RESOURCE-BASED THEORY AND STEM WORKFORCE DYNAMICS: STRATEGIC IMPLICATIONS FOR BUSINESSES AND REGIONS

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ABSTRACT

This study assesses STEM (Science, Technology, Engineering, and Mathematics) workforce dynamics within the context of the resource-based view. As STEM skills may be considered a region's or a business's core competency, there has been ongoing debate about whether the U.S. has shortages in STEM fields. Using several databases (Bureau of Labor Statistics, Kauffman Foundation Survey, American Community Survey, and MTSU STEM Survey), this study seeks answers to the following questions: Is the STEM shortage a myth? What impact may a STEM skill shortage have on businesses and regions? How is STEM training related to entrepreneurial activities? The study findings suggest the lack of the right STEM skill set may have important business and regional implications.

INTRODUCTION

STEM Workforce Dynamics

What is the STEM workforce? A review of several studies shows there is no consensus on what the STEM workforce should include.[1] A recent study suggests the studies use different frameworks to analyze the STEM workforce (Arik, 2016). In terms of the meaning of the STEM workforce, two general definitions emerge: (1) individuals in a STEM occupation, or (2) individuals holding a STEM degree.

Although a hybrid approach combining both definitions may provide a better understanding of the STEM workforce, the former is easily quantifiable for research purposes. Which occupations then should be considered STEM occupations? The following options are widely used by individual researchers and agencies: STEM occupations, STEM-related occupations, and (sometimes) social science occupations.

In this study, we use an occupational definition of the STEM workforce. Consistent with the definition of the U.S. Census Bureau, the occupation-based approach includes both STEM and STEM-related occupations, including several social science occupations. Why is the STEM and STEM-related workforce important to an economy? Since the early 1990s, fast-paced economic transformations within the United States and across the globe have dramatically reduced industry and product life cycles. This in turn has created tremendous challenges and opportunities. For example, Tennessee lost its traditional manufacturing base throughout the 1990s and 2000s. Only during the past decade has the state started rebuilding its manufacturing base, not in traditional

[1] See multiple reports and crosswalks developed by the National Science Foundation (www.nsf.gov), U.S. Census Bureau (www.census.gov), and Bureau of Labor Statistics (www.bls.gov).

sectors such as textiles and furniture but in the advanced manufacturing and automotive sectors. In this transformed manufacturing space, the STEM workforce plays a critical role as a driver of innovation and competitiveness (Arik, 2016).

In Tennessee, for example, the main sectors driving the economy are advanced manufacturing, automotive, professional and business services, health care, transportation, and logistics. To compete globally, these sectors require well-trained STEM and STEM-related workforce.

What are some characteristics of STEM occupations? One important aspect of the STEM workforce is that individuals in these occupations are highly educated. For example, the percent of bachelor's degree holders in STEM occupations is twice as high as the percent of bachelor's degree holders in all other occupations in Tennessee. These ratios have two implications for any economy. First, wages and salaries are closely related to educational attainment levels; the higher the educational attainment level of the workforce, the higher the purchasing power of individuals in the economy. Second, a highly educated workforce is a major source of innovation and entrepreneurial activity (Arik, 2016).

However, in terms of STEM workforce characteristics, two issues require further elaboration. First, not all workers in STEM occupations have a bachelor's degree or above; many technical occupations that play a critical role in highly competitive industries require only specific training after high school. Second, not all individuals in STEM occupations have STEM degrees. For example, a STEM survey conducted by the Business and Economic Research Center (BERC) at Middle Tennessee State University indicates that about 65 percent of STEM workers in Tennessee have STEM degrees. The remaining 35 percent have degrees in other fields or no degree beyond high school. This means either companies are facing difficulty hiring employees with the right credentials, or STEM degree holders are not seeking opportunities in their areas of expertise (Arik, 2016).[2]

The STEM Debate

Recently there has been a call for better STEM (science, technology, engineering, and mathematics) education in the United States. This comes after seeing declining U.S. international test scores in math and science as well as a shortage of skilled STEM workers in the economy. However, there has been ongoing debate over the extent of emphasis on education in STEM versus the humanities as well as the meaning of STEM education.

Education in the United States is controlled by the states, meaning states differ in STEM education. In the past several years, many states have decided to give more incentives and scholarships to college students in STEM majors. Often companies must hire underqualified employees, such as those with two-year degrees or high school diplomas, to fill positions that would normally go to those with a bachelor's or master's degree (Berman, 2016). These vacancies have led companies to petition the government to allow for more H1-B visas (Rothwell and Ruiz, 2013), which go to foreign workers in STEM or highly specialized careers and allow them to work for businesses in the United States. According to businesses and some industry insiders, many businesses cannot fill job vacancies for STEM occupations, and there are not enough H1-B visas to go around. Due to this (and contrary to what some believe), H1-B visa workers are getting paid more than U.S. native-born workers with a bachelor's degree, even with the same occupation and similar experience, which suggests that foreign workers have more in-demand skills. Many of the

[2] This part of the analysis is heavily based on a white paper issued by one of the study authors in 2016 (Arik, 2016).

H1-B visa occupations, however, could be filled by U.S. natives with some training at relatively little cost (Rothwell and Ruiz, 2013).

The competition for qualified workers has led many companies to consider providing signing bonuses for graduating college students looking for jobs in STEM fields, especially in engineering and computer science (Otani, 2014). In order to encourage students to go into STEM occupations, President Obama has created a program called the Educate to Innovate initiative. Several different outlets have launched programs and media designed to inspire students' STEM curiosity. Unfortunately, the initiative has been slow to produce any change in test scores or level of interest in STEM degrees (Chang, 2014).

However, this shift to providing more funding and resources for STEM education has led some to argue that states and colleges should not forget about the humanities and liberal arts. Fareed Zakaria, in his article "Why America's Obsession with STEM Education Is Dangerous," calls for a holistic approach to education, arguing the focus should not be entirely on STEM. He also writes that the understanding of culture and politics is integral to the human condition (Zakaria, 2015). This article sparked a rebuttal by Chad Orzel in *Forbes*, in which he argued that curiosity about how the world works is also inherent in the human condition and that the sciences attempt to answer those questions (Orzel, 2015). For example, A few states have discouraged students from studying the humanities by decreasing state funding for those majors (Cohen, 2016). This is designed to increase the number of students going into STEM careers, as qualified STEM employees are in high demand, and many companies across the country are seeking more employees to fill these positions.

Another debated aspect of STEM education is that it needs to be redefined to include art due to the creative components of engineering and technology. Several engineering programs in universities throughout the country are beginning to incorporate art classes into their curriculum, such as basic drawing and graphic design (Fountain, 2014). This has led to an initiative to change STEM to STEAM: science, technology, engineering, art, and mathematics.

Opponents to the emphasis of STEM education have contended some careers that are more STEM-based actually require a diverse educational background in order to create better work environments and different outlooks. The *Economist* cites a story about anthropologists working on Wall Street who can see the overall picture and thus put finance in a cultural context (M.S., 2011). Another example from *Forbes* cites the many great thinkers and business people who have taken interest both the humanities and STEM: Leonardo da Vinci, Steve Jobs, and Admiral Grace Hopper.

In addition to these arguments, some studies have found there is a surplus of native STEM workers. However, they are not necessarily in the selected fields an industry is seeking or have left the STEM field for careers in other areas, such as finance or business (Anft, 2013). Once graduates find jobs, they often face difficulties in getting promotions or raises. In a statement before Congress in 2016, Hal Salzman, a professor at Rutgers University, provided evidence that only half of STEM graduates enter the STEM workforce and that there is a glut of scientists at the Ph.D. level due to the lack of research funding. He argues that despite the call for more H1-B visas, there is a substantial number of layoffs in the STEM industry, ranging from 696,000 in 2001 to 37,000 in 2011 (The Impact of High-Skilled Immigration on U.S. Workers, 2016).

Despite the debate, most agree the United States is underperforming in STEM and agree there should be an amplification of STEM education in schools. Businesses are struggling to find employees with the proper qualifications for STEM careers, and those positions go unfilled or go to underqualified people. While the debate over whether there is a shortage in the STEM fields and the extent to which STEM education should be incentivized over other fields of study has continued, one thing is clear: the labor market in certain STEM fields is extremely tight, suggesting skilled workforce shortages in those fields. Table 1 compares the current unemployment rate in the United States with the unemployment rates in some of the fastest-growing STEM occupations.

Table 1: Characteristics of the Fastest Growing Occupations in the U.S.: Tight Labor Market for STEM Occupations

2014 National Employment Matrix title and code		Change, 2014-24		Median annual wage, 2015	2014 Unemployment Rate	Significant Source of Training		
U.S. Unemployment Rate: 4.9 % (June 2016)		Number	Percent			Some College	Bachelors Degree	Graduate Degree
Total, all occupations	00-0000	9,788.9	6.5	$36,200				
Nurse practitioners	29-1171	44.7	35.2	$98,190	1.30%			93%
Physical therapists	29-1123	71.8	34.0	$84,020	1.20%		8%	76%
Statisticians	15-2041	10.1	33.8	$80,110	4.00%		28%	68%
Physician assistants	29-1071	28.7	30.4	$98,180	0.20%		30%	65%
Operations research analysts	15-2031	27.6	30.2	$78,630	3.80%		30%	67%
Web developers	15-1134	39.5	26.6	$64,970	3.40%	33%	43%	
Occupational therapists	29-1122	30.4	26.5	$80,150	1.10%		19%	76%
Diagnostic medical sonographers	29-2032	16.0	26.4	$68,970	1.90%	66%	17%	
Emergency medical technicians and paramedics	29-2041	58.5	24.2	$31,980	3.00%	85%		

Source: (1) Data are from the Occupational Employment Statistics program, U.S. Bureau of Labor Statistics.
(2) Wall Street Journal: http://247wallst.com/investing/2015/01/16/unemployment-by-occupation-2014/
(3) O*Net Online (onetonline.org)

In order to understand the effect of a STEM shortage on the economy, this study will consider STEM as a core competency. Core competency can be defined as "the ability to build, integrate and reconfigure internal and external competencies to address rapidly changing environments" (Hsu, Tan, Jayaram, and Laosirihongthong, 2014). STEM is an important resource that can benefit the economy through business and entrepreneurship. Specifically, we aim to answer three questions:

(1) Is the STEM shortage a myth?
(2) What impact may a STEM skill shortage have on businesses and regions?
(3) How is STEM training related to entrepreneurial activities?

To answer these questions, this paper draws on a widely used strategic management theory, the resource-based view (RBV).

THEORETICAL FRAMEWORK

Resource-Based View

Made popular by Wernerfelt (1984) and Prahalad and Hamel (1990), the resource-based view argues resources are what make an organization competitive in the marketplace. If these resources are sustainable, they can become the core competencies of organizations. Core competencies of successful firms are described as rare, hard to imitate, and valuable to others (Wernerfelt, 1984; Prahalad & Hamel, 1990). According to this theoretical perspective, to maintain the competitive advantage, firms must utilize resources and capabilities that are valuable (Ray, Barney, & Muhanna, 2004).

How does this perspective treat human capital? Although a significant emphasis has been placed on the role of tangible assets such as technology within the framework of this perspective, human resources have also been treated as a significant source of competitive advantage and should be assessed strategically (Wofford, 2002; Evans & Novicevic, 2010). This study treats the STEM workforce as a core competency. Especially in an advanced manufacturing and innovation-driven economy, a sustainable STEM workforce pipeline may create a sustainable competitive advantage for companies and regions.

Myth of the STEM Shortage: Skill Gap

When treating the STEM workforce as a valuable source of competitive advantage, a skill shortage in this area may increase a firm's cost of doing business. Often companies must hire underqualified employees, such as those with two-year degrees or high school diplomas, to fill positions that would normally go to those with a bachelor's or master's degree (Berman, 2016). These vacancies have led companies to petition the government to allow for more H1-B visas (Rothwell and Ruiz, 2013). These visas go to foreign workers in STEM or highly specialized careers and allow them to work for businesses here. Many of these businesses cannot fill job vacancies for STEM occupations, and there are not enough H1-B visas to go around. Due to this, H1-B visa workers are getting paid more than U.S. native-born workers with a bachelor's degree, even with the same occupation and similar experience, which suggests foreign workers have more in-demand skills. Many of the H1-B visa occupations could be filled by U.S. natives with some training at relatively little cost (Rothwell and Ruiz, 2013). This study addresses the STEM shortage issue by highlighting two aspects of STEM workforce dynamics, the skill gap in the existing STEM workforce and actual shortages in critical STEM occupations.

STEM in Businesses and Regions

Where do our regions or businesses rank compared with our peers? The impact of STEM shortages and skill gaps affect not only the competitiveness of firms but also the growth potential of a region. From a resource-based perspective, communities with rare STEM skill sets can provide organizations with capabilities that will also make the whole region competitive. From a regional perspective, a company looking to establish a business location will carefully review the availability of STEM workforce in different areas before selecting one. If firms choose a location based on the availability of STEM skill sets, we expect areas with more highly skilled and more knowledgeable people to be attractive business destinations. This location decision will ultimately benefit both businesses and communities (Henderson, 2002). However, we also expect to see regions with high STEM skill shortages losing businesses to other regions. When facing a challenge regarding STEM skill sets, a likely course of action for businesses is to relocate to regions with an available STEM workforce.

STEM and Entrepreneurial Activities

With the shortage of STEM workforce, there is difficulty in the development of new engineering and technology firms. Part of the issue is the high demand for new technology and knowledge production in the U.S. economy (ASHE Higher Education Report, 2009). Additionally, many college graduates in STEM majors do not go into entrepreneurship but into already established firms or research positions. According to a Kauffman Foundation report, the number of new and young high-tech firms in the United States fell sharply after the recession and in 2012 was still lower than pre-recession levels. As these firms make up a large proportion of net new jobs overall, the loss of these new firms is significant to the economy (Haltiwanger, Hathaway, and Miranda, 2014).

In terms of the relationship between STEM education and entrepreneurship across countries, generally education beyond a bachelor's degree does not seem to be positively linked to entrepreneurship (Dickson, Solomon, and Weaver, 2008). However, the type of STEM degree makes a difference; for example, those in bioengineering are most likely to enter entrepreneurship at 12 percent, while those in mathematics and statistics are least likely, with only 3 percent becoming entrepreneurs (Blume-Kohout, 2014). A U.S. Small Business Administration study reached a similar conclusion, highlighting the fact that high-tech startup founders rarely hold doctorates in computer science and that those in engineering fields are more likely to engage in entrepreneurship, although they still represent a small percentage.

Despite the low interest of STEM graduates in entrepreneurial activities, there is a correlation between bachelor's degrees in general and entrepreneurship. Students who graduate with a bachelor's degree are more likely to enter into entrepreneurship (Jiménez, Palmero-Cámara, Gonzálex-Santos, González-Bernal, and Jiménez-Equizábal, 2015). In addition, many universities are working to provide interdisciplinary degrees for STEM majors in order to give them business and entrepreneurship training for future careers (Ford, O'Neal, and Sullivan, 2010).

This study treats the STEM skill set as a valuable resource that can be a competitive advantage for businesses and regions. In the absence of these skill sets, businesses may find themselves operating at higher costs due and losing a competitive advantage in the long run or relocating to other areas, and regions may have fewer innovative and high-tech entrepreneurial activities than regions with strong skill sets.

Using national and Tennessee data from several surveys, we carefully address each of the major debates highlighted above.

RESEARCH METHOD

Methods and Sample

In 2015, the Business and Economic Research Center (BERC) surveyed Tennessee businesses to analyze STEM workforce dynamics. BERC received 210 completed surveys representing a wide range of community stakeholders. The lengthy survey included questions in the areas of company demographics, STEM supply, STEM demand, STEM pipeline, STEM workforce characteristics, business perceptions about STEM dynamics, and STEM occupational characteristics.

Table 2: BERC STEM Survey		
Who are the respondents?		
Segment	Responses	Percent
Businesses (including schools)	137	65.24%
Economic Development Officials	25	11.90%
Mayors	17	8.10%
Schools (K-12 + Colleges)	31	14.76%
Total	210	100.00%

Myth of Shortages

In addition to asking community stakeholders directly about current workforce shortages in STEM occupations, BERC gathered supplemental information to highlight critical skill gaps across major STEM occupations. Many of these analyses use the Census Bureau's American Community Survey data. The BERC survey asked businesses to report critical occupations in which they have extreme difficulty filling jobs.

Challenges to Businesses and Regions

Survey respondents were asked specifically about the type of challenges they face with regard to the STEM workforce. One specific area we tried to assess was the likely response of businesses to mounting STEM workforce challenges. Some of these questions include:

(1) What happens if you cannot fill STEM-related positions?
(2) What is your business willing to do to fill unoccupied STEM positions?

Entrepreneurial Activity and STEM

To analyze the relationship between STEM education and entrepreneurial activity, we used two sources of survey data, the American Community Survey (2009–2014) and the Kauffman Foundation entrepreneurship activity survey (2014). We used microdata to test the relationship between entrepreneurial activity and education (STEM) using several control variables.

Models

To test the relationship between STEM education and entrepreneurial activities, we used the following logistic regression analysis specified as

$$ENTR_i = \alpha_1 + \beta_1 IMM + \beta_2 AGE + \beta_3 INCOME + \beta_4 EDUC + \beta_5 SCI + \varepsilon \quad (1)$$

Where $ENTR_i =$ Entrepreneurship indicators that take one of the two values [1=entrepreneur; and 0=not entrepreneur]. "i" subscript refers to different versions of the model. We used three different versions using both Kauffman Foundation and Census Bureau Surveys:

(1) recoded "incorporated self-employed"; (2) recoded "unincorporated self-employed;" and (3) recoded "total self-employed."

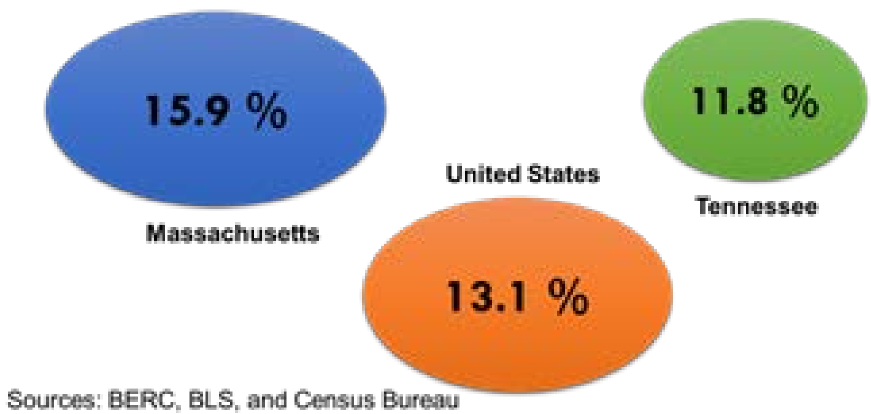
IMM = Immigrant control variable [1= immigrant; and 0= native]
AGE = Age of respondent [in natural log]
$INCOME$ = Income of respondent [in natural log]
$EDUC$ = Educational attainment level of respondent (in years) [in natural log]
SCI = STEM indicator [1=STEM-related degree field; and 0= all other fields]

This study used the logistic regression analysis because the dependent variable (entrepreneurship) included two discrete values.

RESULTS

Is the STEM shortage a myth or reality? We look at this question from two perspectives: (1) the existing skill gap in STEM fields, and (2) hard-to-fill STEM occupations. An analysis of American Community Survey data suggests Tennessee is behind the U.S. average in the percent of STEM workers in all occupations. According to Figure 1, 11.8 percent of Tennessee workers are in a STEM or STEM-related occupation, far below the U.S. average.

Figure 1



In addition, a skill-gap analysis shows that in certain occupations STEM skill gaps are above 33 percentage points. Table 3 suggests a major challenge for Tennessee businesses. Many STEM occupations are filled by individuals who do not have the skill set those occupations require. For example, in the United States, nearly 69 percent of marine engineers and naval architects have an educational attainment level of bachelor's and above, while in Tennessee only 34 percent of job holders in this occupation have similar qualifications, suggesting a skill gap of nearly 35 percentage points. In the long run, if unaddressed, this STEM skill deficit may affect the sustainable competitive advantage of Tennessee's businesses and economy.

Table 3: STEM Skill Gaps

SOC	Occupations	U.S. Bachelor's & Above	TN Bachelor's and Above	Skill GAP (Percentage Point)
172121	Marine engineers and naval architects	68.69%	34.18%	34.51%
151143	Computer network architects	55.41%	22.11%	33.31%
1930XX	Miscellaneous social scientists and related workers	88.64%	57.64%	31.00%
194031	Chemical technicians	39.53%	17.49%	22.04%
1721XX	Enginers, all other	78.57%	56.75%	21.83%
15113X	Software developers, applications and systems software	84.01%	70.19%	13.82%
1910XX	Life scientists, all other	98.52%	85.72%	12.80%
292050	Health practitioner support technologists and technicians	19.17%	6.56%	12.60%
172110	Industrial engineers, including health and safety	72.90%	60.67%	12.23%
172070	Electrical and electronics engineers	77.82%	65.65%	12.18%
191020	Biological scientists	95.88%	84.14%	11.74%
292071	Medical records and health information technicians	17.55%	6.46%	11.10%

We also asked businesses whether they are having any difficulty in filling STEM and STEM-related positions. Table 4 highlights responses from the survey. Participating community stakeholders ranked occupations from 1 to 10 in order of difficulty in filling jobs. A rank of one means an occupation is extremely easy to fill, and a rank of 10 means an occupation is extremely difficult to fill. BERC aggregated results into a master list that provides an average ranking of the difficulty of filling each occupation (Arik, 2016). This part of the analysis shows that although there may be an oversupply of STEM graduates in certain fields, Tennessee businesses have been experiencing difficulty in finding individuals with the right skill set to remain competitive in a vibrant, high-tech economy.

Table 4: STEM Occupations by Difficulty of Filling Jobs

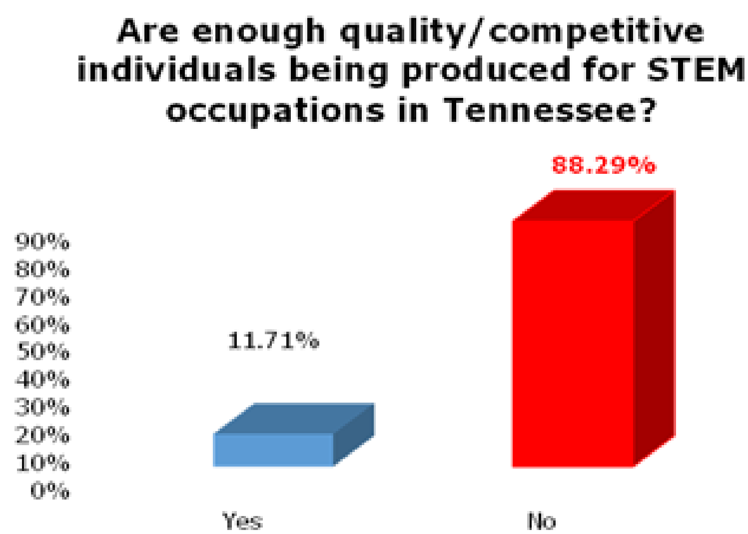
STEM Occupations Ranked by Difficulty of Filling

Occupational Code	Occupational Title	Difficulty of Filling (1=Extremely Easy) (10=Extremely Difficult)
11-3021	Computer and information systems managers	6
15-0000	Computer and mathematical occupations	6
17-3020	Engineering technicians, except drafters	6
19-0000	Life, physical, and social science occupations	6
15-113X	Software developers, applications, and systems software	6
11-9041	**Architectural and engineering managers**	**7**
17-0000	**Architecture and engineering occupations**	**7**
17-2041	**Chemical engineers**	**7**
17-3010	**Drafters**	**7**
11-0000	**Management, business, and financial occupations**	**7**
19-2030	**Chemists and materials scientists**	**8**
17-2051	**Civil engineers**	**8**
15-1131	**Computer programmers**	**8**
17-2070	**Electrical and electronics engineers**	**8**
17-2141	**Mechanical engineers**	**8**
15-1134	**Web developers**	**8**
19-1010	**Agricultural and food scientists**	**9**
15-1143	**Computer network architects**	**9**
17-2081	**Environmental engineers**	**9**
17-2110	**Industrial engineers, including health and safety**	**9**
11-9121	**Natural sciences managers**	**9**
15-2090	**Miscellaneous mathematical science occupations**	**10**

What impact may a STEM skill shortage have on businesses and regions? When businesses lack a valuable resource, their competitiveness will be impacted. Similarly, a region's competitiveness depends on its ability to create and sustain valuable resources. A STEM skill set is an example of such a valuable resource that may have important implications for the competitiveness of both businesses and regional economies. Strategic human resource management at both business and regional levels is necessary to ensure a healthy STEM workforce pipeline. Unless the STEM workforce pipeline is addressed, short-term solutions may not create a core competency for businesses and regions.

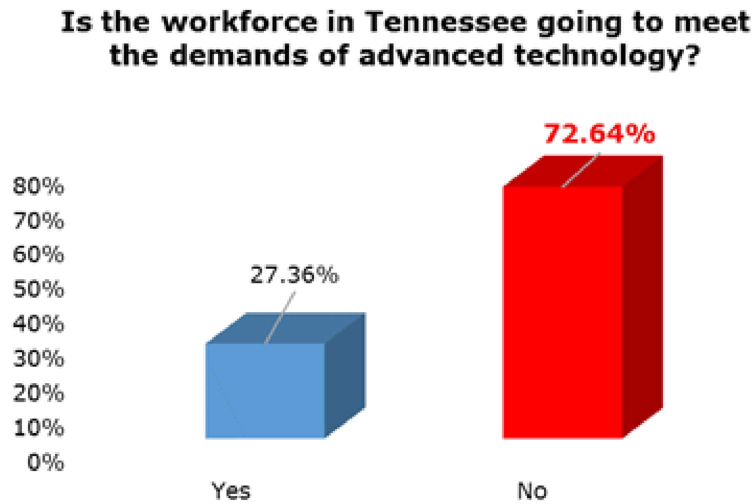
The BERC STEM survey in Tennessee suggests several business and regional challenges. Many STEM occupations have large supply and demand gaps. Many businesses participating in the survey indicated the STEM workforce demand will grow faster than that of other occupations. What happens if they can find employees with the right skill set? Let's review some of the findings: Are enough quality/competitive individuals produced for STEM occupations in Tennessee? An overwhelming majority of community stakeholders (nearly 90 percent) indicated the Tennessee education system does not produce enough quality/competitive individuals. Only 12 percent suggested otherwise (Arik, 2016).

Figure 2



Does Tennessee have the necessary infrastructure to produce a skilled workforce to meet the technology challenge? This question is at the heart of efforts in Tennessee to promote the advanced manufacturing and healthcare information technology sectors. Three out of four community stakeholders think the Tennessee workforce is not ready to meet advanced technology demands (Arik, 2016).

Figure 3



With regard to technology's impact on their businesses, many stakeholders emphasized the efficiency gained through technological advances. As illustrated in Figure 4, technological advancement seems to be a valuable resource for businesses in creating a sustainable competitive advantage. What happens if they do not have the necessary skilled human resources to take advantage of these technological developments?

Figure 4: Impact of Advancement of Technology on Business

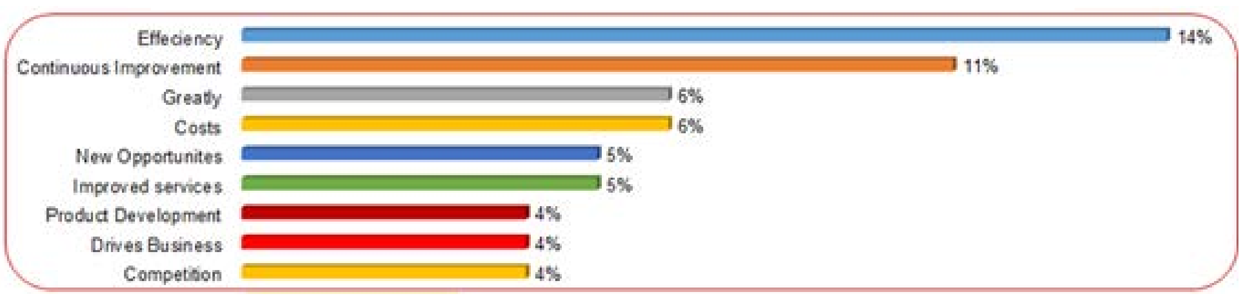
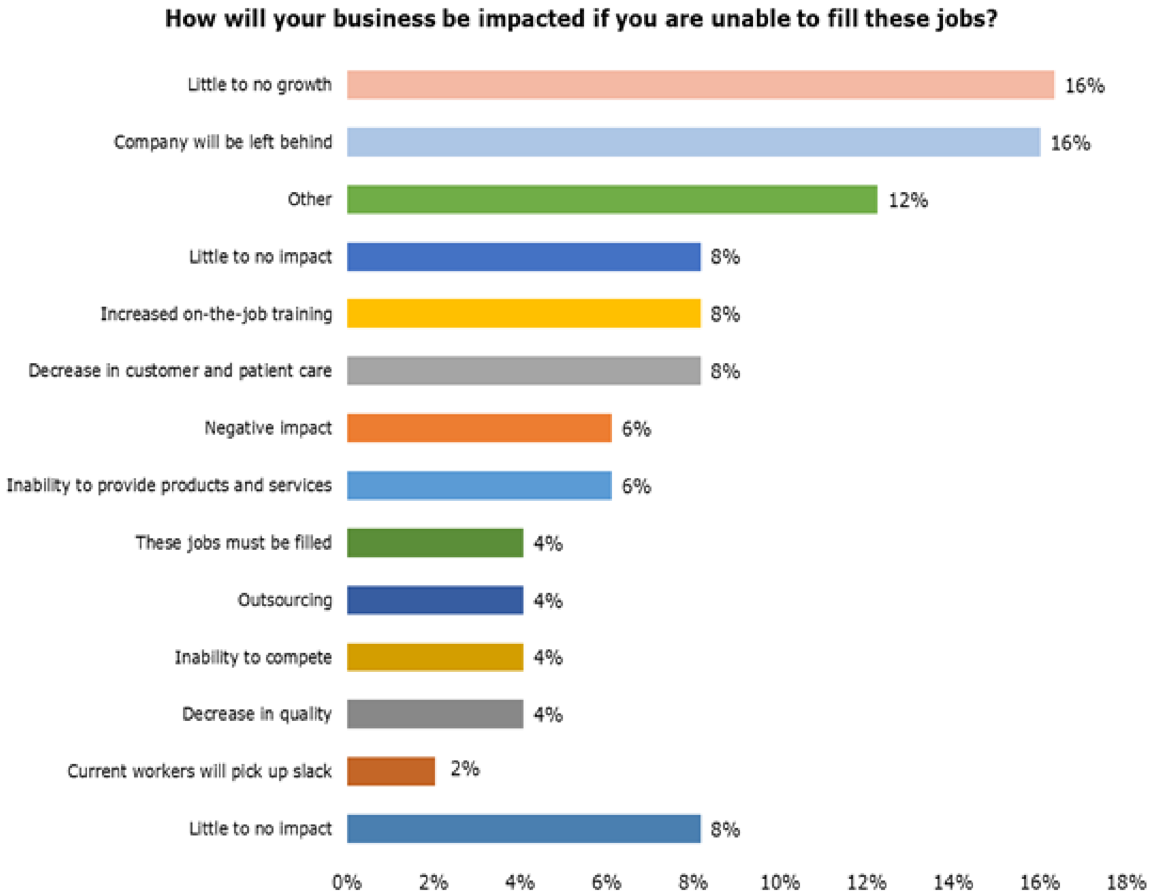


Figure 5 highlights business responses to the question of what happens if they cannot fill needed STEM positions. The top answers, "little to no growth" and "company will be left behind," represent 32 percent of responses. An additional 28 percent of responses also suggest impairment in the sustainable competitive advantage of businesses and regions, including "decrease in customer and patient care," "negative impact," "inability to provide product and services," "inability to compete," and "decrease in quality."

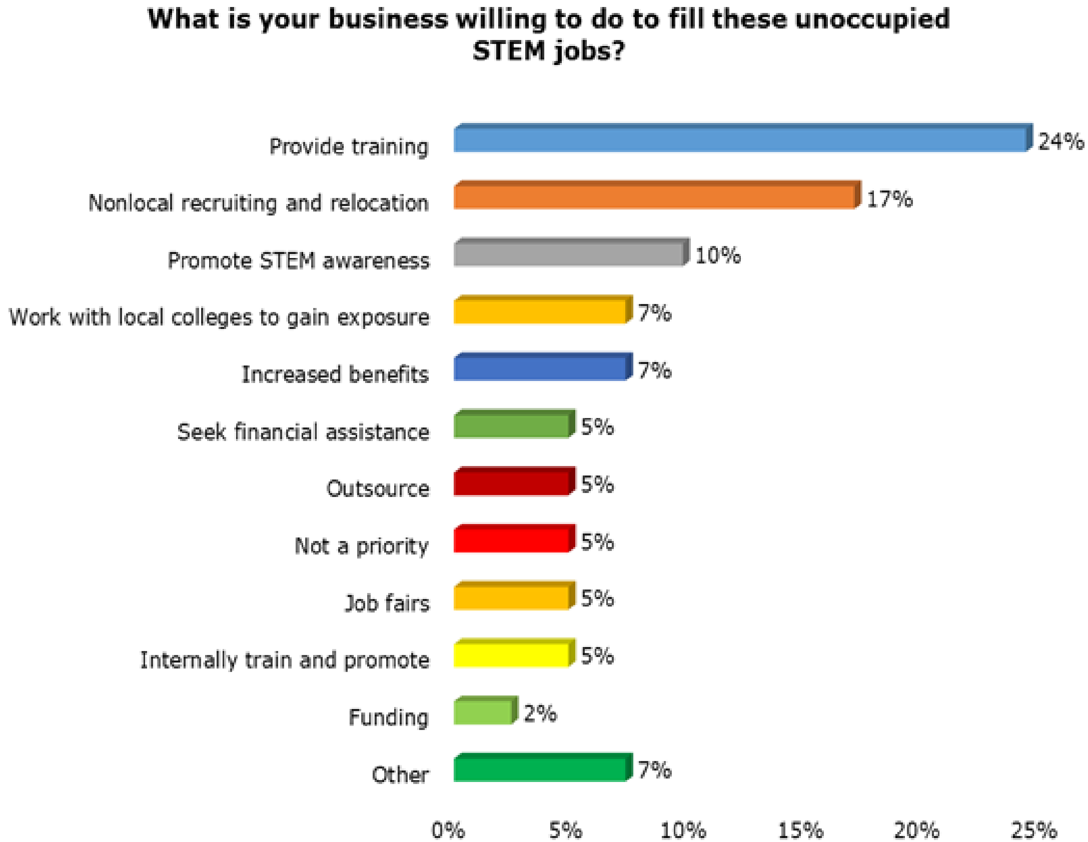
Figure 5: Impact of Unfilled STEM positions



Finally, to demonstrate varying human resource strategies in the STEM area, we asked what the company will do to fill unoccupied STEM positions. Figure 6 suggests significant long-term impact on the region when the STEM workforce supply issue is not addressed. Nearly one in every four businesses suggests a nonlocal solution to STEM workforce challenges in the form of either "outsourcing" or "nonlocal recruiting and relocation." A little over 45 percent of businesses indicated they either internally train their workforce or work with local stakeholders to address the STEM pipeline.

This analysis of the survey data suggests a STEM workforce shortage may create challenges to sustainable regional competitive advantage through human resource strategies that favor out-of-region recruiting, relocation, and outsourcing. Although 46 percent of businesses favor a local solution, the employment losses due to STEM skill shortages are large enough to create problems for regional growth and economic prosperity.

Figure 6: What will you do to fill unoccupied STEM positions?



How is STEM training related to entrepreneurial activity? To answer this question, we ran several logistic regression analyses using two different datasets, the American Community Survey (5-year average) and the Kauffman Foundation Entrepreneurial Activity Survey. The purpose of this analysis is to show that STEM training as a core competency has important implications for businesses and regions. A shortage in this area is likely to create long-run sustainability challenges in economic and business competitiveness.

Results with American Community Survey Data

Table 5 presents a Pearson correlation matrix of the independent variables used in the logistic regression analysis. In identifying the control variables, we conducted a literature review, which suggests characteristics of people engaging in entrepreneurial activities include formal education, age, immigrant status, income, and science education.[3] According to Table 5, the correlations between pairs of indicators are significant; however none of the correlation coefficients is large enough (>|.85|) to exclude from the analysis. We used three logistic regression analyses to compare different definitions of entrepreneurial activities: Model 1 defines entrepreneurial activities as "incorporated self-employed business." This definition includes a formalized establishment operating as a business unit. Model 2 defines entrepreneurial activities as "unincorporated self-employed business." Model 3 includes both incorporated and

[3] List of entrepreneurial activities is taken from OECD website (OECD.org).

unincorporated activities. The reason for using these three models is to demonstrate that science education matters in establishing a structured entity to conduct business.

Table 5: Pearson Correlations

Dependent Variable(s): Entrepreneurship (incorporated, unincorporated, and total)

		AGE	INCOME	IMM	SCI	EDUC
AGE	Pearson Correlation	1				
	Sig. (2-tailed)					
	N	16,913,329				
INCOME	Pearson Correlation	**.083****	1			
	Sig. (2-tailed)	0.000				
	N	15,141,575	15,141,575			
IMM	Pearson Correlation	**-.050****	**-.050****	1		
	Sig. (2-tailed)	0.000	0.000			
	N	16,913,329	15,141,575	16,913,329		
SCI	Pearson Correlation	**-.014****	**.218****	**.073****	1	
	Sig. (2-tailed)	0.000	0.000	0.000		
	N	16,913,329	15,141,575	16,913,329	16,913,329	
EDUC	Pearson Correlation	**-.033****	**.313****	**-.216****	**.326****	1
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	
	N	16,913,329	15,141,575	16,913,329	16,913,329	16,913,329

**Correlation is significant at the 0.01 level (2-tailed).

According to Table 6, the STEM variable controlled by other independent variables is likely to contribute to entrepreneurial activity in the United States. The stronger predictor of entrepreneurial activities seems to be the age of person. All indicators are statistically significant and have the expected sign in Model 1. This means that those individuals who incorporate their own business are likely to be older, have high family income, be highly educated, have an immigrant background, and have a STEM degree.

Table 6: Logistic Regression (STEM and Entrepreneurship)

Model 1: Entrepreneurship: Incorporated [1,0]

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	SCI	.072	.004	272.403	1	.000	1.075
	IMM	.368	.004	9398.200	1	0.000	1.445
	AGE	1.195	.006	39387.582	1	0.000	3.302
	INCOME	.403	.002	60124.327	1	0.000	1.496
	EDUC	.332	.006	2753.308	1	0.000	1.394
	Constant	-13.209	.032	175215.621	1	0.000	.000

a. Variable(s) entered on step 1: SCI, IMM, AGE, INCOME, EDUC

Model Summary: Model 1

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	4156317.276[a]	.010	.040

a. Estimation terminated at iteration number 7 because parameter estimates changed by less than .001.

Model 2: Entrepreneurship: Unincorporated [1,0]

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	SCI	-.182	.004	1916.155	1	0.000	.834
	IMM	.358	.003	16397.915	1	0.000	1.430
	AGE	.977	.004	53891.718	1	0.000	2.656
	INCOME	-.248	.001	93526.605	1	0.000	.781
	EDUC	.122	.003	1410.335	1	0.000	1.130
	Constant	-4.381	.020	48984.838	1	0.000	.013

a. Variable(s) entered on step 1: SCI, IMM, AGE, INCOME, EDUC

Model Summary: Model 2

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	6628694.344[a]	.010	.028

a. Estimation terminated at iteration number 6 because parameter estimates changed by less than .001.

SCI: STEM fields [1,0] IMM: Immigrant status [1,0] AGE: Age of the respondents INCOME: Total family income
EDUC: Years in schooling

The critical difference between Models 1 and 2 in Table 6 is that those individuals with STEM background are less likely to get involved in unincorporated self-employed entrepreneurial activities. Income is also negatively associated with the entrepreneurial activities in Model 2. This finding suggests that both education and STEM education matter in establishing formal businesses.

Results with Kauffman Foundation Survey

We followed a similar approach to estimate three models using the Kauffman Foundation Survey. Including education, age, immigration and income variables, we want to see whether there is a difference between incorporated self-employed business and unincorporated self-employed business in terms of the determinants of entrepreneurship. Table 7 suggests a significant difference between Models 1 and 2. The role of human capital is significantly higher in Model 1.

Table 7: Kauffman Survey (Education vs. Entrepreneurship)

Model 1: Incorporated Self-Employed

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	EDUC	4.174	.007	405283.727	1	0.000	**64.955**
	AGE	1.564	.001	1386177.377	1	0.000	4.776
	IMM	.226	.001	58345.057	1	0.000	1.254
	INCOME	.144	.000	1161553.025	1	0.000	1.155
	Constant	-26.815	.024	1209537.050	1	0.000	.000

a. Variable(s) entered on step 1: EDUC, AGE, IMM, INCOME

Model Summary: Model 1

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	71241645.594[a]	.016	.073

a. Estimation terminated at iteration number 8 because parameter estimates changed by less than .001.

Model 2: Unincorporated Self-Employed

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	EDUC	-.517	.004	14580.850	1	0.000	**.596**
	AGE	1.032	.001	1328832.357	1	0.000	2.807
	IMM	.204	.001	86770.405	1	0.000	1.226
	INCOME	.005	.000	5104.687	1	0.000	1.005
	Constant	-5.076	.016	100594.877	1	0.000	.006

a. Variable(s) entered on step 1: EDUC, AGE, IMM, INCOME

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	115815740.559[a]	.005	.016

a. Estimation terminated at iteration number 6 because parameter estimates changed by less than .001.

Model 3: Both Incorporated and Unincorporated Self-Employed

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	EDUC	1.152	.004	100037.044	1	0.000	**3.165**
	AGE	1.255	.001	2780269.166	1	0.000	3.507
	IMM	.239	.001	177297.600	1	0.000	1.269
	INCOME	.047	.000	522981.005	1	0.000	1.048
	Constant	-12.106	.014	793491.897	1	0.000	.000

a. Variable(s) entered on step 1: EDUC, AGE, IMM, INCOME

Model Summary: Model 3

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	158698539.710[a]	.014	.035

a. Estimation terminated at iteration number 6 because parameter estimates changed by less than .001.

What do these results mean? These results suggest that human capital in general and STEM skill in particular is an important asset for businesses and regions. STEM skills not only create a sustainable competitive advantage for businesses and regions but also become instrumental in creating new incorporated businesses with an aim to grow opportunities for the region. In this sense, STEM skill may be treated as a core competency for businesses and regions.

DISCUSSION

This study analyzed STEM workforce dynamics from the resource-based view. The findings suggest several theoretical and practical implications. From the theoretical perspective, STEM workforce skill should be treated as one of the core competencies of businesses and regions in creating sustainable competitive advantage. Although the literature on strategic human resource management considers human resources among strategic considerations, there are still gaps in the literature in shedding light on the persistent mismatches occurring in the STEM marketplace.

As this study demonstrates, STEM shortages manifest as outright shortages in high-technology areas, relative skill gap in existing occupations, and mismatch between market demand and educational supply. Refocusing our theoretical lenses to treat this issue as a core competency may help us to solve the skill shortage using internal capabilities and dynamics rather than resorting to short-term tactics.

From entrepreneurial activity to increased purchasing power in a region, the STEM workforce issue also deserves a regional view. For example, in Tennessee alone, closing the STEM skill gap may create an additional economic impact of nearly $4.5 billion. With the addition of entrepreneurial implications, the impact becomes significantly larger.

Many entrepreneurial activities that are incorporated and in certain growth sectors are associated with higher educational attainment levels and science education. In order to increase regional economic dynamism, business challenges associated with STEM workforce issues should definitely be addressed. For example, Table 8 compares the characteristics of entrepreneurs by industry. About 43.3 percent of entrepreneurs in manufacturing, professional business services, and health and education services have a degree beyond college, compared to only 25 percent in other industries.

Table 8: Educational Attainment of Entrepreneurs

In Manufacturing, Professional and Business Services, and Health and Education Sectors		In All Other Sectors	
Educational Attainment Level	Percent	Percent	Educational Attainment Level
Less than high school	13.0	15.3	Less than high school
High school	23.2	29.4	High school
Some college (academic and vocational)	20.5	30.1	Some college (academic and vocational)
College	24.8	19.0	College
Graduate	18.5	6.2	Graduate

Source: BERC and Kauffman Foundation Survey

Table 9 presents a different perspective: educational attainment levels of entrepreneurs by industry. It is not surprising to see that entrepreneurs in manufacturing, information, professional and business services, financial services, and educational and health services have a high degree of educational attainment. In many cases, the degrees of these entrepreneurs are closely related to STEM or STEM-related fields. Table 9 suggests that to create a sustainable competitive business environment, STEM focus is a necessary building block.

Table 9: Entrepreneurial Activities and Educational Attainment

	Less than high school	High school	Some college (academic and vocational)	College	Graduate
Agriculture, forestry, fishing, hunting	1.65%	**26.07%**	**48.75%**	23.53%	0.00%
Construction	**36.21%**	**31.77%**	**28.57%**	2.06%	1.39%
Manufacturing	0.00%	**26.86%**	**49.08%**	10.66%	**13.39%**
Wholesale & retail trade	8.14%	**29.38%**	**29.69%**	**28.66%**	4.13%
Transportation and utilities	5.21%	**58.16%**	18.55%	11.40%	6.68%
Information	0.00%	0.00%	21.88%	**58.91%**	**19.21%**
Financial activities	0.00%	**30.13%**	24.26%	**32.68%**	**12.93%**
Professional and business services	12.68%	22.91%	14.01%	**30.50%**	**19.90%**
Educational and health services	16.14%	23.00%	24.35%	19.06%	**17.45%**
Leisure and hospitality	5.03%	19.11%	**37.17%**	24.04%	**14.64%**
Other services	16.97%	**25.50%**	**36.35%**	20.65%	0.53%

Source: BERC and Kauffman Foundation Survey

Limitations and Future Research

This study primarily addresses business challenges associated with STEM workforce shortages. We discussed many aspects of these shortages and explored their implications within the context of Tennessee and national survey data. Our review of the findings suggests further research is needed to better understand the reasons behind persistent mismatches in STEM workforce areas across the nation.

A particular question to explore would be why businesses are consistently pushing for human resource strategies that involve outsourcing STEM skill sets. The second line of inquiry would be to focus on the dynamics behind mismatches in the market: who is not getting the information, and why individuals are not taking advantage of opportunities to eliminate shortages in the market?

A final line of inquiry regarding STEM shortages would be to explore the issue within the interdisciplinary educational framework and connect subject matter with the innovation ecosystem.

CONCLUSION

The debate about STEM workforce shortages is not over. This study suggests the STEM shortage is not a myth but a reality—resulting from significant mismatches in the marketplace. While some STEM fields have been overproducing/oversupplying for years, many other fields have been experiencing chronic shortages.

Given the importance of the STEM skill set for the economy, it is time to treat the STEM skill set as a core competency of firms and regions. This is critically important because the gap in skill and shortage in this area results in significant economic losses, as suggested by this research.

Acknowledgements:

Initial research was conducted by the Business and Economic Research Center through a contract with Mind2Marketplace and Tennessee Small Business Development Center.

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