THE RELATIONSHIP BETWEEN STEM EDUCATIONAL ATTAINMENT AND UTILITY PATENT CONFERALS: A STATE-LEVEL ANALYSIS

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ABSTRACT

The utility patent, as a legal record of invention, is widely believed to be a close proxy for innovation among firms, industries, and economies as a whole. One of the critical drivers of patenting – and ultimately, innovation – is education. The science, technology, engineering and math (STEM) fields in education are of special importance. There is, however, little empirical research to substantiate a connection between STEM education and innovation outcomes. Seeking to fill this gap, this paper finds that, in general, there is no evidence of a meaningful relationship between STEM educational attainment and utility patent conferrals. The relationship of interest, though generally not statistically significant, is stronger for temporary US visa holders than for US citizens or permanent US residents. However, I find a large and statistically significant association between STEM educational attainment and utility patent conferrals for states that have above-average college educational attainment or above-average advanced industries workforce concentration.
Acknowledgements

I would like to thank all of those individuals who have assisted me in accomplishing this thesis. My deepest gratitude goes to my thesis supervisor Adam Thomas for his tremendous assistance during this whole process. I could not have made it without his careful guidance and constant support.

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Last, my heartfelt thanks go to my parents for their unconditional love and support over my years of schooling.
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Introduction

The total number of utility patents of US origin, also known as patents for invention, conferred by the United States Patent and Trademark Office (USPTO) has more than doubled from 53,231 in 1994 to 133,593 in 2013, as shown in Figure 1. Contained within this overall trend is, however, a sharp decline in utility patent conferral growth during 2007 and 2008, with the financial crisis as background. After the recession, the number of utility patent conferrals started growing again, but at an increasingly slow rate, starting in 2011.

Figure 1: Total Number of Utility Patent Conferrals of US Origin

Despite debates about its representativeness, the utility patent, as a legal record of invention, is widely believed to be a close proxy for innovation among firms, industries, and economies as a whole, and is widely used in economic studies (Griliches, 1998). Rothwell et al. (2013) found that patenting is correlated with higher levels of regional productivity growth and lower regional unemployment rates. The authors also found that the incidence of patent conferrals is positively associated with
the number of publicly-traded companies and initial public offerings.

One of the critical drivers of patenting – and ultimately, innovation – is education (Chi & Qian, 2010; Lavoie, 2009), especially in science, technology, engineering, and math (STEM) (National Science and Technology Council, 2013; Atkinson and Mayo, 2010). Policy makers in the US have long advocated for STEM education, highlighting its crucial role in boosting the country’s innovation and economic prosperity (Fitzpatrick, 2007). The “Educate to Innovate” campaign, initiated by the Obama administration in 2009, is a case in point (Bement, 2015). There is, however, little empirical research to support such a connection. Among the limited number of studies, Winters (2014) found evidence of a positive and statistically significant association between STEM educational attainment and utility patent conferrals, while Ray (2015) found little evidence of such an association.

This paper aims to reexamine this relationship, using state-level panel data from 1994 to 2013 to study the relationship between STEM educational attainment and utility patent conferrals in the United States.

The paper is organized as follows. The next section provides background information on STEM educational attainment in the US, focusing on variation in this metric over years and across states. Then, a literature review summarizes empirical research findings related to this topic, and is followed by discussions of the conceptual framework and hypothesis, data and methods, and descriptive statistics. I conclude by presenting my empirical results and discussing the policy implications of my findings.
Background

In 2009, amid growing concern over a shortage of students and professionals in STEM fields, the Obama administration announced the "Educate to Innovate" campaign to engage more students in STEM fields in order to boost the country’s innovation process (National Economic Council, 2015). This national recognition of the importance of STEM education received mixed reviews. Some researchers and policy makers claimed that the initiative failed to address the underlying problems of the education pipeline (Burke & McNeil, 2011). Others argued that there is no shortage of STEM degree recipients and STEM workforce participants (Freeman, 2008). Figure 2 supports this claim. The average number of STEM graduate degrees per 1000 members of the US population aged 25 to 34 steadily increased from 1994 to 2013 (the last year for which data are available).¹

Figure 2: US STEM Graduate Degrees Conferred per 1,000 Persons Aged 20 to 34

Author's analysis of data from the National Center for Education Statistics and the American Community Survey

¹ A full list of STEM degree programs is available at the US Department of Homeland Security (2014).
Nonetheless, proponents of the "Educate to Innovate" initiative contested such claims, noting the wavering trend in the share of STEM graduate degrees as a percentage of all graduate degrees conferred in the US. In terms of this particular measure, the evidence supports the proponents. As Figure 3 shows, at the national level, STEM graduate degrees as a share of all graduate degrees conferred in the US decreased from 14.9% in 1994 to 12.9% in 2002, followed by a period of fluctuation.

Figure 3: US STEM Graduate Degrees as a Percentage of All Graduate Degrees Conferred

For the purpose of the present study, it is also important to recognize the substantial variation across states in the STEM educational attainment indicator. As is documented later in this paper, there is a wide range in the extent of STEM educational attainment at the state level. This variation across states and across time allows this study to explore the relationship between STEM educational attainment and utility patent conferrals at the state level.
Literature Review

There is an extensive literature on the relationship between education and innovation (Baumol, 2005; Feldman & Stewart, 2007; Meisenzah & Mokyr, 2011). However, this literature offers conflicting findings regarding the relationship between STEM educational attainment and utility patent conferrals. Some studies emphasize the variation in this relationship across various demographic categories; for example, immigration status, gender, race, and ethnicity. This section summarizes past empirical work in this area and describes how the present study contributes to the existing literature.

The relationship between STEM educational attainment and innovation indicators

Only two previous studies directly examine the effect of the STEM educational attainment on the utility patent conferrals, and they reveal mixed findings. Adopting both an OLS method and a time-differenced instrumental variables method, in which he instruments for the presence of STEM degree holders using predicted flows of STEM graduates from US colleges and universities to metropolitan areas, Winters (2014) finds that the geographic concentration of STEM graduates has a statistically significant and substantial impact on patent conferrals. However, Ray’s (2015) findings in a state-level study differ from those of Winters. Ray finds little if any relationship between the number of STEM degrees as a proportion of all higher education degrees and utility patent conferral per capita at the state level.
Subgroup analysis: immigration status

Much of the related literature focuses on the effect of various characteristics of immigrant students on the nation’s innovation outputs, usually measured by patent conferrals per capita, patent citation counts, or university publishing counts. (Lerner & Stern, 2010). In their analysis of state-level panel data from 1940 to 2000 and individual-level data from 2003, Hunt and Gauthier-Loiselle (2010) estimate that a 0.7 percentage-point increase in the share of the population composed of post-college immigrant graduates is associated with a 21 percent increase in the number of patents per capita. Studies by Hunt (2010) and Stuen et al. (2012) echo this result, finding that immigrant students significantly out-perform their US counterparts according to a series of indicators including wages, patents granted or commercialized, and academic publishing. There is more evidence from the US (Borjas, 2014), and also evidence from Australia (Islam & Fausten, 2008) and the UK (Gagliardi, 2013) of a positive connection between the number of skilled immigrants and innovation.

The empirical work that compares international and US students on innovation indicators usually focuses on doctoral students. The number of international PhD students in the US has been found to be positively associated with the frequency of academic publishing (Gaulé & Piacentini, 2013), patent citations (Stuen et al., 2006), patent applications, and patent conferrals (Chellaraj et al., 2006). However, Stephan et al. (2007) reach an opposite conclusion, finding a negative and significant association between the number of international PhD students and patent counts in the US. The
authors attribute such findings to “cultural reasons” and the quality of training received by international PhD students.

**Subgroup analysis: other factors**

Previous research also examines factors influencing the link between STEM educational attainment and utility patent conferrals. For example, Hunt (2012a) finds evidence of a higher exit rate from science and engineering fields among women than among men. In a follow-up study, the same author (2012b) finds that women’s underrepresentation among science and engineering degree holders is associated with a lower probability of obtaining commercialized patents among women. Other studies also examine differences in patenting by ethnicity and race and find evidence of a significantly higher patent output among Chinese and Indian ethnic groups (Kerr, 2008), and a significantly lower patent output among African Americans (Cook, 2007).

**The present study**

The present study contributes to the literature in multiple ways. First, using different, yet up to date, data from the National Center for Education Statistics and the Census Bureau, it sheds new light on the mixed findings about the connection between STEM educational attainment and utility patent conferrals. In addition, taking note of the nuanced difference in the key independent variables of the two most relevant studies – Winters (2014) uses the share of STEM bachelor’s degree holders among the adult population, while Ray (2015) uses the share of STEM degrees among all higher
education degrees – this study provides an opportunity to test whether this difference in independent variables leads to different results. Last, rather than focusing mostly on doctoral degree recipients, this study extends the contributions of the prior literature by considering STEM attainment among all graduate and undergraduate degree holders.

**Conceptual Framework and Hypothesis**

Based on the discussion in my literature review, I hypothesize that STEM educational attainment is positively associated with utility patent conferrals at the state level, as I expect individuals with STEM degrees to be a driving force for innovation. Figure 4 lays out the conceptual model for this study. It accounts for various factors that are plausibly related to STEM educational attainment and utility patent conferrals in a given state. Below, I discuss these factors in more detail.

**Figure 4: Conceptual Framework**

- **Demographics**
  - Race
  - Gender
  - International Student
  - Population Growth
  - College Degree Attainment

- **Macroeconomic Factors**
  - Gross State Product
  - Unemployment
  - Median Household Income
  - Level of Entrepreneurship
  - R&D Expenditure
  - Advanced Industries

- **STEM Degree Attainment**
- **Utility Patent Conferrals per Workforce**

**Demographic Factors**

A number of demographic factors are plausibly associated with both STEM educational attainment and utility patent conferrals. As the literature reveals, in both
STEM educational attainment and patenting, statistically significant differences exist by race (Kerr, 2008; Cook, 2007), gender (Hunt, 2012a; Hunt, 2012b), and immigration status (Lerner & Stern, 2010; Hunt & Gauthier-Loiselle, 2010; Stuen et al., 2012; Islam & Fausten, 2008; Gagliardi, 2013; Borjas, 2014; Winters, 2014). In addition, the growth rate (Rosenbloom, 2004; Rothwell et al., 2013) and college degree attainment (Peri et al., 2014; Hunt, 2010) of a state’s population have the potential to influence both ends of the equation. These demographic factors are thus included as controls in my analysis.

**Macroeconomic Factors**

Macroeconomic factors are also likely to be associated with both STEM educational attainment and patenting. The literature generally suggests that the intensity of patenting activity is higher in areas with more robust economies (Rothwell et al., 2013; Falk, 2007). State economic health has also been found to be positively associated with STEM education participation (Rothwell, 2013; Carey, 2012). Measures of state economic strength include Gross State Product, state unemployment rate, state median household income, and state average firm size. Two additional indicators that are plausibly correlated with both STEM educational attainment and utility patent conferrals are the share of the workforce that is in advanced industries and state-level research and development (R&D) expenditures.  

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2 Glaeser et al. (2009) found that average establishment size is negatively correlated with employment growth of a region.

3 In a recent report, Muro et al. (2015) identify “advanced industries” as industries that conduct large amounts of R&D and employ a disproportionately large share of STEM workers.
Data and Methods

This study makes use of state-level data for the 50 US states between 1994 and 2013, drawing from a variety of sources. The dependent variable – the number of utility patent conferrals per 1000 members of the labor force – is calculated by combining data on the number of utility patent conferrals, taken from the U.S. Patent and Trademark Office, with labor force population counts, obtained from the U.S. Bureau of Labor Statistics.

STEM educational attainment – my key independent variable – is measured in three ways. My first measure – STEM degree conferral rate – reflects the number of STEM graduate degrees conferred per 1000 population members aged 20 to 34. I create this measure by combining data on the number of graduate degree conferrals in the STEM fields, which are drawn from an annual survey conducted by the National Center for Education Statistics (NCES), with population counts taken from the US Census Bureau’s American Community Survey (ACS). This measure is available for the period 1994 to 2013, and represents the population-adjusted flow of graduate students into and out of STEM fields in institutions of higher learning in a given state.

My second measure of STEM educational attainment – STEM degree share – reflects the number of STEM graduate degrees as a percentage of all graduate degrees conferred in a given state. Data on the number of STEM graduate degrees and the number of all graduate degrees are also obtained from the above-described NCES survey series. This measure is also available from 1994 to 2013. It represents the extent to which graduate programs are concentrated in STEM fields in each year.
My third measure of STEM educational attainment – STEM degree holding rate – reflects the number of STEM bachelor’s degree holders per 1000 population members aged 20 and above. The data for this measure come from the ACS, which started to collect information about the degree fields of bachelor’s degree holders in 2009. Therefore, this measure is only available for a comparatively short period, from 2009 to 2013. It captures the extent to which a state’s population has received at least undergraduate training in STEM fields.

The ACS data that support the third measure of STEM educational attainment also allow for disaggregation of bachelor’s degree holders into two categories: those who are US citizens and permanent residents, and those who are temporary US visa holders. These data thus allow me to perform subgroup analyses.

This study also controls for the demographic and macroeconomic characteristics that may affect both STEM educational attainment and utility patent conferrals. Data on state demographic factors, including population growth rates, college degree attainment and the distribution of a state’s population by race and by gender, are obtained from the ACS. Data for some state macroeconomic factors, including Gross State Product (GSP) and state unemployment rate, are taken from the US Bureau of Economic Analysis (BEA). Information on average firm size is drawn from Business Dynamics Statistics Data Tables published by the US Census Bureau’s Center for Economic Studies. Data on median household income come from the Current Population Survey, which is administered by the US Census Bureau. Information on state-level R&D expenditures is drawn from NSF’s Higher Education Research and
Development Survey. Data on employment in advanced industries are taken from the Brookings Institution.

This study adopts an Ordinary Least Squares (OLS) specification with state and year fixed effects. State fixed effects control for unobserved state characteristics that do not change over time – for example, unobserved but relatively lasting differences in the natural resource endowments and cultural characteristics of each state. Year fixed effects control for unobserved characteristics that change over time but are common to all states in a given year – for instance, the national economic environment in each year and the introduction of the "Educate to Innovate" campaign in 2009 with the goal of engaging more students in STEM fields nationwide. The use of state and year fixed effects reduces the extent of omitted variable bias in the coefficients for my key independent variables. The regression model estimated for this study is as follows:

\[ Patent_{perworkforce} = \beta_0 + \beta_1STEMshare + \beta_2Population\_growth + \beta_3College\_edu + \beta_4Female + \beta_5White + \beta_6Black + \beta_7Hispanic + \beta_8Asian + \beta_9GSP + \beta_{10}Unemployment + \beta_{11}Median\_hhincome + \beta_{12}Firm\_size + \beta_{13}R\_D + \beta_{14}Advanced\_industries + \alpha_i + \gamma_t + \mu_{it} \]

where the subscript \( i \) denotes each state, the subscript \( t \) stands for each year, \( \alpha_i \) represents state fixed effects, \( \gamma_t \) corresponds to year fixed effects and \( \mu_{it} \) is the error term. In some supplementary analyses, the key independent variables are respectively the number of US and non-US STEM bachelor’s degree holders per 1000
population members aged 20 and above.

| Table 1: Definitions for all variables included in the regression model |
|-----------------------------|---------------------------------------------------------------|
| Variables                  | Definitions                                                                                           |
| **Dependent Variable**     |                                                                                                           |
| Utility patent per workforce| A continuous variable measuring the number of utility patent conferrals per 1,000 members of the labor force in a state. Utility patent conferral counts are obtained from the US Patent and Trademark Office. Labor force data are from the US Bureau of Labor Statistics. |
| **Key Independent Variables** |                                                                                                           |
| STEM educational attainment –
  degree conferral rate | A continuous variable measuring the number of STEM graduate degrees conferred per 1000 population members aged 20 to 34 in a state. STEM graduate degree counts are obtained from the Integrated Postsecondary Education Data System (IPEDS), administrated by the NCES, and population data are taken from the ACS. |
| STEM educational attainment –
  degree share | A continuous variable measuring the number of STEM graduate degrees as a percentage of all graduate degrees conferred in a state. Counts of STEM graduate degrees and all graduate degrees are obtained from the IPEDS. |
| STEM educational attainment –
  degree holding rate | A continuous variable measuring the number of STEM bachelor’s degree holders per 1000 population members aged 20 and above in a state. I was able to disaggregate this 3rd measure of STEM educational attainment into the number of US and non-US bachelor’s degree holders per 1000 population members aged 20 and above in a state. Bachelor’s degree holder and population counts are obtained from the ACS. |
<p>| <strong>Controls: Demographic Factors</strong> |                                                                                                           |
| Population growth | A continuous variable measuring the population growth rate in a state. These data are taken from the American Community Survey. |
| College educational attainment | A continuous variable measuring the percent of a state's population over the age of 25 with a bachelor degree and above. These data are taken from the American Community Survey. |
| Female | A continuous variable measuring the percentage of a state's population that is female. These data are taken from the American Community Survey. |
| White | A continuous variable measuring the percentage of a state's population that is white. These data are taken from the American Community Survey. |
| Black | A continuous variable measuring the percentage of a state's population that is African American. These data are taken from the American Community Survey. |</p>
<table>
<thead>
<tr>
<th>Variables</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hispanic</td>
<td>A continuous variable measuring the percentage of a state's population that is Hispanic. These data are taken from the American Community Survey. <em>a</em></td>
</tr>
<tr>
<td>Asian</td>
<td>A continuous variable measuring the percentage of a state's population that is Asian. These data are taken from the American Community Survey.</td>
</tr>
</tbody>
</table>

**Controls: Economic Factors**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSP</td>
<td>A continuous variable measuring the economic output of a state. This variable captures the sum of value added from all industries in the state. These data are taken from the US Bureau of Economic Analysis.</td>
</tr>
<tr>
<td>Unemployment</td>
<td>A continuous variable used as an indicator for the labor market conditions of a state. These data are taken from the US Bureau of Economic Analysis, and are defined as the number of job seekers who are unemployed as a proportion of the civilian labor force.</td>
</tr>
<tr>
<td>Median household income</td>
<td>A continuous variable used as a proxy for household economic well-being. These data are taken from the US Bureau of Economic Analysis.</td>
</tr>
<tr>
<td>Average firm size</td>
<td>A continuous variable used as an indicator of the economic strength of a state. Average firm size is calculated by dividing the number of employees reported by firms in a given state by the number of firms in that state. These data are taken from the Business Dynamics Statistics (BDS) Data Tables produced by the US Census Bureau’s Center for Economic Studies.</td>
</tr>
<tr>
<td>R&amp;D spending</td>
<td>A continuous variable measuring state-level research and development expenditures at colleges and universities. These data are taken from the NSF’s annual census Higher Education Research and Development Survey.</td>
</tr>
<tr>
<td>Advanced Industries workforce</td>
<td>A continuous variable measuring the percentage of a state’s labor force that is concentrated in R&amp;D-intensive industries. These data are taken from the Advanced Industries Series Report of the Brookings Institution.</td>
</tr>
</tbody>
</table>

*a Hispanic origin is defined as an ethnicity, not a race. Hispanics may be of any race.*
Descriptive Statistics

Table 2 provides descriptive statistics for all variables included in my analysis at the US state level. Unless otherwise indicated, estimates are weighted by the average population of each state over the period of the study.

Table 2: Descriptive statistics for dependent, key independent, and control variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Min</th>
<th>Max</th>
<th>SD</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent Variable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utility patent conferral per 1,000 persons in the workforce</td>
<td>0.58</td>
<td>0.05</td>
<td>2.67</td>
<td>0.35</td>
<td>1,000</td>
</tr>
<tr>
<td>Key Independent Variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STEM graduate degree conferrals per 1,000 population members aged 20 to 34</td>
<td>1.56</td>
<td>0.40</td>
<td>5.39</td>
<td>0.62</td>
<td>1,000</td>
</tr>
<tr>
<td>STEM graduate degrees as a percentage of all graduate degrees conferred</td>
<td>0.14</td>
<td>0.05</td>
<td>0.36</td>
<td>0.03</td>
<td>1,000</td>
</tr>
<tr>
<td>STEM bachelor’s degree holders per 1,000 population members aged 20 and above</td>
<td>59.98</td>
<td>29.61</td>
<td>95.35</td>
<td>12.91</td>
<td>250</td>
</tr>
<tr>
<td>US STEM bachelor’s degree holders per 1,000 population members aged 20 and above</td>
<td>44.67</td>
<td>26.83</td>
<td>79.15</td>
<td>8.61</td>
<td>250</td>
</tr>
<tr>
<td>Non-US STEM bachelor’s degree holders per 1,000 population members aged 20 and above</td>
<td>15.31</td>
<td>1.27</td>
<td>38.27</td>
<td>8.95</td>
<td>250</td>
</tr>
<tr>
<td>Demographic Factors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Population growth rate</td>
<td>0.01</td>
<td>-0.06</td>
<td>0.34</td>
<td>0.01</td>
<td>1,000</td>
</tr>
<tr>
<td>College educational attainment</td>
<td>0.26</td>
<td>0.11</td>
<td>0.40</td>
<td>0.05</td>
<td>1,000</td>
</tr>
<tr>
<td>Percent female</td>
<td>0.51</td>
<td>0.48</td>
<td>0.52</td>
<td>0.01</td>
<td>1,000</td>
</tr>
<tr>
<td>Percent white</td>
<td>0.68</td>
<td>0.23</td>
<td>0.98</td>
<td>0.15</td>
<td>1,000</td>
</tr>
<tr>
<td>Percent black</td>
<td>0.12</td>
<td>0.00</td>
<td>0.37</td>
<td>0.08</td>
<td>1,000</td>
</tr>
<tr>
<td>Percent hispanic</td>
<td>0.14</td>
<td>0.00</td>
<td>0.47</td>
<td>0.12</td>
<td>1,000</td>
</tr>
<tr>
<td>Percent asian</td>
<td>0.04</td>
<td>0.00</td>
<td>0.63</td>
<td>0.05</td>
<td>1,000</td>
</tr>
<tr>
<td>Economic Factors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gross state product (in millions of dollars)</td>
<td>597,560</td>
<td>18,380</td>
<td>2,050,693</td>
<td>522,187</td>
<td>1,000</td>
</tr>
<tr>
<td>Unemployment rate (%)</td>
<td>6.03</td>
<td>2.30</td>
<td>13.70</td>
<td>2.03</td>
<td>1,000</td>
</tr>
<tr>
<td>Median household income (in dollars)</td>
<td>55,610</td>
<td>37,253</td>
<td>79,915</td>
<td>7,418</td>
<td>1,000</td>
</tr>
<tr>
<td>Average number of employees per firm</td>
<td>21.86</td>
<td>11.60</td>
<td>27.60</td>
<td>2.39</td>
<td>1,000</td>
</tr>
<tr>
<td>Federal obligations for R&amp;D (in millions of dollars)</td>
<td>4,441</td>
<td>26</td>
<td>27,227</td>
<td>5.876</td>
<td>1,000</td>
</tr>
<tr>
<td>Share of Advanced Industry employment (%)</td>
<td>0.09</td>
<td>0.03</td>
<td>0.15</td>
<td>0.02</td>
<td>1,000</td>
</tr>
</tbody>
</table>

Between 1994 and 2013, the average number of utility patent conferrals per 1000 persons in the labor force in a state was 0.58. This number, however, varied substantially among individual states and years, ranging from 0.05 (Alaska in 2007) to 2.67 (Idaho in 2002). Over the same period, the average number of STEM graduate degree conferrals per 1000 persons aged 20 to 34 in a state, my first measure of

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4 In earlier analyses, I discovered that the District of Columbia is an extreme outlier and thus excluded it from this study.
STEM educational attainment, was 1.56. Also between 1994 and 2013, the average number of STEM graduate degrees per all graduate degrees conferred, my second measure of STEM educational attainment, was 0.14.

Between 2009 and 2013, on average, out of every 1000 members of the population aged 20 and above, 59.98 individuals held a bachelor’s degree in a STEM field. Across states and time, this third measure of STEM educational attainment also had a wide range, with 29.61 being the lowest (Arkansas in 2009) and 93.18 the highest (Maryland in 2012). Figure 5 illustrates the wide variation in this third measure of STEM educational attainment by using color intensity to reflect the 5-year average number of STEM bachelor’s degree holders per 1000 persons aged 20 and above across all states.

**Figure 5: Variation in STEM Educational Attainment Across States**

Measured as the average number of STEM bachelor’s degree holders per 1,000 population members aged 20 and above between 2009 and 2013.

Author’s analysis of data from the American Community Survey
Not reflected in Table 2 or Figure 5 is the large within-state variation in STEM attainment over time. Taking the first measure of STEM educational attainment as an example, Vermont experienced the most significant growth (192%) from 1994 to 2013 in the number of STEM graduate degree conferrals per 1000 population members aged 20 to 34, while Wyoming saw a 28% decrease in this indicator over the same period.\(^5\)

Also noteworthy is the difference in the average number of STEM bachelor’s degree holders per population members aged 20 and above between US and non-US citizens, with the former group’s share almost triple that of the latter group’s. In fact, the latter was smaller than the former for all state-years included in my analysis. Also worth noting is that there is considerable variation across states in this third measure of STEM educational attainment for both US and non-US citizens.

**Regression Results**

To further assess the relationship between STEM educational attainment and utility patent conferrals, I estimate a series of OLS regression models. Tables 3 through 5 present regression results that use the three different measures of STEM educational attainment respectively as my key independent variable. Tables 6 and 7 compare the relationship between STEM educational attainment and utility patent conferrals by students’ citizenship. Table 8 contains results from models in which I interact STEM educational attainment with two of my most important controls: college degree attainment and Advanced Industries workforce concentration.

\(^5\) These are raw unweighted percentages.
In Tables 3 through 7, I present regression results for six different specifications. The first four models all adopt the number of utility patent conferrals per 1000 labor force participants as the dependent variable. The last two models use the log of the number of utility patent conferrals per 1000 labor force participants as the dependent variable. More specifically, model 1 presents the raw correlation between STEM educational attainment and utility patent conferrals without any control variables included. In Model 2, I regress utility patent conferrals on STEM educational attainment and the full set of control variables, which include both demographic and macroeconomic characteristics. Model 3 builds on the previous two regressions by adding state and year fixed effects. Model 4 reports regression results from specifications that use STEM educational attainment lagged by 1 year as the key independent variable, with the full set of controls and fixed effects. Model 5 is the same model as model 3, except that the dependent variable is logged. Similarly, model 6 resembles model 4, with the only difference being that model 6 uses the log of the number of utility patent conferrals as the dependent variable.

All regressions are weighted using the average population of each state. Robust standard errors are reported under each coefficient. For ease of exposition, I do not report coefficients and robust standard errors for control variables in my main tables. However, complete regression results can be found in Appendices 1 through 6.

---

6 It is reasonable to expect a time lag between receiving a degree in the STEM field and contributing to a patentable innovation.
**STEM graduate degree conferral rate**

Table 3 reports the results from the regression of utility patent conferrals on the number of STEM graduate degrees conferred per population members aged 20 to 34. Model 1 shows that, without any control variables included in the regression, an increase of one unit in this measure of STEM educational attainment is associated with a statistically significant increase of approximately 0.18 utility patent conferrals per 1000 labor force participants, which is equivalent to half of a standard deviation. However, this raw correlation does not account for other factors that are likely to be associated with both STEM educational attainment and utility patent conferrals. For example, it is reasonable to assume that an increase in the economic output of a state, measured by GSP, is associated with increases in both the STEM educational attainment and the utility patent conferrals of that state. Therefore, the raw correlation described above is likely upwardly biased due to the exclusion of GSP in the regression. Indeed, when a full set of control variables is added to the regression in model 2, the coefficient on STEM educational attainment falls and becomes statistically indistinguishable from zero.

The omitted variables bias in my estimates is reduced further by the inclusion of state and year fixed effects, which control for fixed differences between states and time-varying differences that are constant across states. State and year fixed effects explain a large proportion of the variation in the utility patent conferrals. In fact, when I regress the dependent variable on state and year dummies only, I get an r-squared of 0.87. This indicates that only 13% of the variation of the utility patent conferrals is
left to be explained by all the other variables in the model. Therefore, it is not surprising to see no evidence of a meaningful relationship after the inclusion of the state and year fixed effect. This no non-statistical significant finding persists when I lag the STEM educational degree measure by 1 year, or log the patent conferral measures.

**Table 3: Regression of utility patent conferrals on the number of STEM graduate degrees conferred each year per 1000 of population aged 20 to 34 in a given state**

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEM graduate degrees conferred per 1000 individuals aged 20 to 34</td>
<td>0.177***</td>
<td>0.0136</td>
<td>-0.0485</td>
<td>-0.0891</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0204)</td>
<td>(0.0206)</td>
<td>(0.0790)</td>
<td>(0.0784)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STEM graduate degrees conferred per 1000 individuals aged 20 to 34, lagged by 1 year</td>
<td>-0.0638</td>
<td>-0.0876</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0776)</td>
<td>(0.0785)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>950</td>
<td>1,000</td>
<td>950</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.101</td>
<td>0.680</td>
<td>0.915</td>
<td>0.921</td>
<td>0.966</td>
<td>0.969</td>
</tr>
<tr>
<td>Controls</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>State and Year Fixed Effects</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

**STEM graduate degree share**

Table 4 reports results for regressions in which STEM educational attainment is measured as the number of STEM graduate degrees conferred divided by all graduate degrees conferred each year in a given state. Intuitively, this measure represents the extent to which graduate education programs are concentrated in STEM fields. A larger concentration in STEM fields is expected to be associated with a higher level of utility patent conferrals. The raw correlation coefficient shown in model 1 is statistically significant and in the expected direction. However, this association is small in magnitude; because this measure of STEM educational attainment ranges
from 0.05 to 0.36, a 0.01-unit increase, or a 1 percentage point increase in this measure is statistically associated with an increase of approximately 0.025 units in utility patent conferrals, which is equivalent to 0.07 standard deviations. When I include macroeconomic and demographic controls, as model 2 shows, the relationship becomes even smaller and indistinguishable from zero. Also, the sign of the coefficient on STEM educational attainment is unexpected – models 3 through 6 indicate that STEM educational attainment is negatively associated with the number of utility patent conferrals per 1000 labor force participants, although this association is extremely small in magnitude.

Table 4: Regression of utility patent conferrals on the number of STEM graduate degrees as a percentage of all graduate

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEM graduate degrees per all graduate degrees conferred in a given year</td>
<td>2.521***</td>
<td>0.249</td>
<td>-0.866*</td>
<td>-0.903*</td>
<td>-0.983*</td>
<td>-0.867</td>
</tr>
<tr>
<td></td>
<td>(0.492)</td>
<td>(0.292)</td>
<td>(0.457)</td>
<td>(0.533)</td>
<td>(0.505)</td>
<td>(0.555)</td>
</tr>
<tr>
<td>STEM graduate degrees per all graduate degrees conferred in a given year, lagged by 1 year</td>
<td></td>
<td>-0.983*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>950</td>
<td>1,000</td>
<td>950</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.049</td>
<td>0.681</td>
<td>0.915</td>
<td>0.922</td>
<td>0.966</td>
<td>0.969</td>
</tr>
<tr>
<td>Controls</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>State and Year Fixed Effects</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

**STEM bachelor’s degree holding rate**

Table 5 presents results from regressions that use the third measure of STEM educational attainment: the number of STEM bachelor’s degree holders per 1000 of population members 20 and above. As is shown in the earlier section, this measure of STEM educational attainment ranges from 29.61 to 95.35. Model 1 shows the raw
correlation between this measure of STEM educational attainment and utility patent conferrals to be 0.023, which implies that a 10-unit increase in STEM educational attainment is associated with a 0.23-unit increase in utility patent conferrals per 1000 of labor force participants. This relationship, which is statistically significant, may seem small in magnitude, but is in fact the equivalent of almost a two-thirds of a standard deviation increase in utility patent conferrals. When I control for both demographic and macroeconomic characteristics, as shown in model 2, the coefficient on STEM educational attainment falls. As the case earlier, the inclusion of the state and year fixed effects in model 3 further reduces the omitted variable bias and turns the coefficient on STEM educational attainment from statistically significant (in model 2) to not statistically significant.

Models 5 and 6 estimate regression results using the log of utility patent conferrals as the dependent variable. The coefficients – though not statistically significant – are qualitatively similar to coefficients from models 3 and 4, respectively.

Table 5: Regression of utility patent conferrals on the number of individuals with a STEM bachelor's degree per 1000 of population 20 and above in a given state

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) Patents per 1000 labor force</th>
<th>(2) Patents per 1000 labor force</th>
<th>(3) Log of patents per 1000 labor force</th>
<th>(4) Log of patents per 1000 labor force</th>
<th>(5) Log of patents per 1000 labor force</th>
<th>(6) Log of patents per 1000 labor force</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEM bachelor's degree holders per population</td>
<td>0.0223***</td>
<td>0.00928***</td>
<td>-0.00516</td>
<td>0.00255</td>
<td>-0.00163</td>
<td>-0.00278</td>
</tr>
<tr>
<td>20 and above</td>
<td>(0.00314)</td>
<td>(0.00332)</td>
<td>(0.00316)</td>
<td>(0.00196)</td>
<td>(0.00238)</td>
<td>(0.00251)</td>
</tr>
<tr>
<td>STEM bachelor's degree holders per population</td>
<td>20 and above, lagged by 1 year</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>250</td>
<td>250</td>
<td>250</td>
<td>250</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.408</td>
<td>0.796</td>
<td>0.988</td>
<td>0.996</td>
<td>0.994</td>
<td>0.995</td>
</tr>
<tr>
<td>Controls</td>
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<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>State and Year Fixed Effects</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Subgroup analysis: by citizenship

In Tables 6 and 7, I use the third measure of STEM attainment, the bachelor’s degree holding rate, and disaggregate the relationship of interest by students’ citizenship status. I find that, for the most part, the association between STEM educational attainment and utility patent conferrals is stronger for temporary US visa holders than for US citizens or permanent US residents.

Table 6: Regression of utility patent conferrals on the number of individuals with a STEM bachelor’s degree per 1000 of population 20 and above in a given state (US citizens and permanent residents)

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>US STEM bachelor's degree holders per population 20 and above</td>
<td>0.0118***</td>
<td>0.00297</td>
<td>-0.00648**</td>
<td>-0.00320</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.00446)</td>
<td>(0.00363)</td>
<td>(0.00316)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>US STEM bachelor's degree holders per population 20 and above, lagged by 1 year</td>
<td></td>
<td></td>
<td></td>
<td>0.000681</td>
<td>-0.00282</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.00226)</td>
<td>(0.00338)</td>
</tr>
<tr>
<td>Observations</td>
<td>250</td>
<td>250</td>
<td>250</td>
<td>200</td>
<td>250</td>
<td>200</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.050</td>
<td>0.790</td>
<td>0.988</td>
<td>0.996</td>
<td>0.994</td>
<td>0.995</td>
</tr>
<tr>
<td>Controls</td>
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<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>State and Year Fixed Effects</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Robust standard errors in parentheses</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*** p&lt;0.01, ** p&lt;0.05, * p&lt;0.1</td>
<td></td>
</tr>
</tbody>
</table>

Table 7: Regression of utility patent conferrals on the number of individuals with a STEM bachelor’s degree per 1000 of population 20 and above in a given state (temporary US visa holders)

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-US STEM bachelor's degree holders per population 20 and above</td>
<td>0.0358***</td>
<td>0.0145***</td>
<td>-0.00290</td>
<td></td>
<td>0.00200</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.00473)</td>
<td>(0.005461)</td>
<td>(0.00618)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-US STEM bachelor's degree holders per population 20 and above, lagged by 1 year</td>
<td></td>
<td></td>
<td></td>
<td>0.00976**</td>
<td>-0.00444</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.00640)</td>
<td>(0.00470)</td>
</tr>
<tr>
<td>Observations</td>
<td>250</td>
<td>250</td>
<td>250</td>
<td>200</td>
<td>250</td>
<td>200</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.498</td>
<td>0.796</td>
<td>0.987</td>
<td>0.996</td>
<td>0.994</td>
<td>0.995</td>
</tr>
<tr>
<td>Controls</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>State and Year Fixed Effects</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Robust standard errors in parentheses</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*** p&lt;0.01, ** p&lt;0.05, * p&lt;0.1</td>
<td></td>
</tr>
</tbody>
</table>
Subgroup analysis: college educational attainment and advanced industries workforce concentration

Table 8 presents the results of two models in which I interact the bachelor’s degree holding rate – the third of my three measures of STEM educational attainment – with dummied versions of two selected control variables: college educational attainment and advanced industries workforce concentration. These two models, both of which include a full set of controls as well as state and year fixed effects, show statistically significant associations for the relationship of interest for certain states. More specifically, model 1 reveals that, for states that have lower-than-average college educational attainment, the relationship between STEM educational attainment and utility patent conferrals is negative and statistically indistinguishable from zero. For states that have higher-than-average college educational attainment, however, a one-unit increase in this measure of STEM educational attainment is associated with an approximately 0.115 (-0.00384 + 0.119 = 0.11516) unit increase in utility patent conferrals per 1000 labor force participants. This relationship is statistically significant and comparatively large – it is equivalent of one-third of the standard deviation of the utility patent conferrals. Similarly, for states whose advanced industries workforce concentration is higher than the national average, a one-unit increase in the STEM educational attainment is statistically significantly associated with a roughly 0.166 (-0.00453 + 0.171 = 0.16647) unit increase in the measure of utility patent conferrals, which is an increase of almost half of a standard deviation.

7 I estimated regressions interacting dummied versions of my other control variables with all three measures of STEM educational attainment, but found no significant results.
This study examines the relationship between STEM educational attainment and the level of innovation measured by utility patent conferrals at the state level in the United States. In view of the current national debate about whether STEM education could foster innovation, the results of the study are well-timed to inform policy decisions on the promotion of STEM education.

Using regression analysis to control for observed demographic and macroeconomic factors as well as unobserved fixed differences between states and time-varying differences that are constant across states, I find that, in general, there is no evidence of a meaningful relationship between STEM educational attainment and utility patent conferrals. The relationship of interest, though generally not statistically significant, is stronger for temporary US visa holders than for US citizens or permanent US residents. However, I also find that there is a statistically significant

### Table 8: Subgroup analysis: interactions

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) Patents per 1000 labor force</th>
<th>(2) Patents per 1000 labor force</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEM educational attainment</td>
<td>-0.00384 (0.00322)</td>
<td>-0.00453 (0.00271)</td>
</tr>
<tr>
<td>High college educational attainment</td>
<td>-0.236*** (0.0841)</td>
<td></td>
</tr>
<tr>
<td>STEM educational attainment_High college educational attainment</td>
<td>0.119** (0.0462)</td>
<td></td>
</tr>
<tr>
<td>High Advanced Industry workforce concentration</td>
<td>-0.391** (0.168)</td>
<td></td>
</tr>
<tr>
<td>STEM educational attainment_High Advanced Industry workforce concentration</td>
<td>0.171** (0.0786)</td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.989</td>
<td>0.989</td>
</tr>
<tr>
<td>F-Statistics and P-Values for Joint Hypotheses</td>
<td>3.69</td>
<td>2.63</td>
</tr>
<tr>
<td>Controls</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>State and Year Fixed Effect</td>
<td>YES</td>
<td>YES</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1
and large association between STEM educational attainment and utility patent conferrals for states that have above-average college educational attainment or above-average advanced industries workforce concentration.

This study sheds new light on the limited existing literature that directly studies the relationship between STEM educational attainment and utility patent conferrals. As discussed earlier, when adopting an OLS approach, Winters (2014) finds a statistically significant and large association between STEM educational attainment and utility patent conferrals. Contrary to that finding, my results yield no evidence of such a general relationship. This difference may be explained by the fact that, besides controlling for time-varying demographic and macroeconomic factors, my study includes state and year fixed effects, while Winters’s study includes only a limited list of fixed characteristics, including census region, average temperature, and average precipitation. In this regard, because my inclusion of fixed effects reduces a larger proportion of omitted variable bias, my results may be more credible. It should be noted, however, that controlling for fixed effects runs the risk of eliminating much of the variation in utility patent conferrals, thereby limiting my ability to study the relationship of interest.

In addition, my study provides an opportunity to test whether different definitions of STEM educational attainment as well as different data sources lead to dissimilar findings. In Winters’s study, STEM educational attainment is measured as the number of individuals with a STEM bachelor’s degree per members of the adult population. In Ray’s (2015) study, STEM educational attainment is defined as the number of
STEM degrees as a proportion of all higher education degrees conferred each year in a given state. My study, which covers both of these definitions, supports Ray’s findings that, in general, there is no meaningful relationship between STEM educational attainment and utility patent conferrals. The difference between Ray’s and my findings and Winters’s findings may be partly explained again by my inclusion of fixed effects, and also by the fact that Winters’s unit of analysis is the metropolitan level, while Ray’s and my studies target the state level.

My study has several key limitations. The first is that, although I control for demographic, macroeconomic, and fixed state and year characteristics, my regression results may be still subject to omitted variable bias. For example, one time-varying characteristic not included in my regression analysis is the quality of STEM education in each state. It is reasonable to assume some variation in the quality of STEM degrees conferred within states over time, and some variation in the patent-related skill-sets of people who holds STEM degrees within states over time. The quality of STEM education is likely to be positively correlated with both the quantity measures of STEM educational attainment and utility patent conferrals. Therefore, the lack of consideration of STEM education quality likely upwardly biases the coefficient on my key independent variable. In other words, my results may overstate the relationship between STEM educational attainment and utility patent conferrals.

Second, although I adopt three measures of STEM educational attainment, none is perfect in operationalizing this concept. For the first two measures of STEM educational attainment – the number of STEM graduate degrees conferred each year
per population members aged 20 to 34, and the number of STEM graduate degrees as a percentage of all graduate degrees conferred each year – it is possible that students receive their STEM degrees in one state, but move to another after completing their education. The third measure of STEM educational attainment – the number of individuals with a STEM bachelor’s degree per population members aged 20 and above – addresses this concern by focusing on where the STEM degree holders live rather than where they go to school. However, this measure fails to address the possibility that a STEM degree holder who lives in one state is granted utility patents from another state. These examples suggest that the coefficients on my key independent variables could be biased, although the direction of any such bias is unclear.

In addition, my third measure of STEM educational attainment, though the best measure available, is suboptimal. It targets STEM educational attainment at the undergraduate level, but it is reasonable to assume a stronger association between utility patent conferrals and STEM educational attainment at the graduate level. Also, with only 5 years of data available, this third measure of STEM educational attainment suffers from a comparatively small number of observations.

Each of these limitations points to potential directions for further research. In future analyses, as more years of data become available, more variation in utility patent conferrals could be examined. Future research might also identify better ways of measuring STEM educational attainment and identify other analytical strategies that would hold omitted variable bias to a minimum. In addition, I invite future studies to
focus more on the question of whether the relationship of interest differs according to a state’s educational attainment and industrial composition.

The results of this study may provide useful guidance for policy makers. Overall, my results do not suggest any meaningful relationship between STEM educational attainment and utility patent conferrals. However, for states that have above-average college educational attainment or above-average advanced industries workforce concentration, STEM educational attainment is positively, strongly, and significantly correlated with utility patent conferrals. This result could be helpful to policymakers when making decisions about reforming STEM education.
## Appendices

### Appendix 1: Regression of utility patent count on the number of STEM graduate degrees conferred each year per 1000 of population aged 20 to 34 in a given state

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEM graduate degrees conferred per 1000 individuals aged 20 to 34</td>
<td>0.177**</td>
<td>0.0128</td>
<td>0.0048</td>
<td>-0.0381</td>
<td>(0.0267)</td>
<td>(0.073)</td>
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Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1
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<th>(4)</th>
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R-squared, Adjusted R-squared, and number of states are for the final model. Standard errors in parentheses.

*** p<0.01, ** p<0.05, * p<0.1
### Appendix 3: Regression of utility patent conferrals on the number of individuals with a STEM bachelor’s degree per 1000 of population 20 and above in a given state

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<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
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<td>STEM bachelor’s degree holders per population 20 and above</td>
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Observations 250 250 250 200 250 200
R-squared 0.408 0.706 0.854 0.872 0.900 0.791

Number of statecode 50 50 50 50 50

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1
### Appendix 4: Regression of utility patent conferrals on the number of individuals with a STEM bachelor’s degree per 1000 of population 20 and above in a given state (US citizens and permanent residents)

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<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
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<td>STEM bachelor’s degree holders per population</td>
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<td>20 and above - lagged by 1 year</td>
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Robust standard errors in parentheses.  
*** p<0.01, ** p<0.05, * p<0.1
## Appendix 5: Regression of utility patent conferrals on the number of individuals with a STEM bachelor's degree per 1000 of population 20 and above in a given state (temporary US visa holders)

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<th>(5)</th>
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Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
## Appendix 6: Subgroup analysis: interactions

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<td>Percent per 1000 labor force</td>
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Observations: 250
R-squared: 0.968
Number of states: 50

R-hat standard errors in parentheses

*** p<0.001, ** p<0.05, * p<0.1
References


the Study of Labor.


