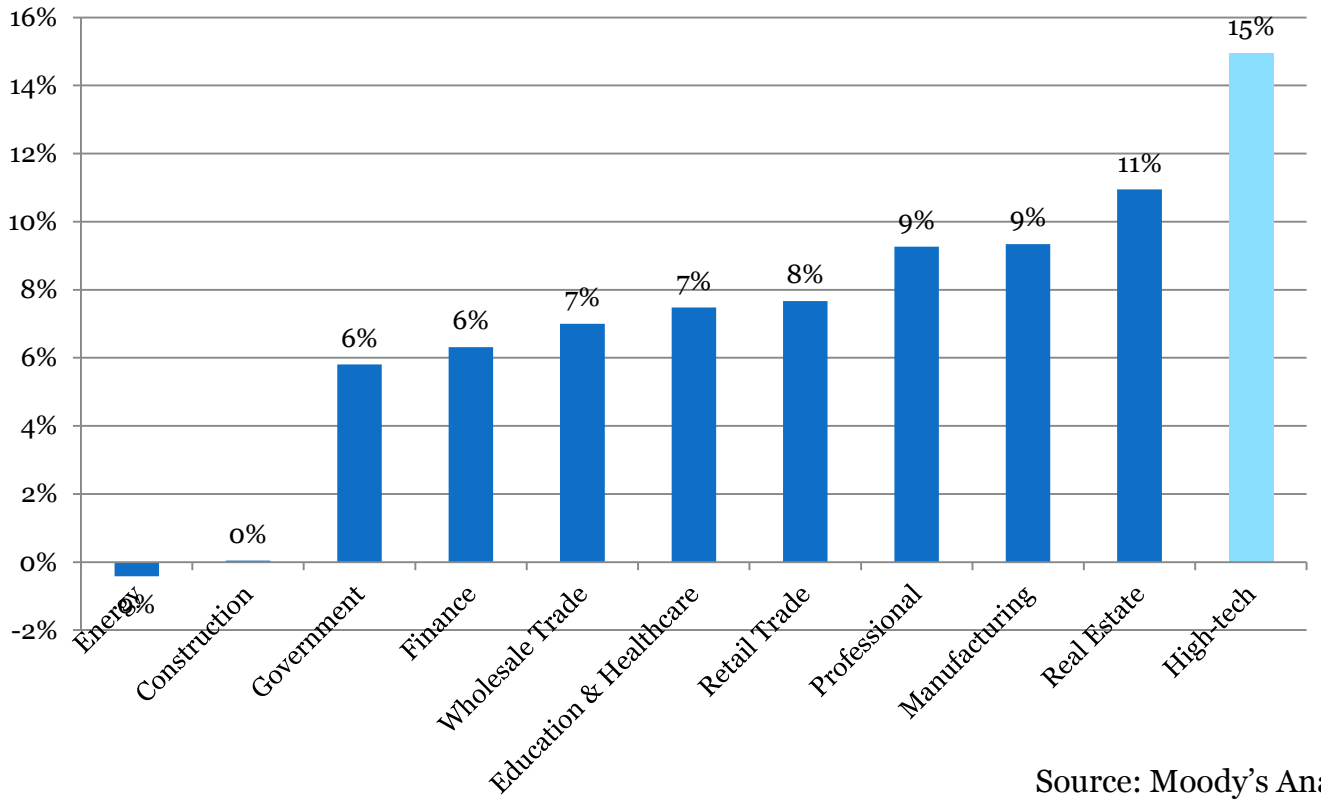
1. STEM: The Conventional View

"There must be a stream of new scientific knowledge to turn the wheels of private and public enterprise. There must be plenty of men and women trained in science and technology for upon them depend both the creation of new knowledge and its application to practical purposes."
-Vannevar Bush, 1945

From "Science, the Endless Frontier: A Report to the President" (Washington: U.S. Government Printing Office, 1945).

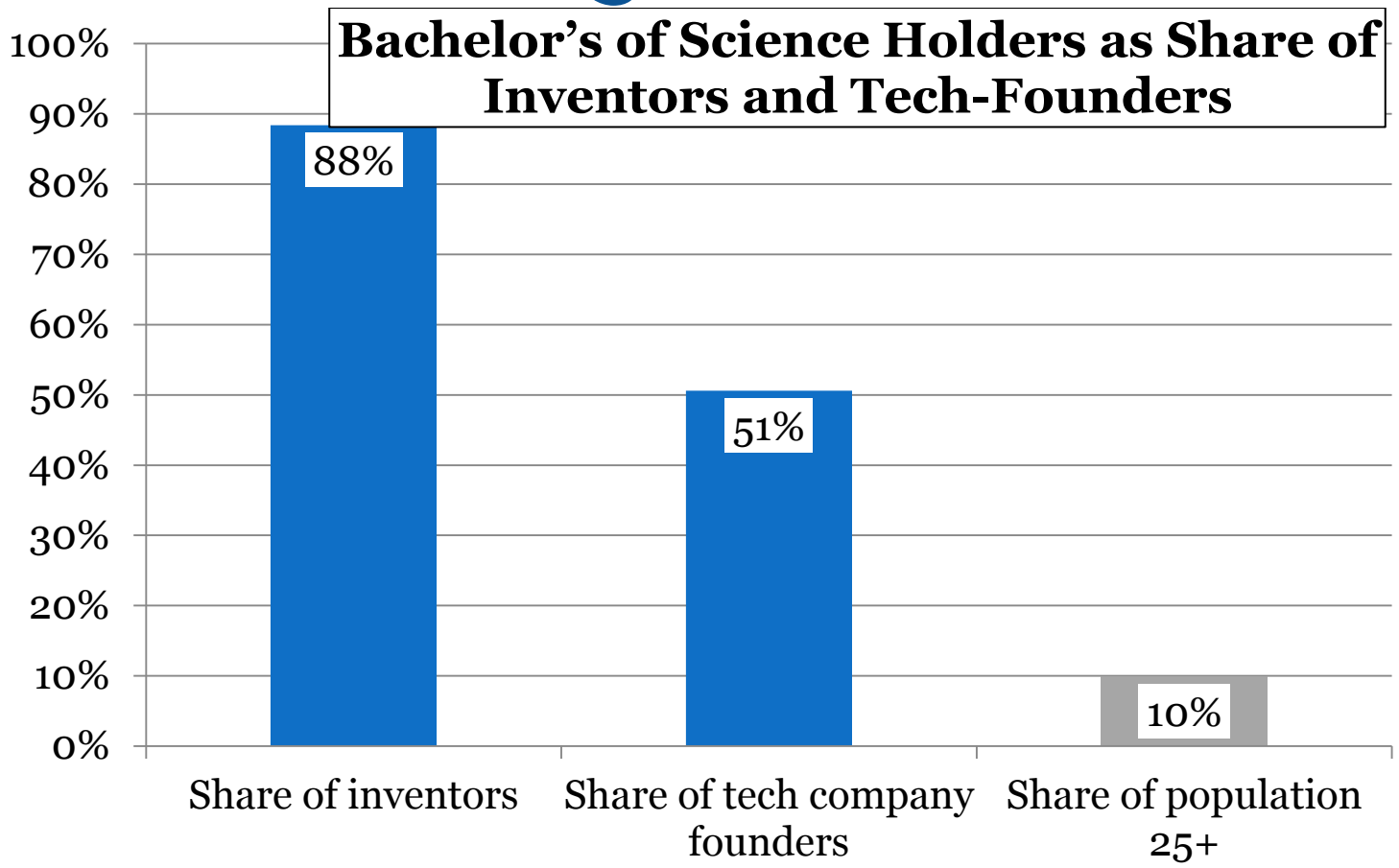
Innovative High-Patenting Industries are Driving even Measured GDP Growth

Tech share of GDP
1980 = 4%
2012 =10%



Source: Moody's Analytics/BEA

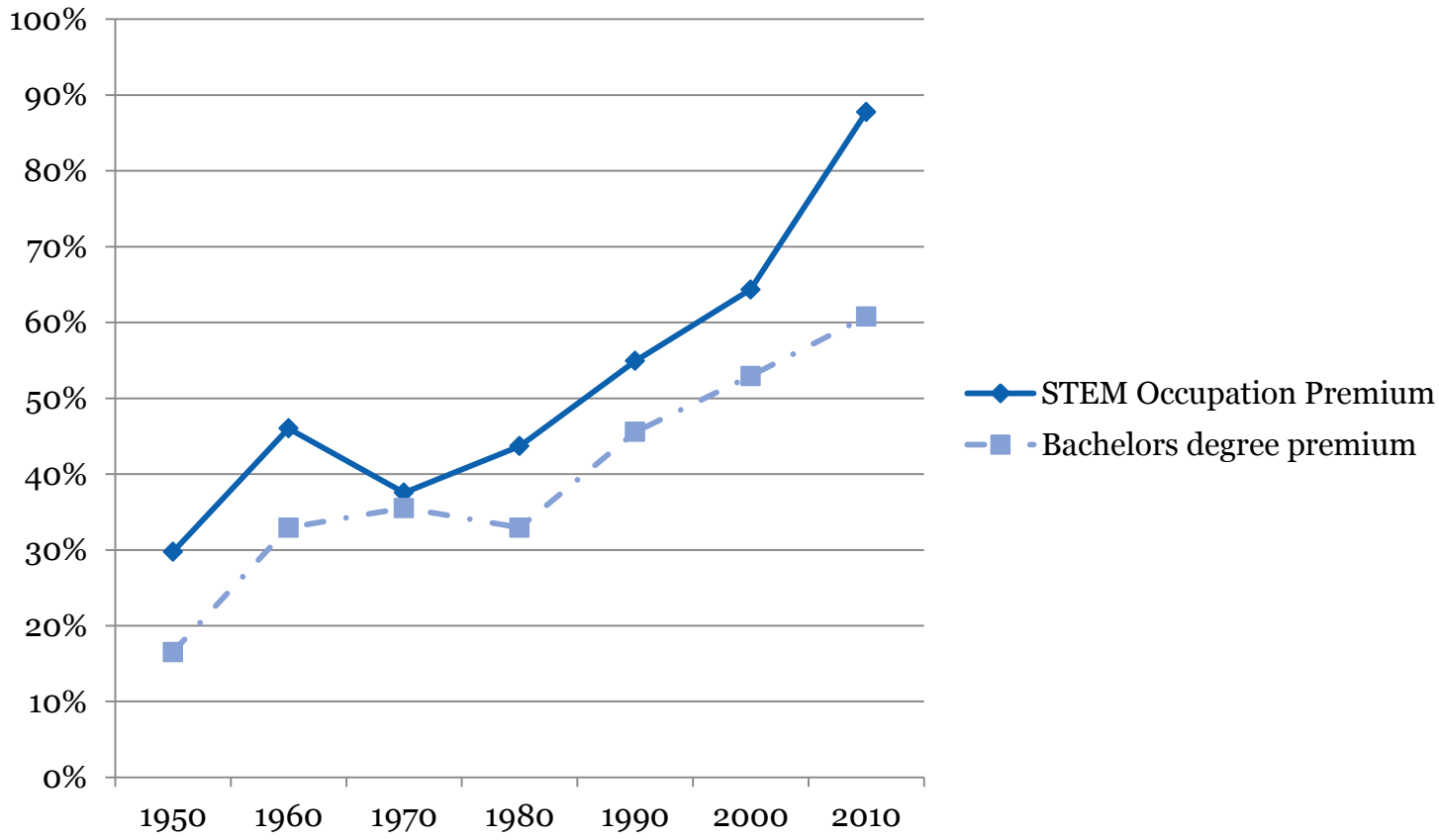
STEM-knowledge drives innovation



Source: Brookings analysis of Georgia Tech Inventor Survey, Kauffman Foundation survey, and 2011 American Community Survey

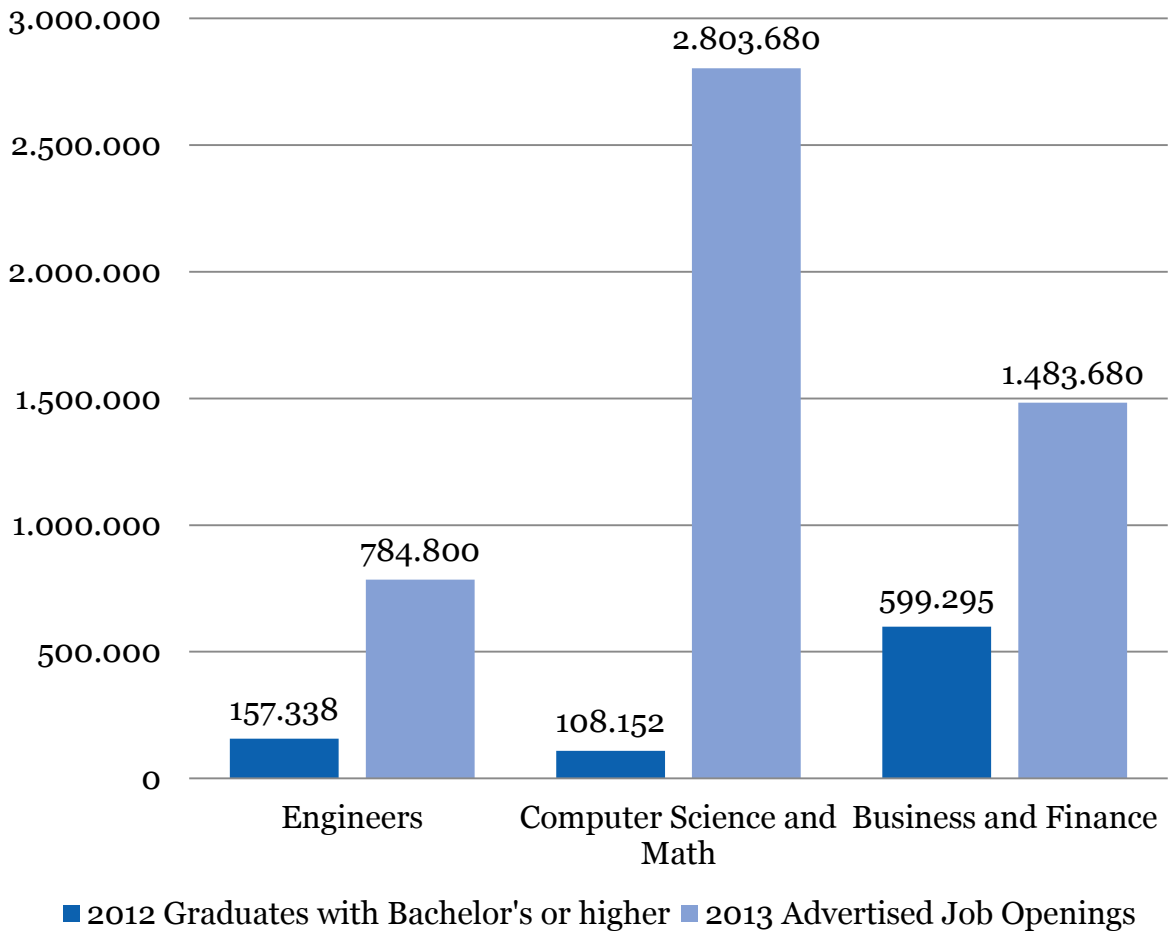
The Returns to Skill Are Increasing

Salary Premium for Bachelor's Degree vs. High School Diploma compared to Premium for Working in STEM Occupation, 1950-2010

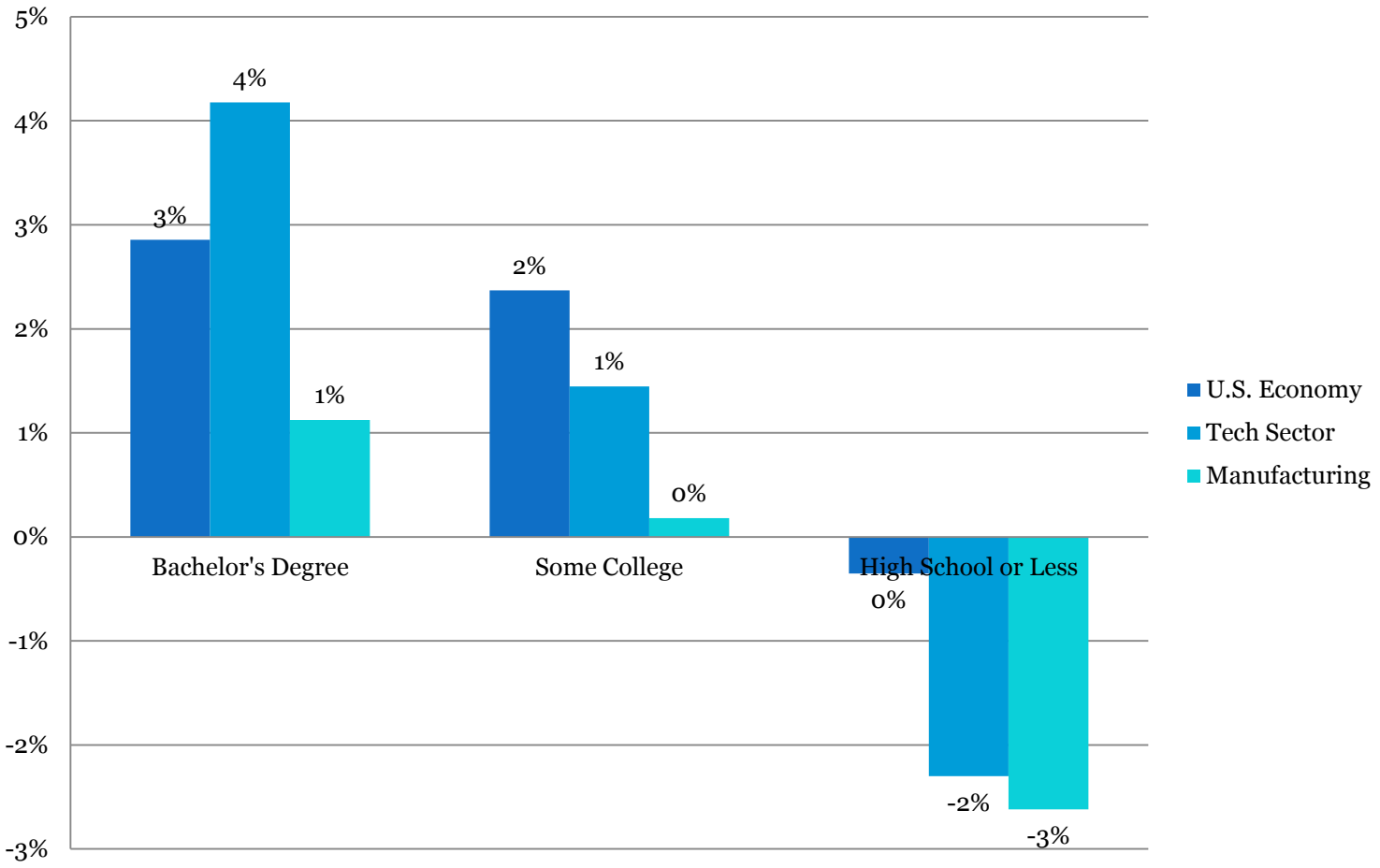


Source: U.S. Census microdata from IPUMS. Regression of ln income on dummy variable for bachelor's degree (or STEM occupation) controlling for cubic in age and sex for employed workers. Bachelor's premium compares only BA earners to high school graduates.

There are many more job openings than graduates for computer, math, and engineering occupations



Annualized Growth Rates in Net Employment by Education for U.S. Economy, Tech and Manufacturing Sectors, 1980-2011



2. Redefining the STEM Workforce

Problems with conventional STEM definitions

- No agreement among federal agencies
  - The NSF uses "Science and Engineering" labor force which roughly corresponds to occupations common to workers with a bachelor's degree in science or engineering fields.
  - 2012 BLS task force adopted very similar approach
  - Dept of Commerce used only part of the NSF definition and added a few occupations to it
- Arbitrary standards.
  - Not based on knowledge or skill requirements, otherwise doctors would be included
  - Not based on research and development activity, otherwise most computer workers would be excluded, as would social scientists
- Class bias?
  - Computer machine programmers and all blue collar occupations are excluded, but any computer worker in an office settings is counted.
  - Science lab technicians are often included, but not electricians
- What about STEM community college programs, industry certifications, etc?

The cure is O*NET

- Occupational Information Network Data Collection Program
- Department of Labor funded data collection program
- Provides the most comprehensive database of job attributes by occupation including education, training, experience, skill, knowledge, tools and technologies, interests, and activities

The Six Core STEM Domains in O*NET Knowledge Survey and Their Survey Anchors

Least Knowledge =1 → Highest Knowledge = 7

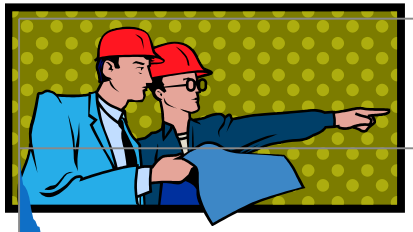
Scales for Science (Physics, Chemistry, Bio), Computers, Engineering, and Math

Computers and Electronics		
1	3	6
Operate a VCR to watch a pre-recorded training tape	Use a word processor	Create a program to scan computer disks for viruses

New Brookings definition of STEM

A STEM occupation is one that requires an extraordinary level of knowledge in one or more core STEM fields.

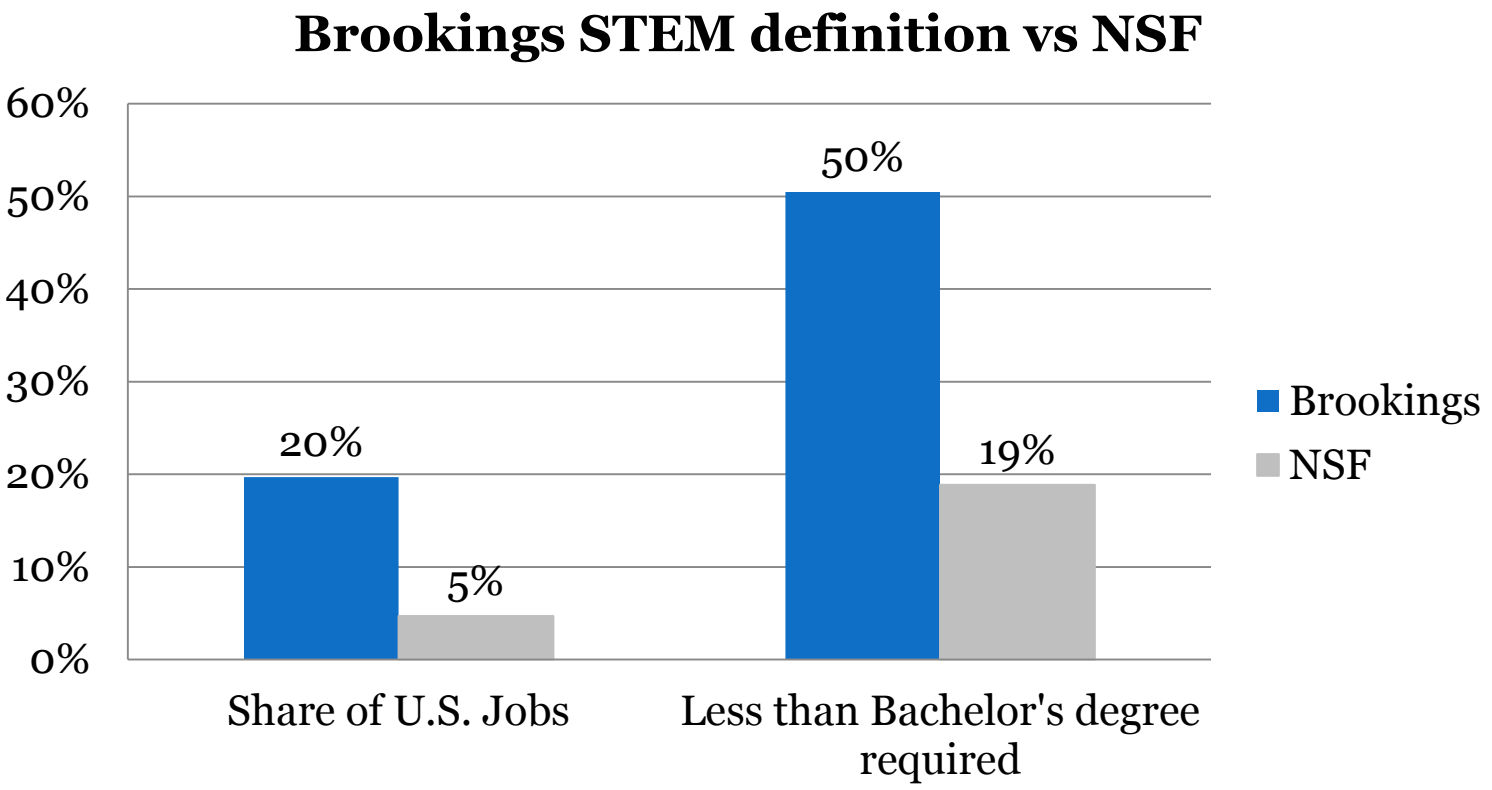
- Extraordinary, here, is defined as at least 1.5 standard deviations above the mean knowledge score for that field (just over 90th percentile), where science fields are grouped together as one
- Advantages over standard approach
  - Non-arbitrary and non-biased
  - Non-binary
  - Self-correcting
  - Comparability to other skills



STEM Score = Sum(Knowledge Score – Mean Knowledge Score)

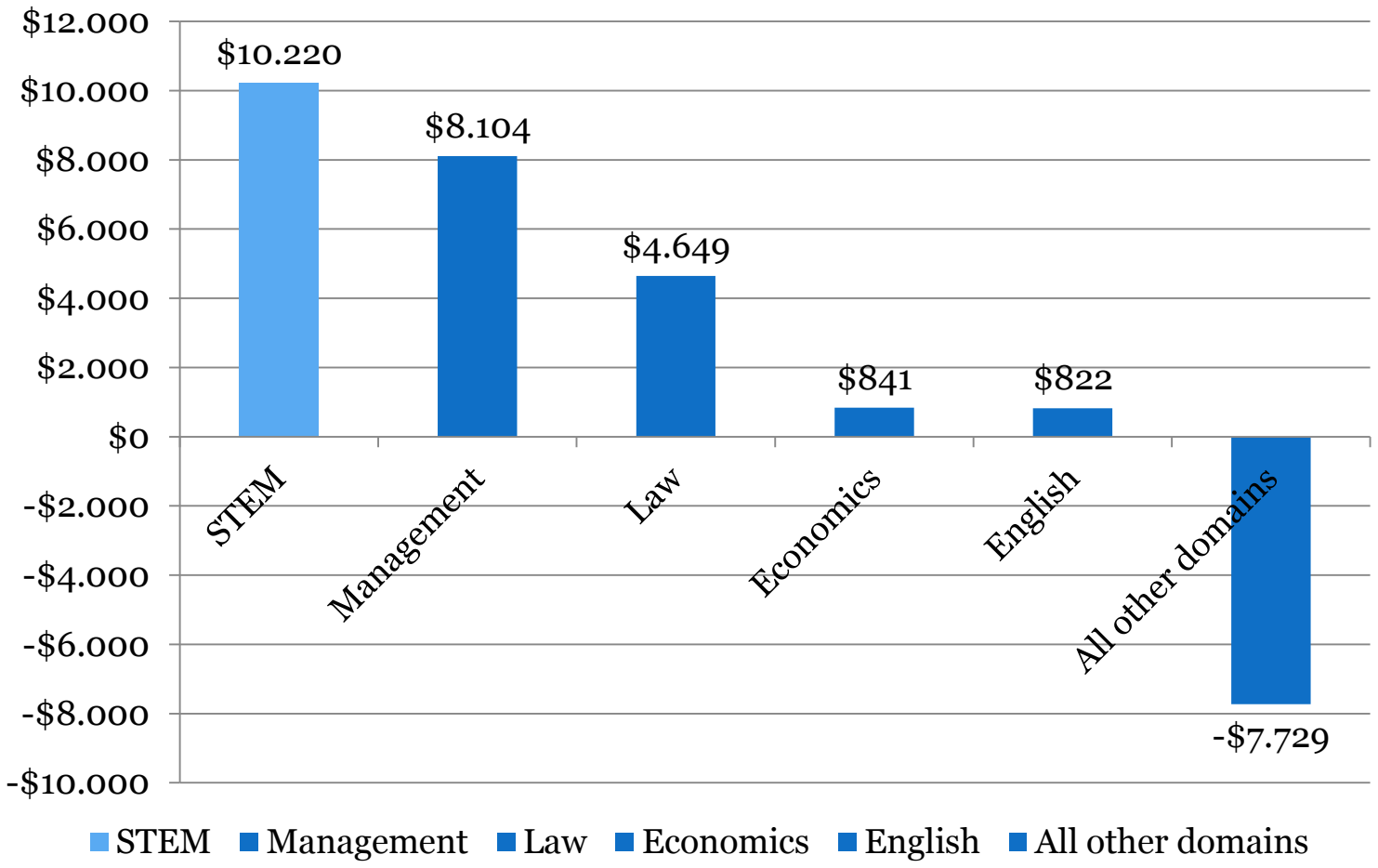
1.5 standard deviations above mean qualified for any field of STEM for binary definition

Results: More jobs, more career pathways to STEM



Source: 2011 BLS OES and O*NET

STEM knowledge is rewarded more than other types of knowledge



Marginal Effect of regression of median wages on standard deviation in STEM Knowledge for 719 detailed Occupations, controlling for Mode Education. Source: Brookings analysis of 2011 BLS OES and O*NET

3. The “hidden” STEM economy

Literature on Sub-bachelor's STEM contribution to innovation

- During industrial revolution:
  - Ross Thomson, *Structures of Change in the Mechanical Age: Technological Innovation in the United States, 1790 to 1865* (Johns Hopkins University Press, 2009);
  - Kenneth L. Sokoloff and B. Zorina Khan, "The Democratization of Invention during Early Industrialization: Evidence from the United States, 1790-1846," *Journal of Economic History* 50(2) (1990): 363-378;
  - Jacob Schmookler, "Inventors Past and Present," *Review of Economics and Statistics* 39(3) (1957): 321-333.
- Presently in terms of lower product defects, higher capacity utilization and efficiency, and R&D quality:
  - Philip Toner, "Workforce Skills and Innovation: An Overview Of Major Themes In The Literature" (Paris: OECD, 2011)

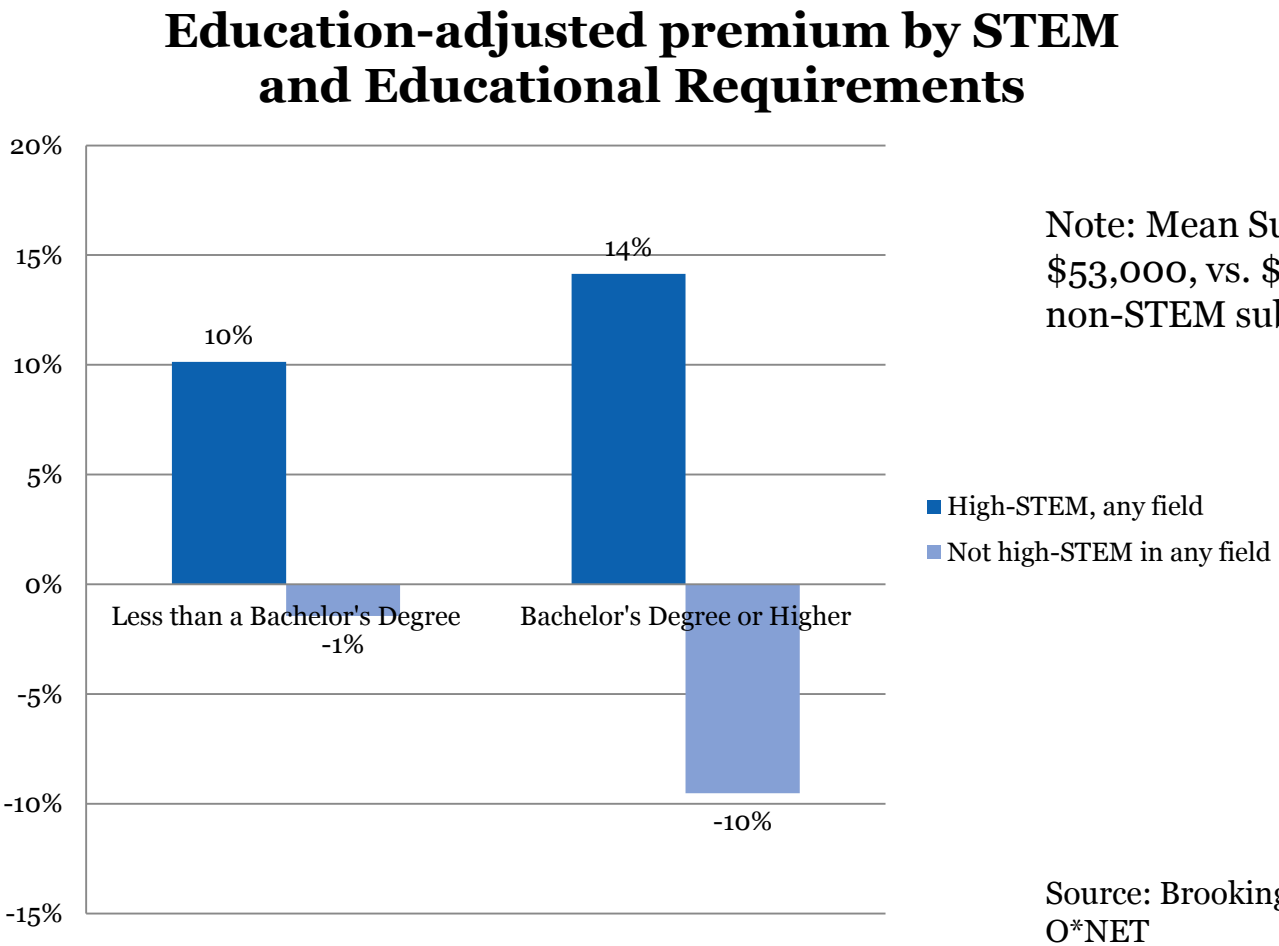
Selected Major Occupational Categories Sorted by STEM Score, with Share of Jobs that are STEM, and Share of U.S. STEM Jobs, 2011

	High-STEM, Percentage of Jobs	Share of U.S. High-STEM Jobs
Architecture and engineering	**100%**	**9%**
Life, physical, and social science	**87%**	**4%**
Healthcare practitioner and technical	76%	22%
Computer and mathematical science	**100%**	**13%**
Installation, maintenance, and repair	53%	10%
Management	27%	6%
Construction and extraction	40%	8%
. . .		
Production	23%	7%
. . .		
Food preparation and serving related	0%	0%
Healthcare support	5%	1%

Large source of STEM jobs

Usually considered 0% STEM

Both STEM Groups Enjoy a Substantial Skill Premium Beyond Education

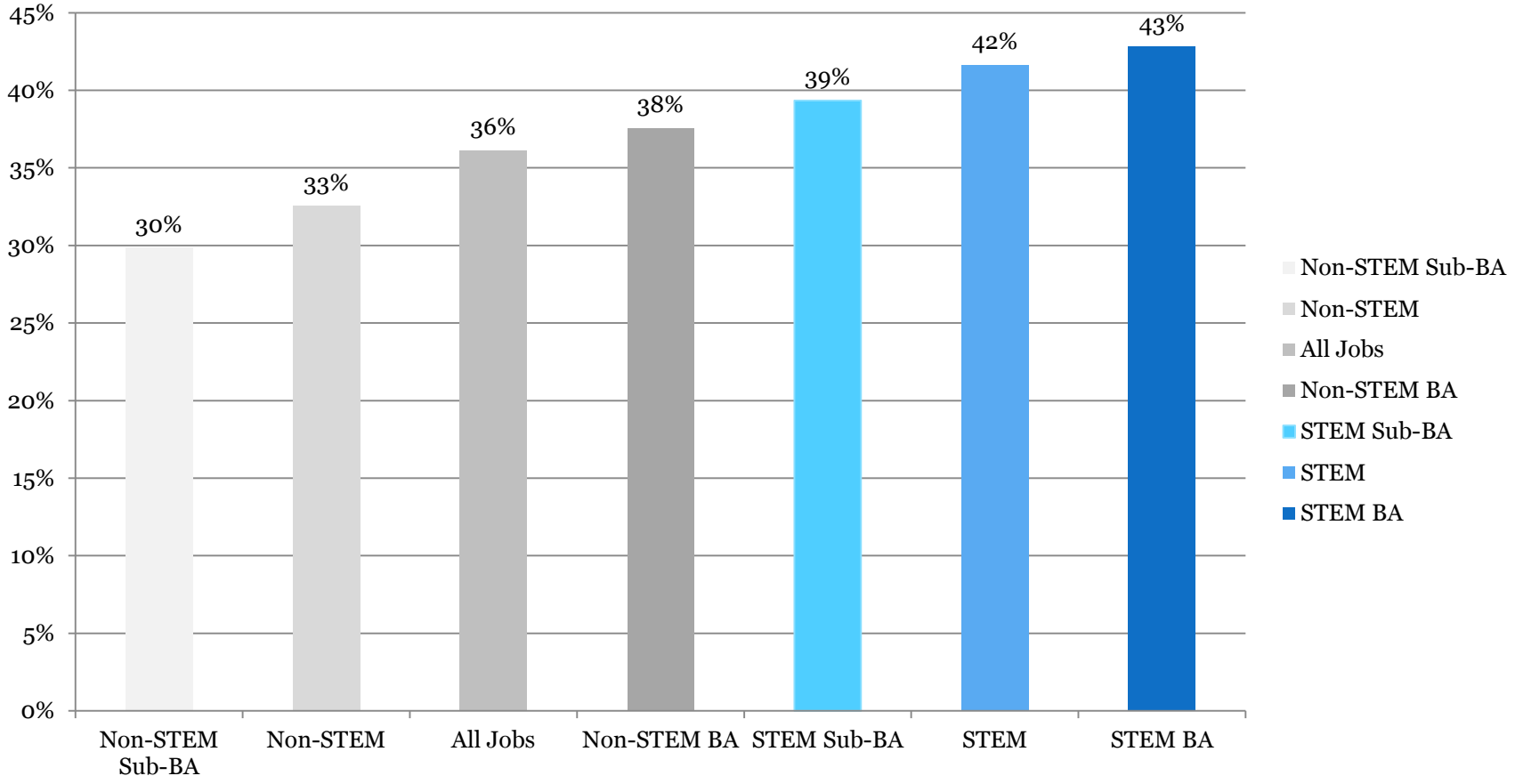


Note: Mean Sub-BA STEM Wage is $53,000, vs. $33,000 for those non-STEM sub-BA workers

Source: Brookings analysis of 2011 BLS OES and O*NET

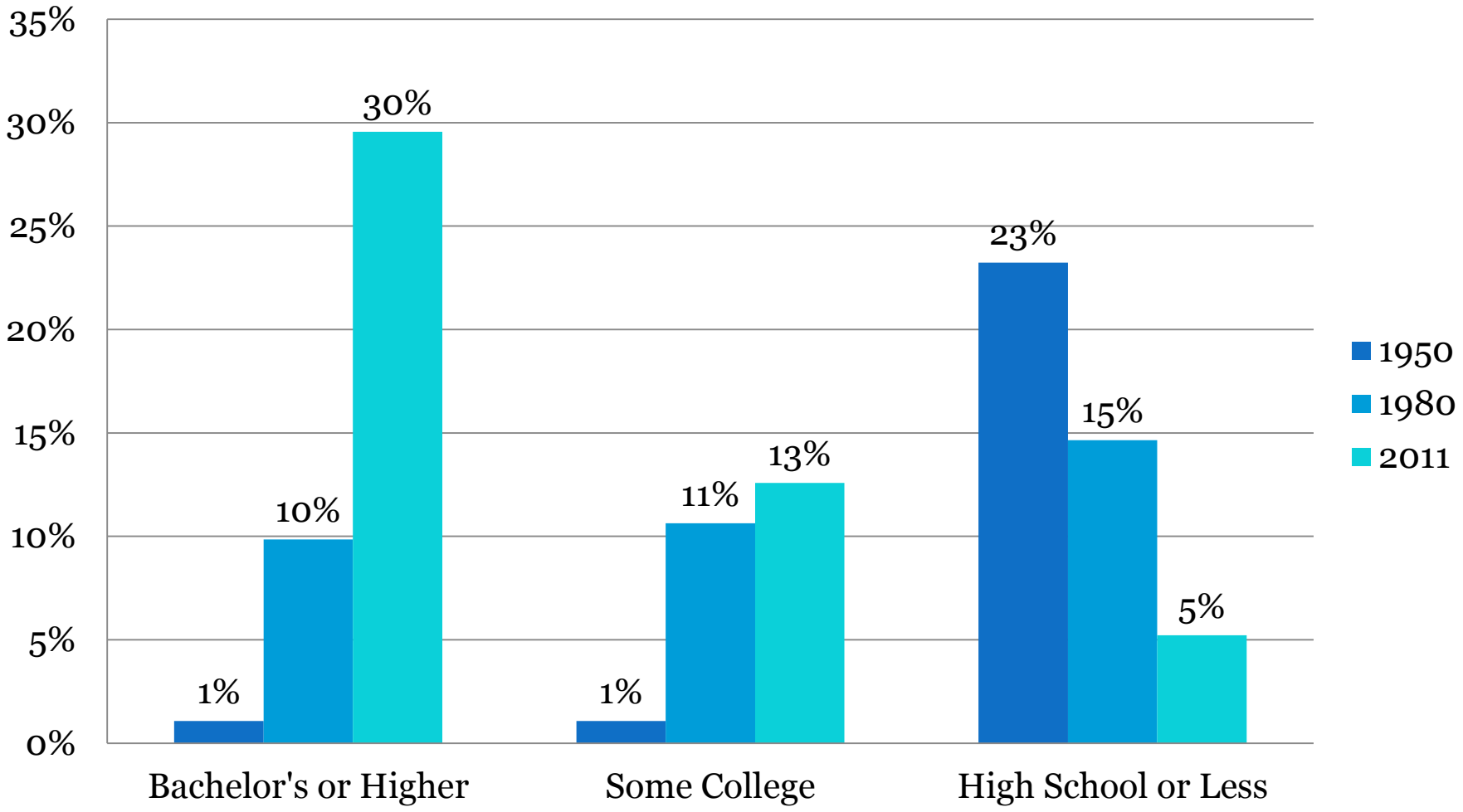
Sub-BA STEM jobs are hard-to-fill

Share of 2011 job openings re-posted after 30 days in 100 largest metropolitan areas



Brookings analysis of Conference Board Help Wanted On-Line and O*NET

Industry Up-Skilling:
STEM Share of Occupations in High-Tech Industries by Education of Workers, 1950-2011



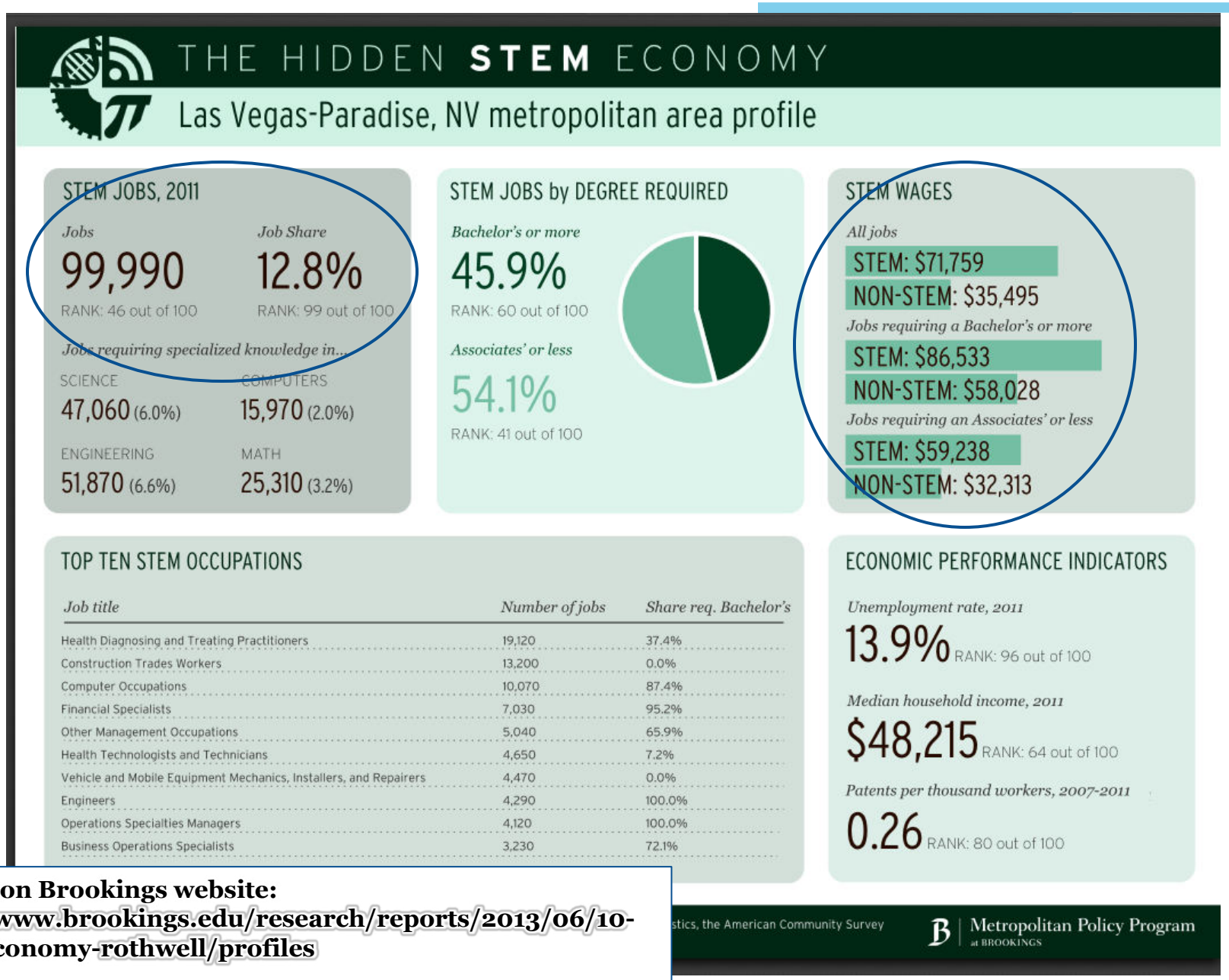
As it happens, STEM metros are:

- Richer
- More innovative
- More export-oriented
- More resilient to economic downturn
- Employ a larger share of their workers

5. Where Does Las Vegas Fit In?

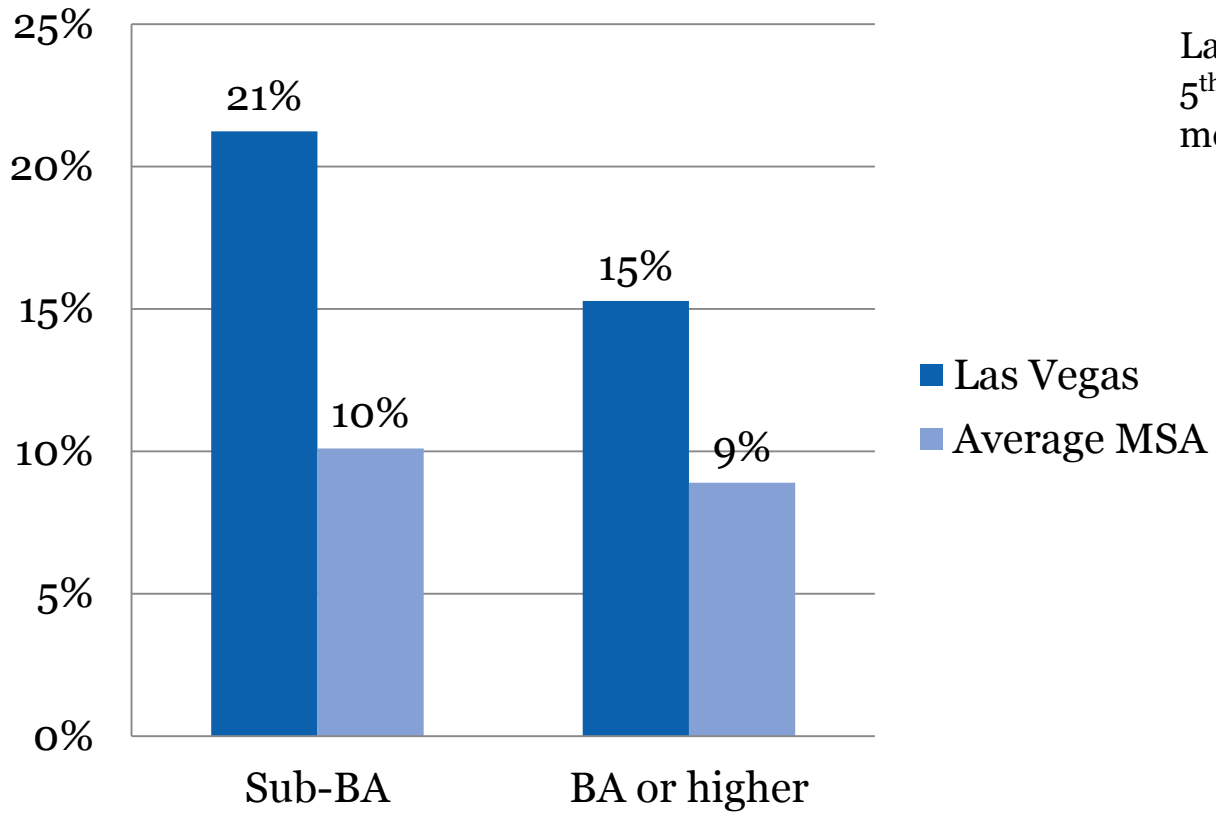
Las Vegas MSA's Ranking on Key STEM Metrics

	Rank out of 356-358 Metro Areas
Patents per worker, 2007-2011	215
Growth rate in productivity, 1980-2010	237
STEM Bachelor's degree attainment rate, 2011	247
Average unemployment rate, 1990-2010	244
STEM knowledge of average occupation	355
STEM Share of Employment	328
Change in STEM Share of Employment, 2007-2011	333



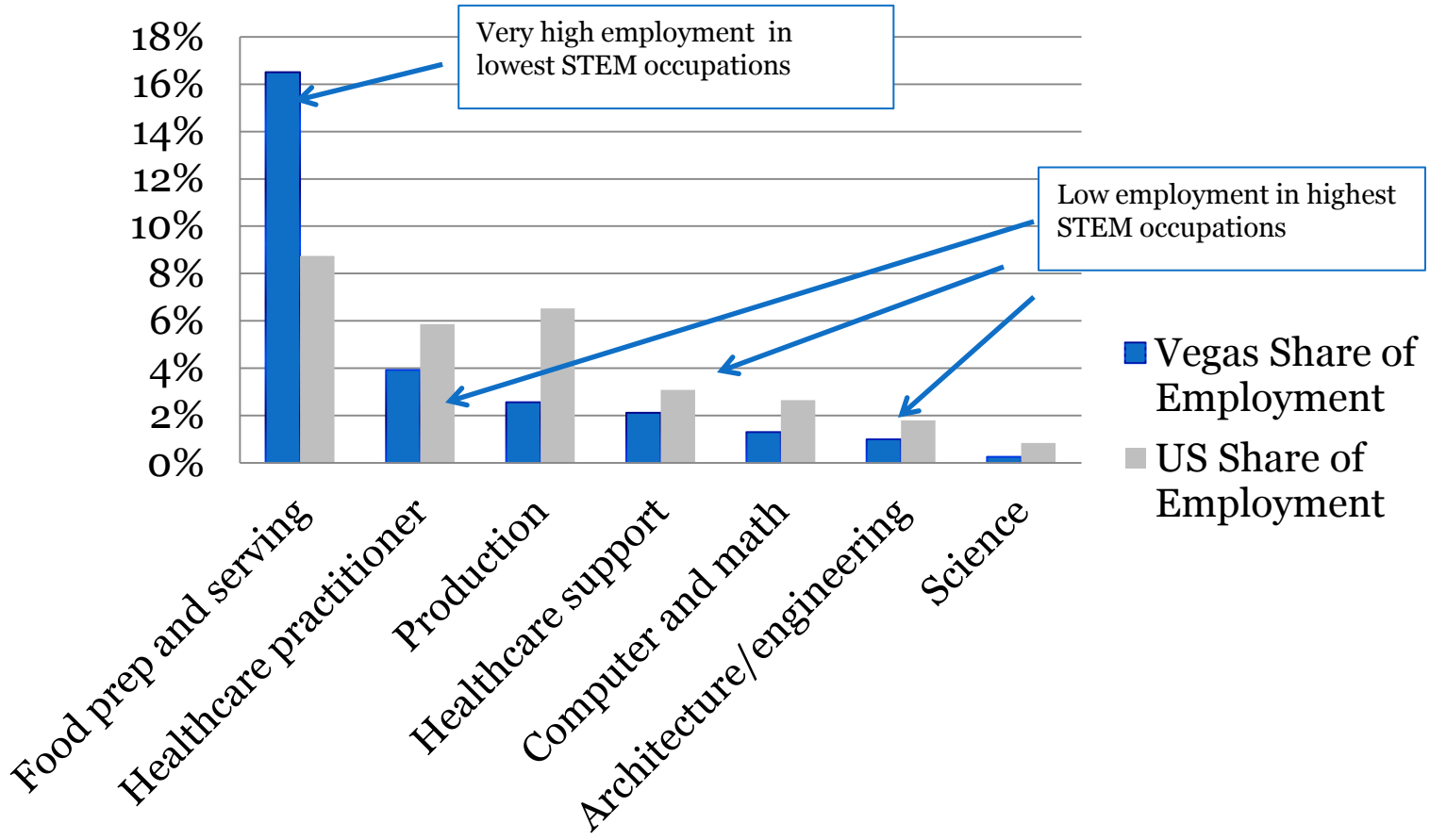
Profile on Brookings website: http://www.brookings.edu/research/reports/2013/06/10-stem-economy-rothwell/profiles

Education-adjusted Wage Premium for STEM Knowledge, Las Vegas vs MSA, by Education, 2012



Las Vegas STEM Premium = 5th highest in largest 100 metros; 22nd of 348

2011 Employment by Major Occupational Group in Las Vegas Compared to USA for Select Occupations



Source: BLS OES. Groups are sorted by LQ (MSA Share/USA Share). Only occupations with location quotient greater than 1.2 or less than 0.8 are shown.

Industries in Las Vegas with Highest Number of STEM Jobs in 2011

Industry	Jobs	Percentage of Workers in STEM Occupation	Average Salary	Share of STEM Workers with Less than Bachelor's Degree
Construction	81,220	42%	$27,072	90%
Hospitals	27,198	62%	$55,355	33%
Professional, Scientific, and Technical Services	56,867	29%	$44,893	44%
Ambulatory Health Care Services	39,015	27%	$40,233	30%
Repair and Maintenance	16,326	54%	$22,304	95%
Las Vegas Metropolitan Area	**1,135,137**	**15%**	**$30,422**	**65%**

Industries with at least 500 Jobs in Las Vegas with Highest STEM Knowledge per Worker in 2011

Industry	Jobs	Percentage of Workers in STEM Occupation	Average Salary	Share of STEM Workers with Less than Bachelor's Degree
Data Processing, Hosting and Related Services	701	73%	$75,000	76%
Mining (except Oil and Gas)	2,116	33%	$67,100	67%
Utilities	6,573	37%	$76,155	52%
Transportation Equipment Manufacturing	2,559	52%	$63,470	72%
Repair and Maintenance	16,326	54%	$22,304	95%
Construction	81,220	42%	$27,072	90%
Las Vegas Metropolitan Area	1,135,137	15%	$30,422	65%

Source: O*NET and American Community Survey, 2011 via IPUMS

5. Policies to boost STEM knowledge

How to boost demand for STEM

- Adopt cluster focus on growing STEM industries
  - Skills, finance, infrastructure
- Foster entrepreneurship
  - E.g. non-profit incubators
- Attract FDI
  - Tax policy, marketing
- Research Universities
  - R&D budget, SBIR, partnerships with industry
- State Fiscal Incentives
  - R&D tax credits, investment funds

How to boost the Supply of STEM

- Improve K-12 Quality
  - STEM targeted magnet schools (NYC, Chicago) or high school curriculum (Virginia Beach) or non-profit programs (MESA in California)
- Expand capacity of universities and community colleges
  - Adopt best practices in recruitment & retention
- Attract STEM-oriented establishments and their workers
- Improve workforce development
  - Intermediation
  - Public (WIBs) or private training (apprenticeships)

More for information

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Brookings homepage:
www.brookings.edu

Hidden STEM Economy report page:
http://www.brookings.edu/research/reports/2013/06/10-stem-economy-rothwell

Supplemental data

Federal Government funding for STEM Education-related Programs by Primary Objective

	Millions of Dollars, approximate	Share of Total
Bachelor's degree or higher STEM Education	$1,942	45%
Training or sub-bachelor's level degree education (upper limit*)	$940	22%
Education Research and Development	$519	12%
Pre- and In-Service Educators	$312	7%
Public Learning	$296	7%
Engagement of Children	$162	4%
Institutional Capacity	$137	3%
Total federal funding for STEM training or education	**$4,308**	

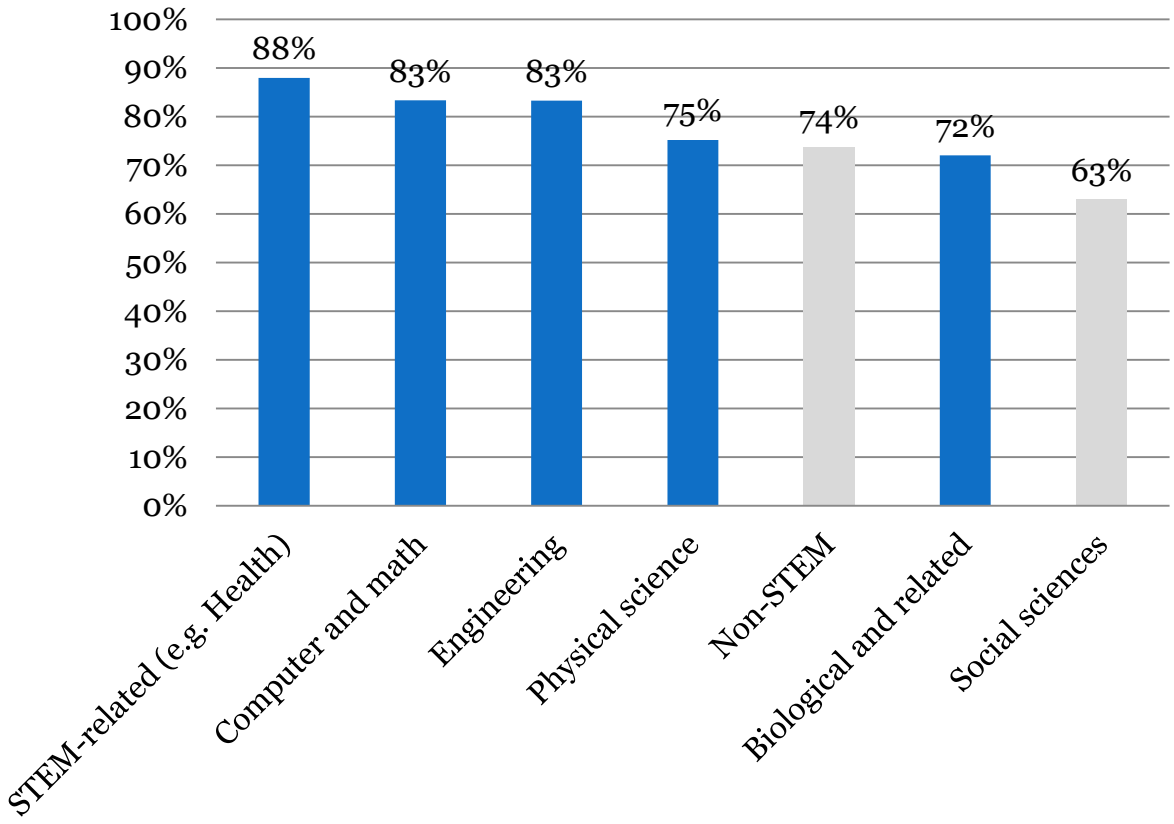
Data is for fiscal year 2010, except the training and sub-bachelor's level degree funded, which is for 2012.Sources: National Science and Technology Council, Department of Labor's Trade Adjustment Assistance Community College and Career Training Grant and H1B Technical Skills Training Grants.
*These funds are not exclusively dedicated to STEM degrees or careers.

Manufacturing Industries Ranked by STEM Score, by STEM Share of Jobs and Share of STEM Jobs held by those with bachelor's degree or higher

	STEM Share of Jobs	Share of STEM workers with BA or higher
Computer and Electronic Product	**46%**	**60%**
Petroleum and Coal Products	46%	34%
Chemical	**35%**	**54%**
Transportation Equipment	41%	41%
Machinery	40%	26%
Fabricated Metal Product	41%	12%
Electrical Equipment, Appliance, and Component	31%	39%
Primary Metal	31%	20%
ALL	35%	9%
Plastics and Rubber Products	21%	23%
Miscellaneous	24%	37%
Paper	24%	29%
Beverage and Tobacco Product	20%	36%
Nonmetallic Mineral Product	22%	24%
Wood Product	19%	12%
Food	15%	24%
Printing and Related Support Activities	16%	27%
Furniture and Related Product	18%	19%
Leather and Allied Product	13%	30%
Textile Mills	18%	19%
Textile Product Mills	12%	18%
Apparel	8%	27%

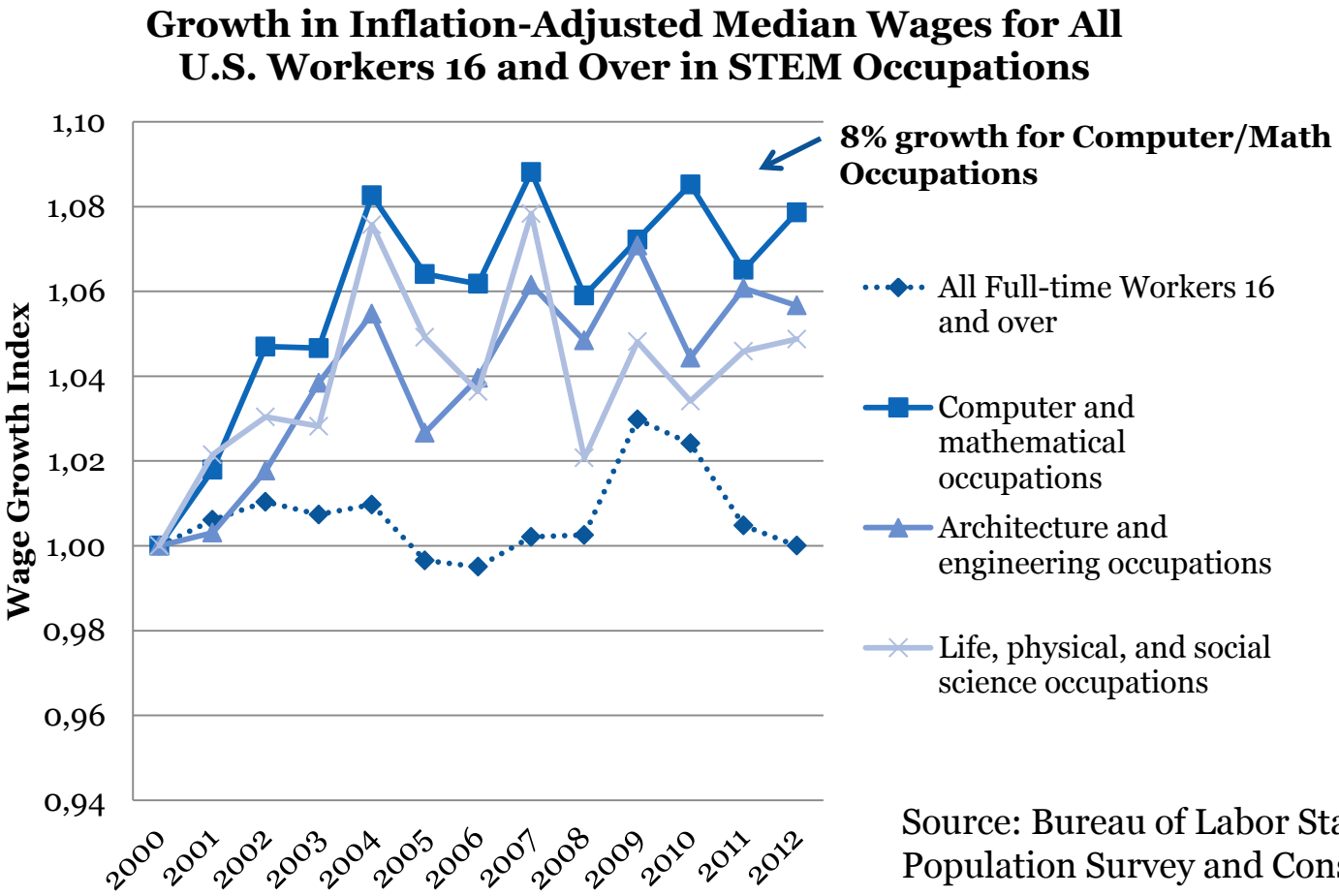
Brookings analysis of O*NET and American Community Survey via IPUMS.

STEM degree holders are the most likely to be working in jobs related to their field of study



Source: Brookings analysis of 2010 National Survey of College Graduates

STEM occupations earn high and growing wages



Source: Bureau of Labor Statistics Current Population Survey and Consumer Price Index

Students drop out of STEM majors at higher rates

A. National longitudinal survey data show 36% of students who start as STEM majors switch to other fields
B. Data from Ohio Board of Regents show 57% of students who select a STEM major when taking the ACT do not finish as STEM majors
C. One explanation is that grades are lower than expected

- References: Xianglei Chen and Thomas Weko, "Students Who Study Science, Technology, Engineering, and Mathematics (STEM) in Postsecondary Education" (National Center for Education Statistics, 2009); Eric Bettinger, "To Be or Not to Be: Major Choices in Budding Scientists" In Charles T. Clotfelter, ed., *American Universities in a Global Market,* Chapter 2 (Chicago: University of Chicago Press, 2010); Todd Stinebrickner and Ralph Stinebrickner, "Math or Science? Using Longitudinal Expectations Data to Examine the Process of Choosing a College Major," Working Paper (The University of Western Ontario, 2012).

Change in STEM Jobs, 1980-2011