Article

New Horizons in Adult Education and Human Resource Development
2023, Vol. 35(1) 5–19

DOI: 10.1177/19394225231171575
journals.sagepub.com/home/nha
Sage

# The STEM Wage Premium Across the OECD

**William E. Even[1], Takashi Yamashita[2], and Phyllis A. Cummins[1]**


## Abstract

Using data from the Program for the International Assessment of Adult Competencies, this paper compares the earnings premium and employment share of jobs in Science, Technology, Engineering and Mathematics (STEM) across 11 member countries of the Organisation for Economic Co-operation and Development. The results reveal that the STEM wage premium is higher in the United States than in any of the other comparison countries, despite the fact that the U.S. has a larger share of workers in STEM jobs. We also find evidence that the premium varies significantly across STEM sub-fields and education levels, and that the premium tends to be higher in countries with lower unionization rates, less employment protection, or a larger share of employment in the public sector.



## Keywords

STEM, PIACC, wage structure, education, human capital


Policy makers throughout the world consider science, technology, engineering, and mathematics (STEM) skills essential to economic growth and improvements in its citizenry's standard of living (Langdon et al., 2011; Xie et al., 2015). As a result, many economically developed countries have instituted policies aimed at increasing the supply of STEM workers. For example, the United States federal government allocated over $4 billion in the 2020 fiscal year to support STEM education (American Institute of Physics, 2020).

While there is broad consensus on the importance of STEM skills to economic growth and technological development vital to national security, some question the extent to which there is a shortage of STEM workers and the wisdom of government policy aimed at increasing the supply of STEM workers. For example, Xue and Larson (2015) argue that there is significant heterogeneity in the STEM labor market and there is a shortage of some skills and a surplus of others. Anft (2013) argues that the perception of a shortage of STEM workers is promulgated by corporations that benefit from lower wages for STEM workers and by universities that benefit from more federal funding for STEM research and education. At the same time, the National Science and Technology Council (2018) points to the above average wages and employment growth for STEM workers as a reason to expand STEM education in the U.S. Also, research shows that a free market may provide too few STEM workers because they create positive externalities in the labor market by increasing economic growth and the wages of other workers. Similarly, institutional control over the educational system can affect the relative supply of different types of skills and it is possible that the current educational system is not placing sufficient emphasis on development of STEM skills.

The debate over how much government should subsidize the creation of more STEM workers is complicated by several factors. First, while there is a fairly strong consensus that STEM employment is critical to a country's ability to innovate and its level of economic growth, there is disagreement about which particular sub-fields of STEM jobs will have the greatest pay-off and where shortages are likely to be most severe. Second, there are numerous ways to increase the size of the relevant STEM work-force ranging from changes in the structure of elementary and secondary education, to subsidies to expand post-secondary enrollments in specific fields of study. Also, subsidies could take the form of grants to support institutions that expand offerings in specific fields or scholarships for students who enroll in those fields. Finally, there is the question of what level of education (e.g. certificates at community colleges, workplace training, associate's degrees, bachelor's or graduate degrees) will have the highest pay-off.

This paper provides new insights into the debate over government support for STEM education by comparing the

[1]Miami University, Oxford, OH, USA
[2]University of Maryland, Baltimore County, MD, USA

**Corresponding Author:**
William E. Even, Department of Economics, Miami University, Oxford, OH 45056, USA.
Email: evenwe@miamioh.edu

STEM wage premium in the U.S. to that in other developed countries. If the U.S. is lagging other countries in the production of STEM skills, we expect this to result in a relatively low share of workers in STEM jobs who earn a relatively high wage premium. This would be of concern since it would suggest that other countries would have a competitive advantage in the STEM labor market and the U.S. could fall behind other countries. On the other hand, if U.S. institutions (e.g., intellectual property law and tax law, institutional knowledge) make STEM workers more productive in the U.S. than in other countries, we should expect a relatively high STEM wage premium and a relatively large share of workers in STEM jobs.

Our analysis compares the STEM labor markets across 11 member countries of the Organisation for Economic Cooperation and Development (OECD). The data are from the Program for the International Assessment of Adult Competencies (PIAAC) developed by the OECD and implemented by each member country. The empirical analysis estimates the STEM wage premium in each country after controlling for a variety of worker and firm characteristics that might influence wages and controlling for the mix of occupations within a country. A comparison of the premia across countries reveals several important findings. First, the overall STEM wage premium is larger in the U.S. than in any of the other countries in the sample. This does not reflect a relatively low supply of STEM workers in the U.S. In fact, the U.S. has a larger share of workers in STEM jobs than the majority of other countries. Second, a separate analysis of sub-fields of STEM jobs reveals significant variation in the wage premium across sub-fields and shows that the U.S. pays an above average premium and has an above average share of workers in each sub-field. Finally, the STEM wage premium is higher for workers with less than a bachelors' degree in all of the countries examined. Moreover, the evidence suggests that the U.S. pays a higher STEM premium for those with less than a bachelors' degree than any other country examined—despite the fact that it has a larger share of such workers in STEM jobs.

## Background

The National Science and Technology Council recently pointed out that the long-term prospects for economic growth in the United States could be damaged by the fact that it is lagging other countries in the development of STEM skills (Holdren et al., 2013). For example, since 2000, India and China have produced nearly one-half of all degrees in science and engineering while the United States produced only 10% (Bridenstine et al., 2018). Also, the U.S. is in the middle of the pack in a group of 33 OECD countries in terms of basic skills in mathematics and science (Koonce et al., 2011). This concern is not new and as a result, the U.S. implemented the America Competes Reauthorization Act of 2010 mandating that the National Science and Technology Committee generate 5-year strategic plans to improve STEM education. The strategic plans under the past two administrations (Presidents Obama and Trump) have allocated billions of dollars annually to improve STEM skills in the United States. In the 2020 fiscal year alone, over $4 billion was allocated by the federal government to support STEM education (American Institute of Physics, 2020). The initiatives aim to improve STEM education ranging from primary school through graduate school, apprenticeships, and on-the-job training. There are also programs promoting efforts to improve the representation of minorities and women in STEM fields (Bridenstine et al., 2018; Stockard et al., 2021).

Global demand for STEM workers is projected to increase over the next decade due to the creation of new positions and demographic changes caused by the retirement of the baby boomer cohort (Carnevale et al., 2011; Shapiro et al., 2015). The U.S. Bureau of Labor Statistics (U.S. BLS, 2020) projects that between 2019 and 2029, employment in STEM occupations in the U.S. will grow by 12.3% as compared to 1.6% for non-STEM occupations. This understates the likely growth in demand for both STEM and non-STEM workers because it does not consider occupational separations (e.g., retirement and occupational switches). For example, the U.S. BLS (2020) projects an increase of 3.2 million STEM positions between 2019 and 2029, but the annual average STEM occupational openings due to occupational switches and retirements over the same period is about 2.4 million, or approximately 9% of the STEM openings in 2019 (U.S. BLS, 2020). Occupational growth and job openings in STEM positions in European Union countries over the next decade are also projected to increase, but at a rate of about half of that in the U.S. (Cedefop, 2018). While there are worker shortages in some STEM occupations; there is a surplus in other areas. For example, there appears to be a surplus of Ph.D.'s seeking tenure track faculty positions in some disciplines (e.g., physical sciences, biomedical scientists) whereas in the government-related sector there are shortages in some specialties (e.g., nuclear engineering, systems engineers, cybersecurity professionals). Foreign-born STEM workers are able to work in academia and the private sector, but they are not permitted to work in many government positions and for contractors involved in defense related projects which is a contributor to shortages in some sectors (Xue & Larson, 2015). Immigrants also account for a disproportionate share of jobs in STEM occupations (Hanson & Slaughter, 2018).

As compared to European countries, the U.S. has fared better in attracting foreign-born STEM professionals, with estimates ranging from 16% to 22% of (non-health related occupations) STEM workers coming from abroad (Anderson, 2016; Carnevale et al., 2011; Shapiro et al., 2015) as compared to 3% in Europe (Shapiro et al., 2015). Historically, the U.S. has been successful in attracting foreign-born students in STEM fields with up to 70% remaining in the U.S. Since 2000, the U.S. share of foreign-born students has declined as competition from other countries, such as China and India, has increased. Trade disputes between the U.S. and China over the past several years resulted in a decline in enrollment of students from China (Bound et al., 2021). In addition, the COVID-19 pandemic resulted in an estimated 43% decline in international student enrollment in the U.S. (Baer & Martel, 2020). In recent years graduate students from China and India are less likely to remain in the U.S. (National Science Board, 2018). The combination of the pandemic, political disputes with China, and anti-immigration sentiment could result in continued declines in enrollment by international students in the U.S. over the next several years (Fischer & Aslanian, 2021; Zavodny, 2021). The current heavy reliance on foreign born STEM workers in the U.S. and the potential for their decline in the future could lead to a rising STEM premium in the U.S.

The evidence supporting the importance of STEM skills is wide ranging. Within economics, there are at least two relevant strands of literature. The macroeconomic growth literature provides evidence that countries with more research and development (R&D) have higher rates of economic growth. For example, Griliches (1992) reviews the literature on the spillovers from R&D and presents evidence that nearly one-half of the growth in U.S. productivity can be accounted for by the returns to R&D where STEM workers are a vital input. A second strand of literature shows that an increase in the number of STEM workers in a local economy drives up the wages of both STEM and non-STEM workers (e.g., Peri et al., 2015; Peri & Shi, 2015; Winters, 2014). The logic for this finding is that STEM workers create positive spillovers that drive up the productivity of other workers—particularly those with college degrees. More STEM workers in the local economy have also been shown to improve employment growth, patenting, and exports (Rothwell, 2013).

While there is little disagreement about the importance of STEM skills for economic growth and the potential for positive spillovers, there is relatively little known about how the U.S. STEM labor market compares with other countries. A good deal can be learned by comparing the labor market outcomes of STEM workers across countries. As an illustration, if STEM skills require strong numeracy skills and such skills are in short supply, a wage premium for STEM workers would be expected in all countries. If a country's STEM premium is higher than that in the rest of the world, this could signal one of several issues. One possibility is that the country has a relatively low supply of STEM workers. This would be a concern since it would suggest that the country has a smaller share of the economy devoted to STEM work, has a cost disadvantage in that area, and the country could underperform in areas like innovation and economic growth. A second possible explanation for a high STEM wage premium is that demand for STEM work is relatively high in the country. This would result in a relatively large STEM premium and a large share of workers in STEM jobs. While the high STEM premium is a signal that STEM workers are relatively more productive than in other countries, the outlook for future growth is more optimistic. That is, with a larger share of workers in STEM, the country can be optimistic about its future prospects for innovation and growth. This "high demand" story for a greater STEM premium is less worrisome than the "low supply" story. In either case, however, a relatively high STEM premium suggests that additional investments in STEM workers would have a relatively high return.

While educational systems are an obvious source of differences in the relative supply of STEM workers across economies, it is perhaps less obvious what could cause differences in the relative demand. Differences in institutional frameworks are one plausible explanation. Countries that have stronger intellectual property protections (e.g., patent laws) or who favor research and development activity through their tax system will have a greater demand for R&D and STEM workers. Also, given the positive spillovers that have been identified with STEM work, the productivity of STEM workers can rise with the number of STEM workers.

While cross-country differences in STEM worker supply and demand may explain cross-country differences in the STEM wage premium, institutional differences across labor markets could also be important. For example, Kahn (2000) studied 15 OECD countries and found that greater unionization leads to a compression of wage distributions and reduces the returns to skill. Also, Hanushek et al. (2015) studied the returns to skills across 23 countries and found that returns are lower in countries with higher unionization rates, a larger public sector share, and stricter employment protection laws.

While numerous studies show that STEM workers command a wage premium, there is no systematic cross-country comparison of the STEM labor market. For the United States, Noonan (2017) reports that STEM workers earn about 29% more than non-STEM workers after controlling for a wide range of worker characteristics (e.g., age, educational attainment, region, and industry). Other studies providing similar estimates of the STEM wage premium in the U.S. include Olitsky (2014), Light and Rama (2019), and Deming and Noray (2020). Compared to workers with a bachelor's degree, the STEM premium in the U.S. is larger (in percentage terms) for those with less than a bachelor's degree and smaller for those with a graduate degree. Research also documents a STEM premium in other developed economies. For example, Greenwood et al. (2011) and Yao (2019) find a STEM wage premium in the United

Kingdom while Croce and Ghignoni (2020) provide evidence for Italy.

It is difficult to rely on existing studies to compare the STEM wage premium across countries. The existing studies use different definitions of STEM (some focus on the amount of education in STEM subjects, others on occupations defined as STEM jobs) and different controls for worker skills. This study tries to remedy that by using a common definition of STEM jobs and a common set of controls for worker characteristics.

## Data and Descriptive Statistics

The data for the analysis are drawn from the PIAAC developed by the OECD. The PIACC data were collected in 2011 and 2012 and include information from household surveys and tests designed to measure individual skills in numeracy, literacy, and problem solving. OECD (2016) provides technical details on the PIAAC data. This is the most recently available PIACC data for the countries studied here. The survey respondents also provide detailed information on their demographic background, education, earnings, and work.

While PIACC includes data from 33 countries, our study focuses on the 11 OECD countries (listed in Appendix Table A1) that provided the necessary data on earnings, occupation, educational background, and skills. Our interest is in the extent to which STEM jobs command an earnings premium, how the U.S. premium compares to that in other countries, and how supply or demand factors might explain any differences in the STEM premium.

The existing literature provides several different definitions of STEM occupations. Koonce et al. (2011) and Noonan (2017) point out that there is fairly wide agreement on the inclusion of occupations in the hard sciences, engineering, and mathematics, but there is less consensus on whether to include educators, managers, technicians, health-care professionals or social scientists. For our analysis, we follow Shapiro et al. (2015) and define STEM jobs to include the following International Standard Classification of Occupations (ISCO) codes:

(1) science and engineering professionals (ISCO 21)
(2) Science and engineering associate professionals (ISCO 31)
(3) information and communications technology professionals (ISCO 25)
(4) Information and communications technicians (ISCO 35)
(5) Health professionals (ISCO22)
(6) Health associate professionals (ISCO 32).

These occupation codes are based on 2008 ISCO 2-digit codes. The codes for the six occupations listed are 21, 31, 25, 35, 22, and 32. While Canada provides occupation data for respondents, these are at the one-digit level and have insufficient detail to identify STEM jobs. Hence, Canada is not included in the analysis.

The occupations labeled as professional (1, 3, and 5) usually require education beyond a bachelor's degree, while those labeled as a technician or associate professional usually require some education beyond high school although a minority of workers in those jobs have the equivalent of a bachelor's degree or above. The share of workers with at least a bachelor's degree ranges from 65% to 72% for the three occupations with professionals in the title, whereas the share ranges from 21% to 26% for the three occupations that are not identified as professionals.

The level of detail on earnings varies across countries in PIACC. For our analysis, we use a measure of the hourly wage provided by PIACC that converts hourly wages into U.S. dollars using purchasing power parity exchange rates. In some countries, PIACC provides a measure of the hourly wage. In other countries, the hourly wage is not reported, but the decile containing the person's hourly wage is reported. For the two countries that report only the decile of the hourly wage (Germany and Sweden), we use the estimated median of the hourly wage within each decile provided by Hanushek et al. (2015).

PIACC data are not a random sample of the population. To obtain population estimates, all of our analysis uses the weights provided in the data. Also, PIAAC used the multistage adaptive testing approach, which selects the assessment item based on the respondent's performance, and the item response theory and latent regression models to generate 10 plausible values for each of the skill scores. OECD (2016) provides a description of how plausible values are created. Proper statistical inference accounting for the sampling design and use of plausible values (e.g., variance estimation) is obtained by using the Stata procedure (repest) developed by Jakubowski and Pokropek (2019).

Table 1 provides summary statistics for each country used in our analysis. The sample is restricted to workers between the ages of 16 and 65. The total number of observations across the 11 countries is 36,660. The percentage of workers in STEM occupations ranges from a low of 9.5% in South Korea to a high of 16.8% in Norway. The share of U.S. workers in STEM is slightly higher (15.2%) than the average across the other 10 countries combined (13.0%). The remainder of Table 1 shows how STEM workers compare to non-STEM workers in terms of their earnings, demographics, and place of employment. For each variable listed, the mean value is provided for STEM and non-STEM workers, the difference between the STEM and non-STEM means, and a *t*-statistic for the hypothesis that the difference is zero. The comparisons reveal that STEM workers in every country earn higher wages, have higher numeracy skills, are more likely to hold a college degree, and are more likely to be employed by large firms with 1,000 or more

**Table 1.** Summary Statistics From PIAAC Data.[a].

| | Australia | Germany | Great Britain | Ireland | Italy | Japan | South Korea | Netherlands | Norway | Sweden | International[a] | United States |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Percent STEM | | | | | | | | | | | | |
| | 13.0% | 15.3% | 11.3% | 12.3% | 11.3% | 13.7% | 9.5% | 14.8% | 16.8% | 16.0% | 13.0% | 15.2% |
| Log wage | | | | | | | | | | | | |
| STEM | 3.09 | 2.95 | 3.12 | 3.23 | 2.82 | 2.81 | 2.83 | 3.06 | 3.35 | 3.05 | 2.93 | 3.23 |
| Non-STEM | 2.79 | 2.71 | 2.70 | 2.87 | 2.54 | 2.54 | 2.54 | 2.84 | 3.05 | 2.84 | 2.64 | 2.78 |
| Difference | 0.30 | 0.25 | 0.42 | 0.35 | 0.28 | 0.27 | 0.29 | 0.23 | 0.30 | 0.22 | 0.29 | 0.45 |
| *t*-Statistic | 13.09 | 9.48 | 15.33 | 11.49 | 7.99 | 10.76 | 6.72 | 11.91 | 20.19 | 20.49 | 23.08 | 15.29 |
| Numeracy score | | | | | | | | | | | | |
| STEM | 299.35 | 291.38 | 296.50 | 287.81 | 282.03 | 310.65 | 289.66 | 305.08 | 312.48 | 312.83 | 299.54 | 283.34 |
| Non-STEM | 272.19 | 274.68 | 267.79 | 261.01 | 251.01 | 289.70 | 264.85 | 284.54 | 279.80 | 283.03 | 275.47 | 260.44 |
| Difference | 27.16 | 16.71 | 28.71 | 26.80 | 31.02 | 20.95 | 24.81 | 20.54 | 32.68 | 29.80 | 24.07 | 22.90 |
| *t*-Statistic | 9.76 | 5.33 | 8.72 | 9.47 | 7.37 | 8.32 | 9.67 | 8.48 | 16.11 | 12.83 | 18.33 | 7.61 |
| Share with a bachelor's degree or higher | | | | | | | | | | | | |
| STEM | 0.63 | 0.36 | 0.54 | 0.53 | 0.36 | 0.46 | 0.55 | 0.46 | 0.70 | 0.47 | 0.46 | 0.49 |
| Non-STEM | 0.23 | 0.16 | 0.25 | 0.23 | 0.14 | 0.25 | 0.23 | 0.27 | 0.29 | 0.21 | 0.22 | 0.29 |
| Difference | 0.39 | 0.20 | 0.28 | 0.30 | 0.22 | 0.20 | 0.32 | 0.19 | 0.41 | 0.26 | 0.24 | 0.20 |
| *t*-Statistic | 14.89 | 8.45 | 9.43 | 10.04 | 5.98 | 8.70 | 9.32 | 6.80 | 19.36 | 10.95 | 20.52 | 7.14 |
| Labor market experience | | | | | | | | | | | | |
| STEM | 17.22 | 17.77 | 19.05 | 17.21 | 18.07 | 16.71 | 10.02 | 18.11 | 19.14 | 19.96 | 16.95 | 20.95 |
| Non-STEM | 18.05 | 19.44 | 19.35 | 16.47 | 17.34 | 18.99 | 13.27 | 18.27 | 18.16 | 19.66 | 18.24 | 19.20 |
| Difference | −0.83 | −1.67 | −0.30 | 0.74 | 0.73 | −2.28 | −3.25 | −0.17 | 0.98 | 0.30 | −1.29 | 1.75 |
| *t*-Statistic | −1.38 | −2.91 | −0.43 | 1.28 | 0.77 | −3.87 | −6.72 | −0.30 | 1.90 | 0.61 | −4.63 | 2.92 |
| Share female | | | | | | | | | | | | |
| STEM | 0.45 | 0.52 | 0.37 | 0.48 | 0.28 | 0.40 | 0.36 | 0.35 | 0.42 | 0.41 | 0.41 | 0.47 |
| Non-STEM | 0.47 | 0.47 | 0.50 | 0.54 | 0.45 | 0.44 | 0.43 | 0.50 | 0.52 | 0.52 | 0.46 | 0.50 |
| Difference | −0.02 | 0.04 | −0.14 | −0.06 | −0.16 | −0.04 | −0.07 | −0.15 | −0.10 | −0.11 | −0.05 | −0.03 |
| *t*-Statistic | −0.53 | 1.96 | −5.08 | −1.98 | −5.18 | −1.45 | −2.21 | −6.37 | −4.68 | −4.96 | −4.39 | −1.07 |
| Share aged 35–54 | | | | | | | | | | | | |
| STEM | 0.44 | 0.55 | 0.54 | 0.54 | 0.60 | 0.53 | 0.41 | 0.51 | 0.57 | 0.53 | 0.52 | 0.46 |
| Non-STEM | 0.43 | 0.52 | 0.47 | 0.43 | 0.59 | 0.48 | 0.55 | 0.46 | 0.45 | 0.48 | 0.50 | 0.43 |
| Difference | 0.01 | 0.03 | 0.07 | 0.11 | 0.01 | 0.04 | -0.14 | 0.04 | 0.13 | 0.05 | 0.02 | 0.03 |
| *t*-Statistic | 0.47 | 1.12 | 2.45 | 3.37 | 0.21 | 1.91 | -5.14 | 1.51 | 6.16 | 2.00 | 1.73 | 1.34 |
| Share aged 55–64 | | | | | | | | | | | | |
| STEM | 0.11 | 0.11 | 0.09 | 0.09 | 0.12 | 0.11 | 0.03 | 0.11 | 0.14 | 0.19 | 0.10 | 0.17 |
| Non-STEM | 0.13 | 0.16 | 0.14 | 0.11 | 0.10 | 0.21 | 0.11 | 0.14 | 0.16 | 0.18 | 0.16 | 0.16 |
| Difference | −0.03 | −0.05 | −0.05 | −0.02 | 0.02 | −0.10 | −0.08 | −0.03 | −0.02 | 0.01 | −0.06 | 0.01 |
| *t*-Statistic | −1.51 | −2.99 | −2.98 | −1.41 | 0.54 | −6.00 | −7.34 | −2.06 | −1.02 | 0.55 | −6.85 | 0.69 |

*(continued)*

**Table 1. (continued)**

| | Australia | Germany | Great Britain | Ireland | Italy | Japan | South Korea | Netherlands | Norway | Sweden | International[a] | United States |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Share involved in life-long learning activities in past 12 months | | | | | | | | | | | | |
| STEM | 0.19 | 0.10 | 0.25 | 0.16 | 0.06 | 0.03 | 0.10 | 0.19 | 0.13 | 0.12 | 0.10 | 0.22 |
| Non-STEM | 0.18 | 0.06 | 0.16 | 0.14 | 0.05 | 0.02 | 0.04 | 0.16 | 0.17 | 0.11 | 0.07 | 0.12 |
| Difference | 0.01 | 0.04 | 0.09 | 0.02 | 0.01 | 0.01 | 0.06 | 0.03 | −0.03 | 0.01 | 0.03 | 0.09 |
| *t*-Statistic | 0.64 | 2.73 | 3.29 | 1.22 | 0.65 | 0.88 | 3.22 | 1.33 | −1.85 | 1.01 | 4.95 | 5.51 |
| Share employed in public sector | | | | | | | | | | | | |
| STEM | 0.35 | 0.30 | 0.39 | 0.43 | 0.34 | 0.12 | 0.12 | 0.30 | 0.41 | 0.37 | 0.24 | 0.19 |
| Non-STEM | 0.18 | 0.20 | 0.26 | 0.26 | 0.20 | 0.12 | 0.16 | 0.27 | 0.35 | 0.37 | 0.19 | 0.22 |
| Difference | 0.17 | 0.10 | 0.13 | 0.17 | 0.15 | 0.00 | −0.04 | 0.03 | 0.06 | 0.00 | 0.06 | −0.03 |
| *t*-Statistic | 8.68 | 4.36 | 4.67 | 6.66 | 3.82 | −0.26 | −1.94 | 1.04 | 2.55 | −0.10 | 5.73 | −1.70 |
| Share employed at firms with 51–100 workers | | | | | | | | | | | | |
| STEM | 0.44 | 0.43 | 0.47 | 0.46 | 0.44 | 0.44 | 0.34 | 0.38 | 0.43 | 0.43 | 0.43 | 0.40 |
| Non-STEM | 0.34 | 0.38 | 0.39 | 0.29 | 0.26 | 0.34 | 0.28 | 0.39 | 0.31 | 0.35 | 0.34 | 0.39 |
| Difference | 0.10 | 0.05 | 0.08 | 0.17 | 0.18 | 0.10 | 0.06 | −0.01 | 0.11 | 0.08 | 0.09 | 0.01 |
| *t*-Statistic | 4.30 | 2.16 | 2.30 | 6.75 | 4.77 | 3.72 | 2.23 | −0.29 | 5.77 | 3.91 | 7.20 | 0.38 |
| Share employed at firms with 1,000 or more workers | | | | | | | | | | | | |
| STEM | 0.16 | 0.16 | 0.28 | 0.15 | 0.15 | 0.17 | 0.18 | 0.20 | 0.25 | 0.20 | 0.18 | 0.23 |
| Non-STEM | 0.06 | 0.09 | 0.11 | 0.06 | 0.07 | 0.05 | 0.07 | 0.07 | 0.07 | 0.06 | 0.07 | 0.09 |
| Difference | 0.10 | 0.08 | 0.17 | 0.10 | 0.08 | 0.12 | 0.11 | 0.13 | 0.18 | 0.14 | 0.11 | 0.14 |
| *t*-Statistic | 5.46 | 3.98 | 6.30 | 5.00 | 3.16 | 5.50 | 4.56 | 6.31 | 9.80 | 8.61 | 10.28 | 5.38 |
| Sample size | 4,371 | 3,369 | 4,792 | 2,811 | 1,947 | 3,273 | 3,116 | 3,191 | 3,178 | 2,863 | 32,911 | 3,749 |

*Note*. Weighted means are presented for workers employed in STEM and non-STEM jobs followed by the difference in the means and a *t*-statistic for the hypothesis that the means are equal for STEM and non-STEM workers.

[a]Includes all countries listed other than the United States.

employees. In the U.S., STEM workers are also more experienced and more likely to be engaged in life-long learning activities. Given the significant attention given to gender differences in STEM involvement, a somewhat surprising result is that there is not a statistically significant difference in the share of U.S. workers that are female by STEM status. The percentage of STEM workers that are female differs substantially across the detailed occupations included in the STEM group. For example, women make up 48% of U.S. workers in the PIACC data, but only 26% of science and engineering professionals, 80% of health associate professionals, and 86% of health professionals. This is largely driven by the fact that women are over-represented in the health sub-fields of STEM jobs and under-represented in the other STEM jobs.

The unadjusted earnings premium for STEM workers (measured as the gap in the mean of log-wages) ranges from a low of 22% (in Sweden) to a high of 45% in the U.S. The large STEM premium in the U.S. is the main focus of this paper. While the U.S. has an above share of its workers in STEM jobs, the fact that there is such a high premium for STEM workers could be of concern. Clearly, U.S. companies who try to compete with foreign countries in areas that rely heavily on STEM skills will be at a significant cost disadvantage—but it is possible that the higher cost for STEM workers is justified by a more skilled STEM workforce or higher productivity of STEM workers. In the next section, we analyze this question in greater detail.

## Analystical Strategy and Results

To provide a better understanding of why the STEM premium varies so much across countries and is so high in the U.S., regression methods are employed. The form of the regression for country *j* is

$$(1)\quad y_{ij} = \alpha_j \text{NonSTEM}_{ij} + \beta_j \text{STEM}_{ij} + X_{ij}\gamma_j + \epsilon_{ij}$$

where the subscripts *i* and *j* index person *i* in country *j*, *y* represents the log of the hourly wage, non-STEM (STEM) is a dummy variable that equals one for people in non-STEM (STEM) occupations, *X* is a vector of characteristics describing the worker, and $\epsilon$ is an error term that is assumed to be independent across workers and homoscedastic. The difference between the country specific coefficients on the STEM and non-STEM dummy variables $(\beta_j - \alpha_j)$ is the STEM premium for country *j*.

One problem with comparing these premia across countries is that the mix of occupations within both STEM and non-STEM jobs differs across countries. For example, the share of STEM workers that are engineers as opposed to health professionals may differ across countries. Countries with a larger share of STEM workers in the jobs with the highest wages will appear to have the highest STEM premium—even if there is no variation in the wages of a given occupation across countries. Similarly, since the STEM premium is based on a comparison of STEM wages with non-STEM wages, countries with a large share of non-STEM workers in low paying occupations will appear to have a high STEM premium.

To adjust the estimated STEM premium for the country-specific mix of jobs in STEM and non-STEM jobs, we estimate the following regression that includes a dummy variable for each of the 6 STEM occupations (measured at the two-digit level) and the 29 occupations making up non-STEM jobs:

$$y_{ij} = \sum_{k=1}^{6} \alpha_{jk} \text{STEM}_{ijk} + \sum_{k=1}^{29} \beta_{jk} \text{NonSTEM}_{ijk} + X_{ij}\beta_j + e_{ij}$$

The STEM premium for a given country can be calculated as the weighted average of the above coefficients with the weights representing the country's share of STEM and non-STEM workers within each of the sub-occupations. Specifically, define $\lambda_{jk}^{s}$ as the share of country *j*'s STEM workers in occupation *k*, and $\lambda_{jk}^{n}$ as the share of country *j*'s non-STEM workers in occupation *k*. The STEM premium ($p_j$) in country *j* can be calculated as:

$$p_j = \sum_{k=1}^{6} \left(\lambda_{jk}^{s} * \alpha_{jk}\right) - \sum_{k=1}^{29} \left(\lambda_{jk}^{n} * \beta_{jk}\right)$$

To remove the effect of cross-country differences in the distribution of workers across occupations on the STEM premium, we re-estimate the STEM premium by replacing the country specific share of workers in each occupation with the international average share obtained by pooling the 10 countries in our sample (excluding the U.S.). That is, we replace the estimates of country-specific occupation employment shares ($\lambda_{jk}^{s}$ and $\lambda_{jk}^{n}$) with estimates of the occupational shares for the group of 10 countries combined when estimating the premium in each country.

In addition to adjusting for the mix of occupations within each country, we also incrementally add controls for worker and firm characteristics to allow for the fact that worker characteristics may account for some of the STEM premium within a country, or differences in the STEM premium across countries. For example, STEM workers are more educated, on average, than non-STEM workers and this is part of the reason STEM workers are paid more. A more accurate picture of the STEM premium is obtained if education is controlled for in the regression. Similarly, it is possible that the differences in education between STEM and non-STEM workers is higher in some countries than others. For example, if the gap is unusually high in the U.S., a failure to control for education would cause the estimated STEM premium to be higher in the U.S. than in other countries.

While we are able to control for several important factors that would lead to a STEM premium, our estimates should not be interpreted as true causal estimates of the STEM premium. Our regression analysis controls for

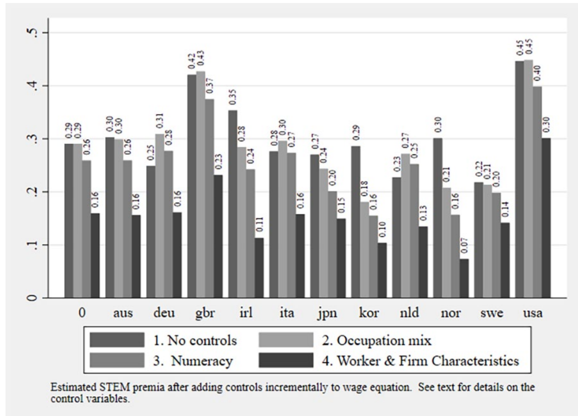


**Figure 1.** Source of STEM premium across countries: all education levels.
*Note*. aus = Australia; deu = Germany; gbr = England and Northern Ireland; irl = Ireland; ita = Italy; jpn = Japan; kor = South Korea; ndl = Netherlands; nor = Norway; swe = Sweden; usa = United States; Intl = All countries excluding U.S.

important observed characteristics that influence wages (e.g., education, numeracy skills, experience), but if selection into occupation is influenced by unobserved factors that affect wages, our estimates of the STEM premium could be biased. Some of the existing empirical research has attempted to remove this bias in the study of the returns to college major using dynamic models of major choice that require panel data on student behavior during their college careers (e.g., Altonji et al., 2016; Arcidiacono, 2004). This work generally suggests that a failure to correct for self-selection into STEM fields may lead to an upward bias in the STEM wage premium. That is, the type of people who select into STEM majors have unobservable characteristics that are partly responsible for their higher earnings. The data employed here do not have the necessary panel features or an obvious instrumental variable for removing this selection bias. We are thus left with estimates that may be biased upward relative to true causal effects—but cross-country differences may reduce the problem if the endogeneity bias is similar across countries. Moreover, our data do have an important advantage relative to some studies of the STEM premium in that it allows us to control for an important source of selection into STEM occupations—numeracy skills.

Figure 1 shows estimates of the STEM premia and the effect of incrementally adjusting the STEM premium for worker and employer characteristics. The left-most bar for each country is the "unadjusted" estimate of the STEM premium. This matches the unadjusted difference in log-wages reported in Table 1 by country. As noted earlier, the U.S. has the largest unadjusted STEM premium of all the OECD countries. Several possible explanations for the larger STEM premium are investigated. First, the STEM premium in a given country is based on the mix of occupations in that country. If the premium in each country is adjusted to reflect the average mix of occupations in the 10 countries other than the U.S., the STEM premium in the U.S. changes only slightly. In some of the other countries, this adjustment makes the adjusted STEM premium smaller (e.g., South Korea and Norway) and in others it makes it larger (e.g., Germany and the Netherlands).

Adding a control for worker numeracy skills reduces the STEM premium in every country since higher numeracy skills command a wage premium and STEM workers have higher numeracy skills. In the U.S., the greater numeracy skills of STEM workers accounts for 5 percentage points of the STEM wage premium (i.e., 45% after adjusting for occupational mix vs. 40% after adjusting for occupational mix and numeracy skills). For the rest of the OECD countries combined, higher numeracy skills account for 3 percentage points of the STEM premium.

The largest share of the STEM premium in the U.S. is explained by the fact that STEM workers and the firms that employ them have characteristics that command higher wages. In addition to controls for occupational mix and numeracy this final estimate of the STEM premium adds controls for years of labor market experience (and its square), gender, age (six dummy variables), education (six dummy variables), class of employer (private, public, non-profit), and the size of the employer (five dummy variables). As seen in Table 1, STEM workers in the U.S. and internationally are more educated, more engaged in life-long learning activities, and more likely to work for large firms. All of these differences favor the wages of STEM workers.

Overall, the results show that about one-third of the U.S. STEM premium in the can be explained by the fact that STEM workers have higher numeracy scores and advantages in worker and firm characteristics, but about two thirds of the premium (30 percentage points of the raw premium of 45%) is due to other factors. Moreover, this adjusted STEM premium is nearly twice as large as that for the pooled sample of other countries and more than twice the premium observed in six of the sampled countries. Clearly, STEM work in the U.S. commands an unusually high wage premium and this is a potential cause for concern since it could put U.S. companies at a disadvantage in STEM intensive industries that are vital to future economic growth.

As noted earlier, a high STEM premium could reflect (i) a relatively low supply of STEM workers, (ii) a relatively high demand for STEM workers, or (iii) institutional differences across countries. To investigate the relative importance of supply or demand conditions, Figure 2 plots the adjusted STEM premium (i.e., the premium after controlling for occupational mix, worker, and firm characteristics) in each country against its share of workers in STEM occupations. The plot illustrates how high the adjusted STEM premium is in the U.S. relative to other countries and shows that it is not driven by a relatively low supply of STEM workers.

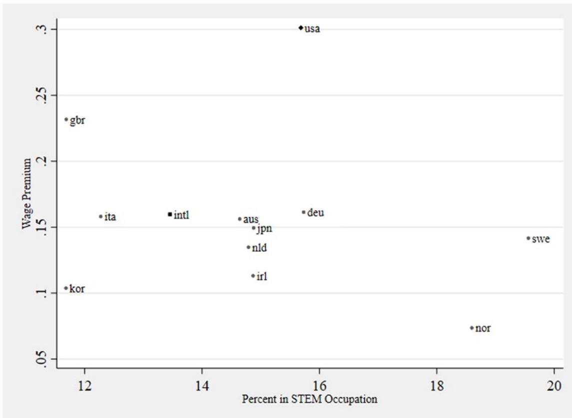


**Figure 2.** The STEM wage premium relative to the share of workers in STEM occupations.
*Note.* aus = Australia; deu = Germany; gbr = England and Northern Ireland; irl = Ireland; ita = Italy; jpn = Japan; kor = South Korea; ndl = Netherlands; nor = Norway; swe = Sweden; usa = United States; Intl = All countries excluding U.S.

In fact, compared to the pooled sample of other countries (labeled "intl"), the U.S. has a larger share of workers in STEM occupations (15.2% in the U.S. vs. 13.0% for the other countries combined). One interpretation of this high premium combined with a relatively high share of workers in STEM jobs is that the demand for STEM workers in the U.S. is relatively high because STEM skills are particularly valuable in the U.S. The greater value of STEM skills in the U.S. could be the result of institutions that, for example, increase the rewards to R&D (e.g., patent or tax laws), or spillovers that cause STEM productivity to rise with the number of STEM workers. It is also possible that, despite controlling for level of education, experience and other worker attributes, the STEM workers in the U.S. are relatively more skilled (or non-STEM are relatively less skilled) than those in other countries. Alternatively, the labor market institutions in the U.S. could lead to a higher return to skill. We will return to evidence on this point later.

While it is clear that the STEM premium is higher in the U.S., there could be significant heterogeneity across STEM sub-fields. To investigate this possibility, we separately estimate the STEM premium for each of the six STEM sub-fields identified in the PIACC data. The majority of workers in three of the six occupations (science and engineering professionals, health professionals, and information and communication technology professionals) have obtained at least a bachelor's degree, whereas the majority of workers in the other three have not. Figure 3 plots the STEM premium for each of the six STEM sub-fields.

Figure 3 shows that the wage premium in the U.S. exceeds that for the pooled sample of other countries pooled (labeled "intl"). Relative to the pooled group, the premium is especially large for information and communication technology professionals (29 percentage points higher in the U.S. than for pooled group) and Science and Engineering Associates (26 percentage points higher in the U.S.). The smallest differential between the U.S. and the other countries pooled is for Health Associates (5 percentage points) and Information and Communication Technicians (5 percentage points higher). The relatively high premia in the U.S. do not appear to be the result of a relatively low supply of workers in any of the six sub-fields. Compared to the pooled group of countries, the U.S. share of workers in the occupations with the highest wage premia exceeds that for the other countries pooled. The U.S. has a relatively large share of workers in each of the STEM sub-fields, but the wage premium for such workers exceeds that in other countries—especially for information and communication technology professionals, and science and engineering associates.

As noted by Rothwell (2013), half of all STEM jobs in the U.S. are available to workers with less than a college degree and yet only about one-fifth of federal funding to promote STEM education has gone toward support for sub-bachelor's level training. To see how the U.S. compares relative to the rest of the world on sub-bachelor's STEM jobs, Figure 4a and b show each country's STEM wage premium by education level. The educational groupings are based on the 2011 International Standard Classification of Education (ISCED) (UNESCO Institute for Statistics, 2012) which accounts for differences in educational institutions across countries. The STEM wage premium is estimated using the same methods as described earlier and controls for the mix of occupations as well as worker and firm characteristics.

Two interesting conclusions can be drawn. First, in most countries, the STEM premium is higher (in percentage terms) for those with sub-bachelor's degrees. Second, the U.S. has the highest STEM wage premium for both education groupings—sub-bachelor's and bachelor's degree or higher. For the sub-bachelor's degree group, the STEM premium in the U.S. is 31% compared to the international premium of 16%. For the bachelor's degree group, the U.S. premium is 19 versus 6% for the international group.

To get a sense of whether supply or demand factors are driving the relatively high STEM wage premium in the U.S., Figure 4a and b plot the STEM wage premium for the two education groups against the share of workers in STEM jobs by country. Consistent with Figure 5, the U.S. has the highest wage premium of any country for both education groups. Also, compared to the average for the rest of the world, the U.S. has a slightly higher share of workers in STEM for both education groups. It is worth noting, however, that for both education groupings, several countries have a higher share of workers in STEM jobs than the U.S.

While supply and demand conditions may play an important role in explaining cross-country differences in

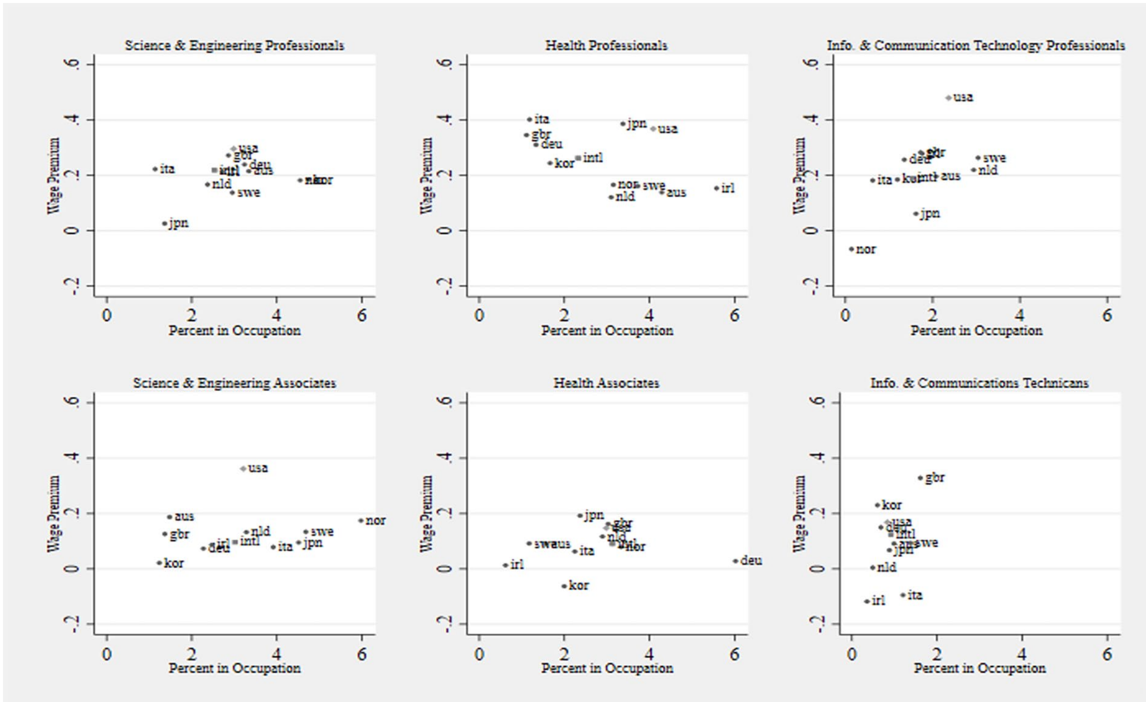


**Figure 3.** Wage premium versus share of workers in STEM occupations.
*Note.* aus = Australia; deu = Germany; gbr = England and Northern Ireland; irl = Ireland; ita = Italy; jpn = Japan; kor = South Korea; ndl = Netherlands; nor = Norway; swe = Sweden; usa = United States; Intl = All countries excluding U.S.

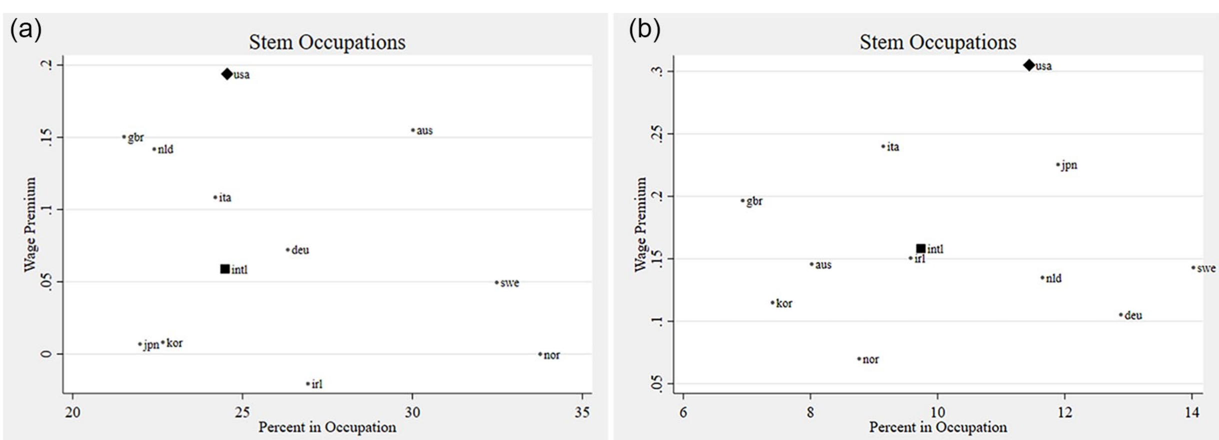


**Figure 4.** (a) STEM wage premium versus share of workers in STEM jobs: bachelor's degree of higher and (b) STEM wage premium versus share of workers in STEM jobs: less than bachelor's degree.
*Note.* aus = Australia; deu = Germany; gbr = England and Northern Ireland; irl = Ireland; ita = Italy; jpn = Japan; kor = South Korea; ndl = Netherlands; nor = Norway; swe = Sweden; usa = United States; Intl = All countries excluding U.S.

the STEM premium, differences in labor market institutions may also be important. To investigate this hypothesis, we pursue methods similar to those in Hanushek et al. (2015). We estimate a pooled regression model of log-wages for workers in all countries. In addition to the controls in the earlier regression model, we include a dummy

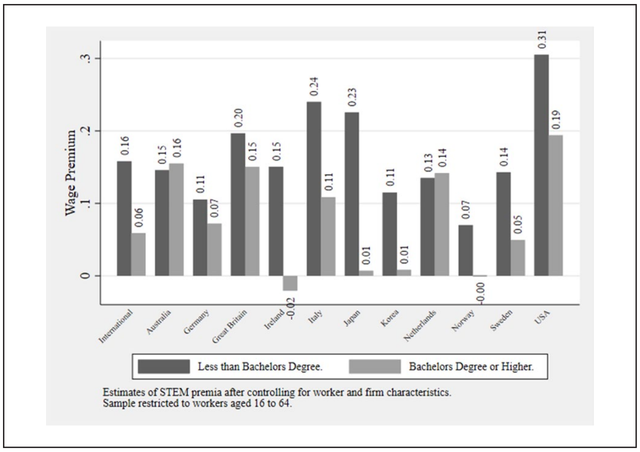


**Figure 5.** STEM wage premium by country and level of education.
International = All countries in sample excluding U.S.

variable for whether a worker is in a STEM occupation and add country fixed effects. To investigate the importance of cross-country differences in labor market institutions on the STEM premium, we obtained three country-specific variables used by Hanushek et al. (2015): union density, the percent of the workforce employed in the public sector, and variable indexing the level of employment protection. The employment-protection indicator measures the extent to which a country's regulations restrict employers from dismissing individual workers or groups of workers. These variables are standardized to have a mean of zero and a standard deviation of one across countries. Interactions between these controls and the STEM premium are added as controls to determine how institutional differences across countries affect the STEM premium. The results are in Table 2.

In the first column, the estimated coefficient on the STEM variable indicates that in a country with average levels of the institutional characteristics (forcing all the interactions to zero), the STEM wage premium is 15.9%. The coefficients on the interaction terms imply that higher union density, greater employment protection, or a smaller share of workers in the public sector contribute to a lower STEM premium. For example, a country with union density that is one standard deviation above the average is predicted to have a STEM premium that is 8.0 percentage points lower than the average country. The fact that union density reduces the STEM premium is expected given that unions compress the wage distribution and reduce the return to skills. The negative effect of employment protection laws on the premium would be consistent with STEM workers placing a high value on such protection (and a willingness to accept a lower wage) because of the relatively high risk that their skills become obsolete as a result of rapidly changing skill requirements. The positive effect of the public share of employment on the premium is a bit more difficult to explain. Hanushek et al. (2015) found that a larger public share reduced the returns to numerical skills, and we find the opposite effect on the return to STEM jobs.

In Columns 2 to 7, the estimated effects of labor market institutions are presented for each of the six STEM subfields. The estimates for a specific STEM occupation are obtained by restricting the sample to all non-STEM workers plus the specific STEM occupation of interest. For example, in specification (2), the wage premium for a Science and Engineering Professional relative to a non-STEM worker is 9.0% in a country with average labor market institutions.

A review of the occupation specific estimates supports a few conclusions. First, for most (but not all) occupations, the STEM premium is lower in countries with greater union density, a lower share of workers in the public sector, and stricter employment protection. The differential effects of labor market institutions across occupations may reflect different rates of unionization or public employment in these fields, or differences in the value that workers place on employment protection.

## Summary and Conclusions

Overall, the evidence suggests that the rewards to STEM work vary substantially across countries and are much higher in the U.S. than in most economically developed countries. The higher premium in the U.S. exists despite the fact that the U.S. has a larger share of workers in STEM jobs than most countries. The evidence also suggests that there is significant heterogeneity in the STEM premium across different jobs, and that the premium is especially high for STEM workers with less than a bachelor's degree in both the U.S. and other developed countries. This fact suggests that expansion of STEM training resulting in certificates or associate's degrees could have an especially high return on investment. In particular, labor and education policies that promote upskilling of existing STEM workers as well as preparation of the future STEM workforce at formal education institutions, such as community colleges, are likely to benefit the wage growth and economic development in the U.S.

Given the substantial variation in the STEM premium and labor market conditions across specific STEM jobs, an efficient policy should carefully consider these differences in the allocation of STEM funding. One possible way to improve the allocation is illustrated by Intel Corporation's new agreement with the state of Ohio and the National Science Foundation (Intel Corporation, 2022). Under the agreements, Intel will invest $100 million over the next 10 years for education and work-force development to

**Table 2.** Estimated Effects of Labor Market Institutions on the STEM Wage Premium.

*STEM occupations included*

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| | All STEM occupations | Science and engineering professionals | Health professionals | Information and communication technology professionals | Science and engineering associates | Health associates | Information and communications technicians |
| STEM | 0.159*** (12.86) | 0.0901*** (3.45) | 0.216*** (8.66) | 0.173*** (6.70) | 0.178*** (5.91) | 0.105*** (5.45) | 0.0958* (2.05) |
| STEM interacted with | | | | | | | |
| Union density | −0.0802*** (−4.61) | −0.134*** (−3.55) | −0.0459 (−1.30) | −0.153*** (−4.38) | −0.122*** (−3.76) | −0.0654 (−1.54) | −0.160** (−2.70) |
| Public employment share | 0.0348* (2.34) | 0.0779* (2.43) | −0.0595 (−1.67) | 0.126*** (3.48) | 0.0836** (2.65) | 0.00112 (0.03) | 0.120* (1.99) |
| Employment protection | −0.0419*** (−4.35) | −0.0362 (−1.76) | −0.0485** (−2.60) | −0.0838*** (−5.24) | −0.0579* (−2.34) | −0.00304 (−0.25) | 0.00185 (0.05) |
| $R^2$ | .419 | .399 | .395 | .401 | .389 | .384 | .385 |
| Sample sizes | | | | | | | |
| Non-STEM | 27,480 | 27,480 | 27,480 | 27,480 | 27,480 | 27,480 | 27,480 |
| STEM | 4,809 | 972 | 1,015 | 555 | 1,028 | 998 | 241 |
| Total | 32,289 | 28,452 | 28,495 | 28,035 | 28,508 | 28,478 | 27,721 |

*Note.* The coefficient estimates presented above are from a regression model of a worker's log-wage on controls for the worker's education, experience, age, firm size (five categories), sex, class of worker (private, public, or non-profit), country fixed effects, a STEM dummy variable indicating whether the worker is employed in a STEM occupation, and interactions between the STEM dummy and three country-specific measures of labor market institutions (union density, public share, and employment protection). The country-specific measures are normalized to have a mean of zero and a standard deviation of one across countries. All regressions include the same set of non-STEM workers and the different specifications listed below restrict the group of STEM workers to the occupation listed at the top of each column. *t*-Statistics are provided in parentheses and are based on standard errors corrected for the PIACC sample design.

*$p < .05$. **$p < .01$. ***$p < .001$.

facilitate expansion of their semiconductor fabrication facilities throughout the United States. The NSF has agreed to match $50 million of Intel's funds for improving STEM education at two-year colleges and four-year universities, inclusive of minority-serving institutions. While such agreements may work for a company with such specialized needs, private support for such investments in training and investment would be more difficult in markets where the workers have a wide range of potential employers to choose from (e.g. medical fields, engineering).

In constructing any government policy to enhance the STEM labor force, it is essential to recognize that the STEM labor market is subject to rapid change as new technologies emerge. Demand for STEM workers is projected to rise at an above average rate and recent trends may reduce an important source of STEM workers for the U.S.—foreign born workers. For this reason, it is important for policy makers to pay close attention to trends in the STEM premium in the U.S. and abroad. By the same token, comparing and contrasting STEM-related labor and education policies across the economically developed nations may inform the U.S. STEM workforce development. The empirical evidence on the STEM premium is certainly a key piece of information for accommodating a dynamic STEM labor market, and ultimately facilitating stable economic growth in the U.S.

This study has also shown that the STEM premium is related to a country's labor market institutions. Greater unionization, more restrictive employment protection policies, and a smaller public share of employment contribute to a lower STEM premium. If a country's labor market institutions reduce the STEM premium, policy makers should consider the potential effect on the ability to attract workers into the field.

## Appendix

**Table A1.** Countries Included in Analysis.

| Country | Abbreviated name |
|---|---|
| Australia | aus |
| Germany | deu |
| Great Britain | gbr |
| Ireland | irl |
| Italy | ita |
| Japan | jpn |
| South Korea | kor |
| Netherlands | nld |
| Norway | nor |
| Sweden | swe |
| United States | usa |

### Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

### Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This research was in part supported by the Institute of Education Sciences, U.S. Department of Education, through Grant R305A170183 to Miami University and University of Maryland, Baltimore County. The opinions expressed are those of the authors and do not represent views of the institute or the U.S. Department of Education.

### Data Availability

The PIACC data used in this study is available to the public at https://www.oecd.org/skills/piaac/

### References

Altonji, J. G., Arcidiacono, P., & Maurel, A. (2016). The analysis of field choice in college and graduate school: Determinants and wage effects. In *Handbook of the Economics of Education* (Vol. 5, pp. 305–396). Elsevier.

American Institute of Physics. (2020). *Federal science budget tracker*. Retrieved September 15, 2020 from https://www.aip.org/fyi/federal-science-budget-tracker

Anderson, D. A. (2016, April). *Foreign-born STEM workforce in the United States: Gaps in STEM employment by native- and foreign-born status by race*. Population Association of America Annual Meeting, Washington, DC. https://www.census.gov/library/working-papers/2016/demo/SEHSD-WP2016-14.html

Anft, M. (2013). The STEM crisis: Reality or myth. *The Chronicle of Higher Education*, *58*(12), 1–14.

Arcidiacono, P. (2004). Ability sorting and the returns to college major. *Journal of econometrics*, *121*(1–2), 343–375.

Baer, J., & Martel, M. (2020). *Fall 2020 international student enrollment snapshot*. https://www.iie.org/wp-content/uploads/2022/12/Fall-2020-Snapshot-Report-Full-Report.pdf

Bound, J., Braga, B., Khanna, G., & Turner, S. (2021). The globalization of postsecondary education: The role of international students in the US higher education system. *Journal of Economic Perspectives*, *35*(1), 163–184.

Bridenstine, J., Cordova, F, & Kratsios, M. (2018). *Charting a course for success: America's strategy for STEM education*. Committee on STEM Education of the National Science & Technology Council. https://eric.ed.gov/?id=ED590474

Carnevale, A. P., Smith, N., & Melton, M. (2011). *STEM: Science technology engineering mathematics*. Georgetown University Center on Education and the Workforce. https://cew.georgetown.edu/wp-content/uploads/2014/11/stem-complete.pdf

Cedefop, Eurofound. (2018). *Skills forecast: Trends and challenges to 2030*. Reference Series No 108. http://data.europa.eu/doi/10.2801/4492

Croce, G., & Ghignoni, E. (2020). The evolution of wage gaps between STEM and non-STEM graduates in a technological following economy. *Applied Economics*, *52*(23), 2427–2442.

Deming, D. J., & Noray, K. (2020). Earnings dynamics, changing job skills, and STEM careers. *The Quarterly Journal of Economics*, *135*(4), 1965–2005.

Fischer, K., & Aslanian, S. (2021). *Fading beacon: The U.S. may never regain its dominance as a destination for international students*. American Public Media. Retrieved August 8, 2021 from https://www.apmreports.org/episode/2021/08/03/fading-beacon-why-america-is-losing-international-students

Greenwood, C., Harrison, M., & Vignoles, A. (2011). *The labour market value of STEM qualifications and occupations*. London: Institute of Education/Royal Academy of Engineering. https://raeng.org.uk/media/pvdeuknv/the-labour-market-value-of-stem-qualifications-and-occupations.pdf

Griliches, Z. (1992). Introduction to “output measurement in the service sectors.” In Z. Griliches (Ed.) *Output measurement in the service sectors* (pp. 1–22). University of Chicago Press.

Hanson, G. H., & Slaughter, M. J. (2018). High-skilled immigration and the rise of STEM occupations in US employment. In C. R. Hulten, & V. A. Ramey (Eds.), *Education, skills, and technical change: Implications for future US GDP growth* (pp. 465–500). University of Chicago Press.

Hanushek, E. A., Schwerdt, G., Wiederhold, S., & Woessmann, L. (2015). Returns to skills around the world: Evidence from PIAAC. *European Economic Review*, *73*, 103–130.

Holdren, J., Marrett, C., & Suresh, S. (2013). *Federal science, technology, engineering, and mathematics (STEM) education 5-year strategic plan*. Committee on STEM Education of the National Science and Technology Council. https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/stem_stratplan_2013.pdf

Intel Corporation. (2022, March 17). *Intel invests $100 million in Ohio and national semiconductor education and research*. Retrieved June 11, 2022 from https://www.intel.com/content/www/us/en/newsroom/news/intel-invests-100m-ohio-national-education.html#gs.4bpcsi

Jakubowski, M., & Pokropek, A. (2019). Piaactools: A program for data analysis with PIAAC data. *The Stata Journal*, *19*(1), 112–128.

Kahn, L. M. (2000). Wage inequality, collective bargaining, and relative employment from 1985 to 1994: Evidence from fifteen OECD countries. *Review of Economics and Statistics*, *82*(4), 564–579.

Koonce, D., Zhou, J., Anderson, C., Dyah, H., & Conley, V. (2011). *What is STEM*? American Society for Engineering Education (ASEE) Annual Conference & Exposition, Vancouver. https://peer.asee.org/what-is-stem

Langdon, D., McKittrick, G., Beede, D., Khan, B., & Doms, M. (2011). *STEM: Good jobs now and for the future*. ESA Issue Brief# 03-11. US Department of Commerce. https://eric.ed.gov/?id=ED522129

Light, A., & Rama, A. (2019). Moving beyond the STEM/non-STEM dichotomy: Wage benefits to increasing the STEM-intensities of college coursework and occupational requirements. *Education Economics*, *27*(4), 358–382.

National Science and Technology Council. (2018). Charting a course for success: America’s strategy for STEM education. https://www.energy.gov/sites/default/files/2019/05/f62/STEM-Education-Strategic-Plan-2018.pdf

National Science Board. (2018). *Science & engineering indicators: 2018 digest*. https://www.nsf.gov/nsb/news/news_summ.jsp?cntn_id=244252

Noonan, R. (2017). *STEM jobs: 2017 update*. US Department of Commerce, ESA Issue Brief# 02-17. https://www.commerce.gov/sites/default/files/migrated/reports/stem-jobs-2017-update.pdf

Organisation for Economic Co-operation and Development. (2016). *Technical Report of the Survey of Adult Skills (PIAAC)*. https://www.oecd.org/skills/piaac/PIAAC_Technical_Report_2nd_Edition_Full_Report.pdf

Olitsky, N. H. (2014). How do academic achievement and gender affect the earnings of STEM majors? A propensity score matching approach. *Research in Higher Education*, *55*(3), 245–271.

Peri, G., & Shih, K. (2015). Foreign scientists and engineers and economic growth in Canadian labor markets. In P. Nijkamp, J. Poot, & J. Bakens (Eds.), *The economics of cultural diversity* (pp. 358–383). Edward Elgar Publishing.

Peri, G., Shih, K., & Sparber, C. (2015). STEM workers, H-1B visas, and productivity in US cities. *Journal of Labor Economics*, *33*(S1), S225–S255.

Rothwell, J. (2013). *The hidden STEM economy*. Metropolitan Policy Program at Brookings. https://www.brookings.edu/research/the-hidden-stem-economy/

Shapiro, H., Østergård, S. F., & Hougard, K. F. (2015). *Does the EU need more STEM graduates?* Publications Office of the European Union. https://op.europa.eu/en/publication-detail/-/publication/d19a5afb-cbd3-11e5-a4b5-01aa75ed71a1

Stockard, J., Rohlfing, C. M., & Richmond, G. L. (2021). Equity for women and underrepresented minorities in STEM: Graduate experiences and career plans in chemistry. *Proceedings of the National Academy of Sciences*, *118*(4), e2020508118.

UNESCO Institute for Statistics. (2012). *International standard classification of education: ISCED 2011*. http://uis.unesco.org/en/topic/international-standard-classification-education-isced

U.S. Bureau of Labor Statistics. (2020). *Employment projections: Employment by major industry sector*. Last Modified September 1, 2020. Retrieved February 23, 2021. https://www.bls.gov/emp/tables/employment-by-major-industry-sector.htm

Winters, J. V. (2014). STEM graduates, human capital externalities, and wages in the US. *Regional Science and Urban Economics*, *48*, 190–198.

Xie, Y., Fang, M., & Shauman, K. (2015). STEM education. *Annual Review of Sociology*, *41*, 331–357.

Xue, Y., & Larson, R. C. (2015). STEM crisis or STEM surplus? Yes and yes. *Monthly Labor Review*. https://www.bls.gov/opub/mlr/2015/article/stem-crisis-or-stem-surplus-yes-and-yes.htm

Yao, K. (2019). Heterogeneous skill distribution and college major: Evidence from PIAAC. *Journal of Applied Economics*, *22*(1), 504–526.

Zavodny, M. (2021). *The impact of U.S. men and women of STEM fields of increases in international students*. National Foundation of American Policy. https://nfap.com/studies/the-impact-on-u-s-men-and-women-in-stem-fields-of-increases-in-international-students/

## Author Biographies

**William E. Even** is professor emeritus in the Department of Economics at Miami University in Oxford, Ohio. His recent research interests relate to the functioning of labor markets broadly, and specifically on the effects of education, unions, and minimum wage laws on employment and earnings.

**Takashi Yamashita**, PhD, MA, MPH, is a professor of Sociology and Gerontology at the University of Maryland, Baltimore County. His primary research areas wider benefits of lifelong learning, social determinants of health and well-being over the life course, health literacy, and gerontology education.

**Phyllis A. Cummins**, PhD, is a senior research scholar at Scripps Gerontology Center, Miami University, Oxford, Ohio. Her research foci include education and training for older workers, the role community colleges play in education and training for older adults, skill development over the life course, and economic security in retirement.