APPRENTICING AMERICA: THE EFFECTS OF TAX CREDITS FOR REGISTERED APPRENTICESHIP PROGRAMS

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ABSTRACT

Despite generally declining wages for workers without a college degree, apprenticeship offers a proven path to improved labor market outcomes. However, use of registered apprenticeship programs in the United States remains far lower than in other nations with developed economies. As the federal and state governments have considered options to increase the use of apprenticeship, a frequently considered proposal has been to provide a tax credit to employers who operate apprenticeship programs. Examining data on the share of apprentices in the labor forces of states without and without apprenticeship tax credits between fiscal year 2011 and fiscal year 2017 using ordinary least squares regressions, this study finds that the existence of an apprenticeship tax credit is associated with a statistically significant increase in the share of apprentices in a state’s labor force of between 28.72 percent and 37.60 percent. Apprenticeship tax credits therefore appear to be an effective policy option to expand use of a program with proven benefits for workers without a bachelor’s degree that could help reduce income inequality. However, apprenticeship tax credits do not appear to significantly affect a state’s real GDP per capita growth rate in the short run, indicating that states seeking an immediate economic stimulus should pursue other policies instead of or in addition to implementing an apprenticeship tax credit.

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INTRODUCTION

Despite nine years of nearly consistent growth in real gross domestic product (U.S. Department of Commerce, 2018), real average hourly wages have remained largely flat in the United States, continuing a trend that dates back roughly 40 years (DeSilver, 2018). A specific point of concern in the labor market is the so-called polarization of employment, in which high-wage and low-wage jobs have expanded at the expense of middle-wage jobs (Autor, Katz, and Kearney, 2006). The results have been markedly deleterious for workers with less education, with real median hourly wages for workers with a high school degree falling by 14.3 percent between 1979 and 2017 (Congressional Research Service, 2018).

Notwithstanding these larger trends in the labor market, verified strategies exist in which workers with less than a bachelor's degree can improve their earnings potential. Participation in a registered apprenticeship program in one such strategy. According to Reed et al. (2012), participation in a registered apprenticeship program is associated with an average gain in annual earnings of $5,839 nine years after enrollment and an estimated average increase in career earnings of $98,718 compared to nonparticipants. Completion of a registered apprenticeship program is associated with an average gain of $12,733 in the ninth year after enrollment and an estimated $240,037 over a career. Reed et al. found similarly promising results for society as a whole, with an average social benefit of $59,606 nine years after enrollment compared to $718 in government costs of overseeing each registered apprenticeship. Although it is difficult to determine the net benefit or cost to employers, who must pay for apprentices' training and wages as well as the costs of establishing and managing the apprenticeship program, employers can gain from a better trained workforce and reduced recruiting costs to find skilled workers.

Despite the clear benefits of registered apprenticeship programs, they remain a small fraction of the U.S. workforce, particularly compared to many other nations with developed economies. Even after a 42 percent increase in the number of registered apprenticeships between 2013 and 2017 (U.S. Department of Labor, 2018), apprentices make up just 0.3 percent of the U.S. labor force[1] compared to 3.0 percent in Germany.[2] With many prospective apprentices experiencing waitlists for desired programs (National Joint Apprenticeship Committee, 2018), the demand for more apprenticeships in the labor market is evident. As policymakers consider strategies to increase wages and create more pathways to economic security that do not require a four-year college degree, ways to create more apprenticeship positions will likely be a significant focus.

To address this policy issue, many state governments have sought to incentivize businesses to create new apprenticeship programs or expand existing ones by offering tax credits to employers. According to the U.S. Department of Labor (2018), 12 states offer a tax credit related to operating an apprenticeship program or employing an apprentice. However, little is known about the efficacy of these policies, a knowledge gap this research intends to fill.

Using the U.S. Labor Department's data on the number of active apprentices in each state, this thesis investigates the following research hypotheses. Do states that implement tax credits for registered apprenticeship programs generate a higher usage rate of apprenticeship positions in their labor force compared to states that do not offer an apprenticeship-related tax credit? And do states that implement tax credits for registered apprenticeship programs generate

[1] The U.S. Department of Labor's Bureau of Labor Statistics estimated the size of the U.S. labor force at the end of 2017 at 160,597,000. The Department of Labor's Employment and Training Administration found that there were 533,607 apprentices in 2017. 533,607 divided by 160,597,000 equals 0.3 percent.
[2] The Federal Statistical Office of Germany found that there were 1,300,000 apprentices in Germany in 2017. The World Bank estimated the size of the German labor force in 2017 at 43,473,200. 1,300,000 divided by 43,473,200 equals 3.0 percent.

a higher growth rate in their real gross domestic product per capita compared to states that do not offer an apprenticeship tax credit? The results of this research can help inform federal policymakers considering adding an apprenticeship tax credit to the federal tax code, as well as state legislatures studying whether to add or preserve their own employer tax credits for apprenticeship programs.

BACKGROUND

The registered apprenticeship system in the United States was created by the National Apprenticeship Act of 1937 (Code of Federal Regulations). The Office of Apprenticeship in the Department of Labor's Employment and Training Administration oversees the registered apprenticeship program in conjunction with State Apprenticeship Agencies that exist in 25 states and the District of Columbia. To meet the standards of a registered apprenticeship, the apprenticeship must provide both on-the-job training and related technical instruction, among other requirements. The on-the-job training must typically last at least 2,000 hours, and at least 144 hours per year of related technical instruction is recommended. Apprentices receive progressively increasing wages to mark their increasing productivity over the duration of their apprenticeship, and upon fulfilling the requirements of their apprenticeship, they receive a nationally recognized certificate of completion. Sponsors of a registered apprenticeship, typically employers, employer associations, or labor management organizations,[3] deliver the apprenticeship, connecting the apprentice with an employer and the related technical instruction.

[3] Apprenticeship and labor management organizations have historically been closely linked, particularly in the skilled trades, as trade unions developed many early apprenticeship programs. By creating and controlling the rules for the apprenticeship programs in their fields, trade unions established some control over the flow of workers into the market for their respective crafts. In fields with equally powerful employer associations and labor management organizations, the employer associations and trade unions mutually determined the rules and size of early American apprenticeship programs (Motley, 1907).

Employers cover the costs of the training and the wages paid to the apprentice. Registered apprenticeships are designed to improve the productivity and the labor market value of the apprentices while allowing them to simultaneously earn money, a differentiating factor from many other forms of human capital accumulation. Employers benefit from the apprentice's labor, which gets increasing skilled over the course of the apprenticeship, as well as access to a skilled potential employee upon the completion of the apprenticeship.

LITERATURE REVIEW

Several studies have documented the benefits of the registered apprenticeship program, both to the apprentice and to society. A difference-in-differences examination of apprentices in the state of Washington found that one year after exiting the apprenticeship, participants increased their average quarterly earnings by $2,370 compared to similar non-participants (Hollenbeck and Huang, 2006). The apprenticeship participants also had a higher hourly wage by $6.60, worked 33.5 more hours per quarter, and had a higher employment rate by 7.4 percentage points. They also received significantly fewer benefits from Medicaid and food stamp programs. These gains continued with only minor fade-out three years after apprentices exited their programs, though the apprenticeship participants did receive significantly more unemployment compensation. Over a worker's lifetime, apprenticeship participation was associated with a net benefit to the worker of $220,873 and a net benefit to the public of $46,917. An examination of apprentices across 10 different states found similar positive benefits for the participants and society. Reed et al. (2012) used a dosage model to find that apprenticeship participants earned an average of $6,595 more in annual earnings than similar non-participants in the sixth year after enrollment in the apprenticeship. Completers of the apprenticeship earned $14,404 more than non-participants. In the ninth year after enrollment, participants earned an average of $5,839 more and completers earned $12,733 more. Over the course of the worker's career, an apprenticeship participant would earn $98,718 more than a similar non-participant, and an apprenticeship completer would earn $240,037 more. The increase in wages was statistically significant for both men and women at the six-year and nine-year marks and over a career. The social benefits of the apprenticeship exceed its social costs by $58,888 on average nine years after enrollment and by $124,057 over the apprentice's career. The benefits stem from increased productivity and decreased use of social safety net programs, outweighing the costs of administering the apprenticeship and providing the related technical instruction.

Multiple studies of apprenticeship programs in other countries have found largely positive results for apprenticeships. Male apprenticeship completers in Canada earn 17.3 percent more in weekly wages than similar workers who did not participate in an apprenticeship (Boothby and Drewes, 2010). However, female apprenticeship completers earn 3.5 percent less than their non-apprenticeship-participating peers. In Germany's apprenticeship programs, the returns to apprenticeship for even the lowest ability of workers who leave school before college is comparable to estimates of the returns to school (Clark and Fahr, 2001).

However, all of these studies suffer from the limitation that despite controls for pre-apprenticeship earnings, labor force participation, and demographic characteristics, it is possible that the apprenticeship participants were different in unobservable ways from non-participants. Fersterer, Pischke, and Winter-Ebmer (2008) avoided this issue by examining how an event unrelated to the apprentice – whether the apprentice's employer remains in business – affects how much of the apprenticeship that the apprentice completes. Using instrumental variable estimation with the amount of time between when the apprentice joined the firm and when the firm failed as an instrument of the apprentice's apprenticeship duration, they found that apprenticeship training raises wages by 3.8 percent per year of apprenticeship training in Austria.

Increased utilization of apprenticeship programs can also correspond with better labor market statistics across a country. Across the European Union, regression analysis shows that a one percentage point increase in the apprenticeship coverage rate in a country is associated with a 0.95 percentage point increase in the youth employment rate and a 0.8 percentage point decrease in the youth unemployment rate (Ecorys, Institute for Employment Studies, and Istituto per la Ricerca Sociale, 2013).

While the benefits to the apprentices demonstrate that apprenticeships are an effective human capital investment and the benefits to society and a nation's economy validate governments' interest in expanding use of apprenticeships, that expansion may be contingent on employers' interest in hiring apprentices. A rigorous cost-benefit analysis of hiring apprentices does not exist for employers in the United States. However, 97 percent of sponsors of apprentices in the United States from a survey with a random stratified sample said they would recommend the registered apprenticeship program, including 86 percent who would "strongly" recommend it (Lerman, Eyster, and Chambers, 2009). Eighty percent said the registered apprenticeship program helped to meet their demand for skilled workers. In evaluating problems with the registered apprenticeship program, 55 percent identified apprentices' failure to complete the program, 54 percent identified competitor firms bidding away trained apprentices, 41 percent identified the cost of experienced workers' time to instruct apprentices, and 36 percent identified the costs of the related technical instruction.

Several studies have examined the cost-benefit analysis for employers of apprentices in other countries. In European countries with "a well-functioning apprenticeship training system," Muehlemann and Wolter (2014) found that firms that hire apprentices recoup the costs of their investments by the end of the apprenticeship. Because apprentices often remain with the company after the conclusion of their apprenticeship, hiring apprentices can be an effective strategy for a company to gain a supply of skilled labor. In Switzerland, firms reported €57,100 in benefits over the course of a three-year apprenticeship compared to €54,400 in costs (Muehlemann et al., 2010). Although German firms reported just €24,000 in benefits compared to €46,600 in costs, the authors concluded that German firms must derive post-program benefits that allow them to recoup their investment in training apprentices. Given the time that newly hired employees, even skilled employees, take to reach full productivity, the costs of that period of sub-full productivity exceed the net costs of apprenticeships for employers (Wagner, 1998). This matches the findings of a study of apprenticeship in the United Kingdom in the engineering, construction, business administration, and retail sectors (Hasluck and Hogarth, 2010). While the employers' total costs exceeded the benefits in all four sectors during the apprenticeship and in the first year after the apprenticeship, the overall net benefits became positive by the second year after the apprenticeship in retail and business administration and by the third year in engineering and construction. Apprentices' rapidly improving productivity helps their employers recoup their investments quickly. Over the course of a three-year apprenticeship, the productivity of a Swiss apprentice rises from 37 percent of a skilled workers in the apprentice's first year to 75 percent by the final year, while German apprentices improve from 30 percent of a skilled work's productivity to 68 percent (Muehlemann et al., 2010). A survey of Canadian employers found that the benefits of apprenticeships to employers exceed the costs by an average of C$74,206 over the duration of the apprenticeship without even including tax credits available to the employer (Canadian Apprenticeship Forum, 2006). The net benefit to employers was positive in all 15 trades examined, ranging from C$8,250 for mobile crane operators to C$132,780 for sprinkler system installers.

Nevertheless, the evidence of long-term benefits to employers who hire apprentices can only stimulate increased usage of apprenticeship programs to the extent that employers recognize their benefits. In a survey of Canadian employers in skilled trades, 13 percent of employers who formerly hired apprentices but did not continue to do so said the training costs of apprenticeships were too high or required too much time (Canadian Apprenticeship Forum, 2011). Twenty-five percent of all the employers in the survey identified a perceived need for financial assistance as something that could make apprentices a more attractive option.

Employers who participate in apprenticeship programs presumably determine that the benefits of participation from access to a supply of skilled workers exceed the costs of setting up their program, providing the training, and paying wages to apprentices. In contrast, employers who do not participate in apprenticeship programs presumably determine that the costs exceed the benefits. The costs of establishing an apprenticeship program and getting it registered with the federal Office of Apprenticeship or a State Apprenticeship Agency create a fixed upfront cost that may serve as a barrier to employers hiring apprentices even if the long-term net benefits are positive. Providing a tax credit for hiring apprentices increases the benefits to employers. This additional benefit should, on the margin, make the net benefits of hiring an apprentice positive for some employers, increasing employer participation in apprenticeship programs. If the net social benefits of registered apprenticeships in the United States are sufficiently positive, increasing the social costs of the registered apprenticeship by the value of the tax credit would still leave the net social benefits positive. Increasing the number of apprentices would therefore increase the total social benefits of apprenticeship in the United States.

No rigorous studies exist that examine the effects of tax credits for employers who hire apprentices. This study aims to fill that gap. However, many other studies have examined other employer tax credits that could influence business decision-making and hiring. In perhaps the closest parallel to tax credits for hiring apprentices, studies have assessed the effects of the Work Opportunity Tax Credit (WOTC). The WOTC provides a tax credit to employers who hire certain categories of disadvantaged workers, including ex-offenders, recipients of certain social safety net programs, and some veterans. In 2007, the WOTC was expanded, to include increasing the tax credit to $4,800 for employers who hired disabled veterans who were recently discharged or unemployed for more than six months. Using a difference-in-differences model, Heaton (2012) found that this increased tax credit was associated with a statistically significant 1.8 percentage point increase in employment among the target group of disabled veterans. Because the pre-credit earnings for this population were low, the tax credit was associated with a 39.9 percent increase in wage income. However, not all studies of the WOTC have produced as promising results. Examining the WOTC among welfare recipients in Wisconsin, Hamersma (2008) found only short-term benefits that faded out quickly. Eligibility for the WOTC was associated with a 5.9 percentage point increase in the likelihood of being employed six months after becoming eligible, but by one year after becoming eligible and in the second year of eligibility, there was no statistically significant difference in the probability of employment. The author remarks that a low take-up rate may contribute to the limited long-term employment effects. It is worth noting that the WOTC is designed specifically to improve the labor market outcomes of several types of hard-to-employ workers. Although some apprentices may also come from these groups of workers, apprentices represent a broader array of workers, including those with greater employability.

Several other studies have examined the effects of tax credits on business behavior via tax credits for research and development. In a close analog of what this study will attempt to examine regarding apprenticeship tax credits, Wu (2005) assessed research and development tax credits across 13 states over 17 years. The author found that the establishment of a state research and development tax credit was associated with an increase in private per capita research and development spending of $75 to $118. Larger per capita numbers of doctoral degrees and state expenditures on higher education were associated with larger increases in private research and development spending resulting from the tax credit. The size of the credit also appears to matter, as a study across all 50 states found that a one percentage point increase in a state's effective research and development credit rate was associated with a three-to-four percent increase in research and development spending within the state in the long run (Wilson, 2005). International studies have likewise shown an increase in research and development spending associated with a research and development tax credit. Across nine countries in the Organization for Economic Co-operation and Development, a 10 percent decrease in the cost of research and development was associated with slightly more than a one percent increase in the level of research and development in the short run and slightly less than a 10 percent increase in the long run (Bloom, Griffith, and Van Reenen, 2002). Researching the varying effects of research and development tax credits across different sectors, Castellacci and Lie (2015) found in a meta-regression analysis that the tax credits are most effective at stimulating increased private spending on research and development at small and medium enterprises, firms in the service sector, and firms in low-tech sectors.

Despite robust evidence of the positive personal and social benefits of apprenticeships and of employers' willingness to respond to targeted changes in tax policy related to business decisions, there is an absence of research into the effects of tax credits for employers who hire apprentices. With 12 states currently offering a tax credit related to operating an apprenticeship program or employing an apprentice, according the United States Department of Labor, the data to evaluate apprenticeship tax credits clearly exists. Moreover, the existence of the employer tax credits for apprenticeships demonstrates a palpable interest in the efficacy of such policies. As the United States weighs policy solutions to increase the utilization of apprenticeship programs, this study strives to provide valuable evidence regarding the effectiveness of a prominent option.

METHODS AND DATA

To examine the effects of employer tax credits for hiring apprentices on the use of apprentices in a state's labor force, I use an ordinary least squares regression with the share of a state's labor force that is composed of apprentices, expressed as the number of active apprentices per 1,000 workers, as my dependent variable. My independent variable of interest is a dummy variable of whether the state had an employer tax credit related to hiring apprentices in effect for at least six months of the fiscal year.[4] If the upfront costs of hiring an apprentice and managing an apprenticeship program demotivate employers from sponsoring apprenticeship programs, then the existence of a tax credit for hiring apprentices should increase the share of apprentices in the workforce.

In this regression analysis, I control for the real gross domestic product per capita growth rate in the state, lagged by one year; the percentage of the state's population with an associate degree or higher; the percentage of the state's labor force that works in a blue-collar field; the

[4] Because the apprenticeship tax credit must have been in effect for at least six months of the fiscal year, this means that Maryland's apprenticeship tax credit is not counted for fiscal year 2017. Although the tax credit created by the More Jobs for Marylanders Act of 2017 applied to the 2017 taxable year, it was not signed into law until April 11, 2017. This left employers with little time to alter their hiring plans in response to the tax credit in fiscal year 2017.

race and ethnicity proportions of the state's population; the percentage of workers in the state's labor force who are members of a labor union; and the fiscal year. I control for GDP growth because it is possible that higher GDP growth would be associated with a higher percentage of apprentices in the state's labor force due to employers being more willing to invest in an apprentice when the economy is more robust. However, it is also possible that the relationship could be negative if the size of the workforce expands faster than the number of apprentices in a growing economy. Regardless, the GDP data is lagged by one year because employers need time to respond and adjust to economic indicators in their hiring practices. States with a higher percentage of adults with an associate degree or more may have a lower percentage of apprentices. Apprenticeship is an alternative path after high school that allows apprentices to enter the labor market while increasing their human capital. It may therefore be a substitute for other forms of postsecondary training, such as studying full-time at a two- or four-year college. Although apprenticeships exist in newer, growing sectors of the labor force, such as healthcare, the most common professions for apprentices remain in blue-collar trades such as electrical work, carpentry, and truck driving (U.S. Department of Labor, 2018). Thus, states with a higher percentage of workers in blue-collar professions may have a higher share of apprentices. I control for the racial and ethnic demographics of the state by including the percentage of the state population that is black, the percentage that is Hispanic, and the percentage that is Asian-American. These variables allow me to determine if the racial configuration of the state influences its use of apprenticeship programs. Modeling my regression with these control variables reflects practices used to study the effects of employer tax credits for research and development (Wu, 2005). I also control for the percentage of workers in each state who are union members because of the role unions can play as sponsors of apprenticeship programs. States with more robust union representation may have more established potential sponsors for apprenticeship programs, leading to greater use of apprentices. Lastly, controlling for the fiscal year allows me to control for nationwide factors that may have affected the use of apprentices or the creation of apprenticeship tax credits, such as changes in the federal government's investment in apprenticeship programs.

Model 1

$$\text{apprentsharelf} = \beta_0 + \beta_1\text{*apprenttaxcredit} + \beta_2\text{*lagstateGDPgrowth} + \beta_3\text{*percentpostsecondary} + \beta_4\text{*percentbc} + \beta_5\text{*percentblack} + \beta_6\text{*percenthisp} + \beta_7\text{*percentasian} + \beta_8\text{*percentunion} + \beta_k\text{*Fiscal Year Dummies} + \varepsilon$$

In this model, the dependent variable apprentsharelf is the number of apprentices per 1,000 workers in a state's labor force; apprenttaxcredit is the dummy variable of whether the state has a tax credit for hiring apprentices; lagstateGDPgrowth is the real GDP per capita growth rate in the state, lagged by one year; percentpostsecondary is the percentage of the state's population with an associate degree or higher; percentbc is the percentage of the state's labor force that is employed in blue-collar fields; percentblack is the percentage of the state's population that is black; percenthisp is the percentage of the state's population that is Hispanic; percentasian is the percentage of the state's population that is Asian-American; percentunion is the percentage of the state's workers who are members of a union; and Fiscal Year Dummies represent the dummy variables to control for each fiscal year in the model.

To further examine the effects of employer tax credits for hiring apprentices on the use of apprentices in a state's labor force, I use a second model utilizing ordinary least square regression. This model is structured in the same way as Model 1 but excludes Hawaii from the regression. Hawaii is an outlier in many of the variables included in Model 1, most notably in its use of apprentices. Among all the states and years included in the data for this research, Hawaii's share of apprentices in its labor force in each year was higher than in any other state in any other year. In each year in the dataset, there were at least 10 apprentices for each 1,000 workers in Hawaii's labor force, reaching a high of 14.74 apprentices per 1,000 workers in 2017. The District of Columbia in 2017 was the only other state to have 10 or more apprentices per 1,000 workers in any year in the dataset. To account for the outsized impact that Hawaii's liberal use of apprenticeship programs might have on Model 1, my second model removes Hawaii from the dataset used in the regression. The variables in the model remain the same.

Model 2*

$$apprentsharelf = \beta_0 + \beta_1*apprenttaxcredit + \beta_2*lagstateGDPgrowth + \beta_3*percentpostsecondary + \beta_4*percentbc + \beta_5*percentblack + \beta_6*percenthisp + \beta_7*percentasian + \beta_8*percentunion + \beta_k*Fiscal\ Year\ Dummies + \varepsilon$$

*Hawaii excluded

To examine the effects of employer tax credits for hiring apprentices on the real gross domestic product per capita growth rate, I use an ordinary least squares regression with a state's real GDP per capita growth rate in a given fiscal year as my dependent variable. As in Models 1 and 2, my independent variable of interest is a dummy variable of whether the state had an employer tax credit related to hiring apprentices in effect for at least six months of the fiscal year. Employer tax credits are typically believed to have a stimulative effect on the economy by reducing costs on employers, allowing them to invest more in their businesses and expanding their output.

This model uses the same control variables as Models 1 and 2 to account for the same factors that might affects the involvement of apprentices in a state's labor force and therefore in its economic output. The GDP per capita growth rate in a state one year prior should be highly correlated with the state's GDP per capita growth rate in a given year. States in which a higher share of the population has a postsecondary degree may be more productive as a result of that increased education, producing higher GDP growth. Controlling for the fiscal year is particularly important for this model because there are many factors that could cross state lines that could affect a state's real GDP per capita growth rate and alter its willingness to implement an apprenticeship tax credit.

Model 3

$$\text{stateGDPgrowth} = \beta_0 + \beta_1\text{*apprenttaxcredit} + \beta_2\text{*lagstateGDPgrowth} + \beta_3\text{*percentpostsecondary} + \beta_4\text{*percentbc} + \beta_5\text{*percentblack} + \beta_6\text{*percenthisp} + \beta_7\text{*percentasian} + \beta_8\text{*percentunion} + \beta_k\text{*Fiscal Year Dummies} + \varepsilon$$

Accounting for Hawaii's role as an outlier in its use of apprenticeship programs, I also use a model that is similar to Model 3 but excludes Hawaii from the dataset in the regression. Although this model does not examine the share of apprentices in a state's labor force, Hawaii's extensive use of apprentices could alter its GDP growth and exert outsized weight on the results of the regression. This last model also uses the state's real GDP per capita growth rate as its dependent variable, whether the state has an apprenticeship tax credit in effect as its independent variable of interest, and the same group of control variables as Models 1, 2, and 3.

Model 4*

$$stateGDPgrowth = \beta_0 + \beta_1*apprenttaxcredit + \beta_2*lagstateGDPgrowth + \beta_3*percentpostsecondary + \beta_4*percentbc + \beta_5*percentblack + \beta_6*percenthisp + \beta_7*percentasian + \beta_8*percentunion + \beta_k*Fiscal\ Year\ Dummies + \varepsilon$$

*Hawaii excluded

The data to conduct these four regression analyses comes from a variety of sources within the federal government. The share of apprentices in a state's labor force is a self-calculated statistic that uses the number of active apprentices in the state divided by the size of the state's labor force. The U.S. Department of Labor's Office of Apprenticeship (OA) collects the annual number of active apprentices in each state (U.S. Department of Labor, 2018). For 34 of the states, this data comes from OA's Registered Apprenticeship Partners Information Management Data System (RAPIDS), which records individual data on apprentices. The remaining states do not use RAPIDS but instead submit information on the number of apprentices in their state to OA on a quarterly basis. The size of the state's labor force comes from U.S. Census Bureau's Current Population Survey, which samples around 60,000 households nationwide and collects data on a variety of aspects of the labor market, including labor force participation and employment (U.S. Department of Commerce, 2018). I use the total nonfarm, seasonally adjusted, labor force from each state. Because OA presents its totals on active apprenticeships by fiscal year, I use the size of the state's labor force in September, the final month of the fiscal year. I have independently identified states that have implemented a tax credit for hiring apprentices. To do this, I began with OA's list of "States that offer tax credits to employers for hiring apprentices" and independently verified when those states implemented their tax credits (U.S.

Department of Labor, 2018). The data on states' real GDP per capita growth rate comes from calculations by the Bureau of Economic Analysis (U.S. Department of Commerce, 2018). The percentage of each state's population with an associate degree or higher and the racial and ethnic demographics of the states are drawn from the U.S. Census Bureau's American Community Survey, a national monthly survey used to produce estimates of demographic information about the United States, individual states, and smaller areas (U.S. Department of Commerce, 2018). The Current Population Survey also provides the percentage of workers in each state who are members of unions. Lastly, the Occupational Employment Statistics survey offers data regarding the percentage of workers in blue-collar fields in each state. This survey is conducted semiannually by the Bureau of Labor Statistics and state workforce agencies and samples 200,000 establishments throughout the country. To determine the fields that I am considering the blue-collar sector, I identified the major occupation groups that hosted the most common occupational titles among apprentices. These groups include the transportation and material moving occupations; the construction and extraction occupations; the installation, maintenance, and repair occupations; and the production occupations. Summing up the employment percentages of each of these four groups in each state produced the percentage of the state's labor force in blue-collar fields that I use in my analysis.

My sample includes data from all 50 states in addition to the District of Columbia. OA provides data on the number of active apprentices for each fiscal year from 2011 to 2017.[5] This leaves me with 357 state-years in my dataset. In 60 of those state-years, the state had a tax credit

[5] OA did not report data on the number of active apprentices for the District of Columbia, Montana, and Rhode Island in 2013 and the District of Columbia in 2012. For Montana and Rhode Island, I computed a figure for the missing values by taking the respective averages of the states' number of active apprentices in 2011, 2012, 2014, and 2015. For the District of Columbia, I first computed a figure for 2013 by taking the average for the District in 2011, 2014, and 2015. I then computed a figure for 2012 by taking the average for the District in 2011, 2013, and 2014, using the aforementioned computed value for 2013 in this calculation.

for hiring apprentices in effect. The mean share of the apprentices in the workforce in my sample is slightly more than three apprentices per 1,000 workers (Table 2). The mean GDP per capita growth rate is 0.85 percent while the mean lagged GDP per capita growth rate is 0.90 percent. The mean percentage of the state's population with an associate degree or higher is 39.60 percent while 21.96 percent work in a blue-collar field. The mean percentage of the population of the states that is black is 11.18 percent, with 10.98 percent Hispanic and 3.89 percent Asian-American. The mean percentage of workers in a state who are members of a union is 10.25 percent.

RESULTS

This research evaluates state employer tax credits related to operating registered apprenticeship programs and the effects those tax credits have on the use of apprenticeship programs in the United States. It also examines the extent to which those tax credits stimulate economic growth. To conduct this analysis, I use state-level data from a variety of sources within the federal government covering all 50 states and the District of Columbia from fiscal year 2011 to fiscal year 2017. Data on the number of active apprentices in each state comes from the U.S. Department of Labor's Office of Apprenticeship. The U.S. Census Bureau's Current Population Survey provides data on the size of state labor forces and the percentage of workers in each state who are members of labor unions. I have independently verified states that have implemented a tax credit related to hiring apprentices. The U.S. Bureau of Economic Analysis provides data on the real gross domestic product per capita growth rate in each state, while the U.S. Census Bureau's American Community Survey provides the percentage of each state's population with an associate degree or higher and the racial and ethnic demographics of each state. Lastly, the

Occupational Employment Statistics survey offers data for a self-calculated measure of the percentage of workers in blue-collar fields in each state.

To conduct my analysis of the effects of the apprenticeship tax credits on the use of apprenticeship programs, I use an ordinary least squares regressions with the share of a state's labor force that is composed of apprentices as my dependent variable. This variable expresses the number of active registered apprentices per 1,000 workers in the state. My independent variable of interest is a dummy variable reflecting whether the state had an employer tax credit related to hiring apprentices in effect in that year. Model 1 includes all states in each year from fiscal year 2011 to fiscal year 2017. To account for Hawaii's considerably larger use of apprentices in its labor force than in any other state, Model 2 excludes Hawaii from the regression. In both of these regression analyses, I control for the real gross domestic product per capita growth rate in the state, lagged by one year; the percentage of the state's population with an associate degree or higher; the percentage of the state's labor force that works in a blue-collar field; the race and ethnicity of the state's population; and the percentage of workers in the state who are members of a union. I also control for the fiscal year to account for any nationwide effects on the use of apprenticeship tax credits or apprenticeship programs, such as increased investment from the federal government in expanding apprenticeship. If upfront financial costs related to establishing a registered apprenticeship program and hiring apprentices create a barrier to employers choosing to operate apprenticeship programs, then the existence of a tax credit for hiring apprentices should increase the share of apprentices in the workforce.

To evaluate the effects of apprenticeship tax credits on economic growth, I use similar ordinary least squares models to Models 1 and 2 with the same control variables. However, the dependent variable is the state's real gross domestic product per capita growth rate. The independent variable of interest remains whether the state had an employer tax credit related to operating an apprenticeship program in effect in that year. Model 3 includes all states in each year from fiscal year 2011 to fiscal year 2017. Similar to Model 2, Model 4 excludes Hawaii from the regression. To the extent that the tax credit incentivizes employers to hire apprentices to expand their businesses, the tax credit should increase economic growth.

The data for my analysis comes from all 50 states and the District of Columbia for each fiscal year from 2011 to 2017. During this period, most states did not offer an employer tax credit related to operating an apprenticeship program. However, by 2017, 10 states had an apprenticeship tax credit in effect. Because the data covers every state, it includes a wide variety of economies, workforces, and populations with different demographics. The period covered begins shortly after the end of the Great Recession and continues through the economic recovery.

Univariate Results

Examining the share of apprentices in the labor force in states with and without an apprenticeship tax credit indicates that the tax credit may be associated with increased use of apprenticeship programs. States with a tax credit for hiring apprentices did have a higher share of apprentices in their labor force than states that did not have a tax credit (Table 3).

Additionally, a univariate OLS regression of the share of apprentices in the state's labor force on whether the state had a tax credit indicates a statistically significant increase in the apprenticeship share in states with a tax credit (Table 4).

A scatterplot and line of best fit of the share of apprentices per 1,000 workers in states with and without tax credits related to operating apprenticeship programs further illustrates that the apprenticeship share is higher in states that have an apprentices tax credit than in states that do not (Figure 1).

However, analyzing the real GDP per capita growth rate in states with and without an apprenticeship tax credit indicates that the tax credit may be associated with decreased economic growth. States with an apprenticeship tax credit had lower growth rates in their real GDP per capita than states that did not have the tax credit (Table 5).

This aligns with a bivariate OLS regression of the state real GDP per capita growth rate on whether the state had an apprenticeship tax credit, which found a statistically significant decrease in the real GDP per capita growth rate in states with a tax credit (Table 6). Although these results are counter to what economic theory would suggest, they may simply indicate that states with lower economic growth are more likely to implement an apprenticeship tax credit.

Correlation Results

A statistically significant positive correlation between states with an apprenticeship tax credit and the share of apprentices in the state's labor force provides further indication that the tax credit appears to be associated with an increased use of apprenticeship (Table 7). Other variables, such as the percentage of the state population with an associate degree or higher, the percentage of Asian-Americans in the state population, and the percentage of workers who are union members, are also positively correlated with an increased use of apprentices in the state labor force. Surprisingly, the percentage of workers in the state employed in blue-collar fields is negatively correlated with the share of apprentices in the state labor force. The percentage of Hispanics in the state population is also negatively correlated with use of apprenticeship.

Consistent with the idea that states with low economic growth are more likely to implement a tax credit for operating an apprenticeship program, the existence of an apprenticeship tax credit is negatively correlated with the real state GDP per capita growth rate and the lagged real state GDP per capita growth rate. Apprenticeship tax credits appear to be a counter-cyclical policy measure. The existence of an apprenticeship tax credit is also negatively correlated with the percentage of the state population with an associate degree or higher, perhaps indicating that states that place more emphasis on traditional forms of postsecondary training are less likely to prioritize increasing apprenticeship programs.

Multivariate Results

The results of Model 1 indicate that the existence of an employer tax credit related to operating a registered apprenticeship program does increase the share of apprentices in a state's labor force by a statistically significant amount. According to the model, the existence of the tax credit increases the share of apprentices by 0.862 apprentices per 1,000 workers, controlling for the state's economic growth and other factors of the state's labor force and population (Table 8). Although this may appear to be a rather modest increase, because that the share of apprentices currently in the labor force in U.S. states is so small, the increase associated with the tax credit represents a sizeable jump. The average state has only 3.11 apprentices per 1,000 workers in its labor force. Thus, an uptick in the share by 0.862 apprentices amounts to a 27.75 percent increase. In a state as large as California, the results of Model 1 indicate that the introduction of an apprenticeship tax credit could increase the number of active registered apprentices by more than 14,500. The average share of apprentices in the labor force in states without an apprenticeship tax credit is 3.00 apprentices per 1,000 workers. According to the results of the model, implementing an apprenticeship tax credit could increase that share by 28.72 percent (Figure 2).

These results provide evidence that the financial costs of operating an apprenticeship program and hiring apprentices create a barrier that prevents some employers from creating an apprenticeship program. The financial incentive of the apprenticeship tax credit appears to make the decision to implement or expand an apprenticeship program profitable for some employers, leading them to do so and expanding the number of apprentices in the labor force.

The percentage of Asian-Americans in the state population is also associated with a statistically significant increase in the share of apprentices in the state labor force, according to Model 1. Each additional percentage point of Asian-Americans in a state's racial demographics is associated with 0.236 more apprentices per 1,000 workers (Table 8). However, this finding is heavily influenced by Hawaii, which has a considerably larger share of Asian-Americans in its population than any other state as well as the largest share of apprentices in its labor force of any state. Model 1 also indicates that the percentage of Hispanics in the state population is associated with a statistically significant decrease in the share of apprentices in the state labor force. Each additional percentage point of Hispanics in a state's ethnic demographics is associated with 0.068 fewer apprentices per 1,000 workers. This may indicate that Hispanic workers are less likely to seek out apprenticeships or that employers are less likely to offer apprenticeships to Hispanic workers.

The percentage of workers in the state employed in blue-collar fields is also associated with a decrease in the share of apprentices in the state labor force, according to Model 1. An additional percentage point of blue-collar workers is associated with 0.065 fewer apprentices per 1,000 workers. This is a surprising finding given that blue-collar fields include many of the most common professions for apprenticeships. It is possible that states with robust blue-collar industries have infrequent shortages of full-time jobs and trained applicants and thus employers feel less need to provide training through apprenticeship programs. Further research on the occupational breakdown of state labor forces and apprenticeship positions may provide insights into this topic.

Given the relatively high R^2-statistic and F-statistic for this regression, Model 1 appears to explain a sizeable amount of the variation in the share of apprentices among the different states.

When Hawaii is removed in Model 2, several results change considerably. Most notably, the increase in use of apprenticeship programs associated with apprenticeship tax credits becomes stronger. According to Model 2, the existence of an apprenticeship tax credit is associated with an increase in the share of apprentices in a state's labor force by 1.129 apprentices per 1,000 workers, controlling for the state's economic growth and other factors of the state's labor force and population (Table 9). Because Hawaii has such a strong use of apprentices in its labor force and because it does not have an apprenticeship tax credit, it noticeably decreases the relationship between apprenticeship tax credits and increased use of apprenticeship programs. Removing Hawaii from the model in Model 2 thus makes the link between the tax credits and a rise in the share of apprentices more robust. Based on the results of Model 2, the average state without an apprenticeship tax credit could increase the share of apprentices in its labor force by 37.60 percent by implementing the tax credit. This finding provides further evidence to support the theory that reducing the financial costs of operating an apprenticeship program can generate a significant increase in the use of apprenticeship in the U.S.

As expected, removing Hawaii from Model 2 reduces the relationship between the percentage of a state's population that is Asian-American and the share of apprentices in the state's labor force. In fact, the relationship is no longer statistically significant in Model 2. This highlight how much of an outlier Hawaii is in both of these two variables, allowing it to have a significant effect on Model 1's finding of a relationship between the two variables.

Model 2 surprisingly finds a significant, positive relationship between the percentage of a state's population with a postsecondary degree and the share of apprentices in the state's labor force. Each additional percentage point of the population with a postsecondary degree is associated with an increase of 0.061 apprentices per 1,000 workers in the state. Although apprenticeship may be viewed as a substitute for other forms of postsecondary education, states in which more of the population pursues a postsecondary degree may be more likely to seek out all possible paths of postsecondary skills development. Furthermore, the related technical instruction of an apprenticeship could form the basis for earning an associate or bachelor's degree either as part of the apprenticeship or afterward. Additional research into the relationship between apprenticeship and postsecondary degree attainment could provide more insight into this finding.

Model 2 also finds a significant, positive relationship between the percentage of workers in a state who are members of a union and the share of apprentices in the state's labor force. Each additional percentage point of union membership among workers in the state is associated with 0.102 more apprentices per 1,000 workers. This finding supports the important role unions can play as sponsors of apprenticeship programs. In states where more workers are members of unions, these stronger unions appear to be better able to organize apprenticeship programs and partner with employers to hire and train the apprentices.

Although Model 2 does not have as high of an R^2-statistic and F-statistic as Model 1, it still explains a significant amount of the variation in the share of apprentices among different states' labor forces.

According to the results of Model 3, the existence of an employer tax credit related to operating a registered apprenticeship program does not have a statistically significant effect on a state's real GDP per capita growth rate when controlling for the state's economic growth a year earlier and other factors of the state's labor force and population (Table 10). This finding is not surprising given the relatively small share that apprentices comprise of a state's labor force. To the extent that the apprenticeship tax credit increases the hiring of apprentices or reduces employers' labor costs, this effect is likely too small to stimulate significant growth in the state's entire economy. In fact, because apprentices' productivity improves rapidly over the course of their apprenticeship (Muehlemann et al., 2010), an increase in the number of apprentices in a state's labor force may initially decrease the average productivity of the state's workers before increasing it in the long run. Regardless, while apprenticeship tax credits do appear to increase the use of apprentices, this increase does not appear to have a short-term stimulative effect on the state's economy.

The R^2-statistic and F-statistic for Model 3 are both rather low, though the model is statistically significant. This makes sense given that the control variables generally relate to factors that might affect the use of apprenticeship programs in a state. Most of these variables do not appear to have a statistically significant effect on the state's economic growth. Only the state's real GDP per capita growth rate of the prior year has a statistically significant relationship with the state's current-year real GDP per capita growth rate.

Similar to Model 3, Model 4 finds that the existence of an employer tax credit related to operating a registered apprenticeship program does not have a statistically significant effect on a state's real GDP per capita growth rate when controlling for the state's economic growth a year earlier and other factors of the state's labor force and population (Table 11). This reinforces the theory that apprentices constitute too small of a share of a state's labor force to significantly change the economic output of the state in the short run. Additionally, the savings to employers from apprenticeship tax credits are too small of a share of their overall budget to drive a significant increase in output. Although apprenticeship tax credits can alter the hiring approach of employers with regard to apprentices, the effect of this change on a state's economic growth rate would likely not be felt until a much longer term.

As with Model 3, Model 4 has a low R^2-statistic and F-statistic but remains a statistically significant model. This again is largely due to the strong relationship between the real GDP per capita growth rate in a state in the prior year to its real GDP per capita growth rate in the given year.

The regressions for each of the four models do not include dummy variables for each specific state. Although including those variables could attempt to control for other factors within states that affect the share of apprentices (such as the awareness of employers regarding apprenticeship programs and the marketing efforts of states to promote apprenticeship to employers and workers) or the economic growth rate, the models utilize state-level data for the independent variables. Thus, including a dummy variable for each state would create an issue of multicollinearity.

DISCUSSION AND CONCLUSION

My research evaluates the effectiveness of employer tax credits related to operating registered apprenticeship programs, specifically examining the extent to which the existence of apprenticeship tax credits increases the use of apprenticeship programs and increases economic growth. To evaluate these questions, I use ordinary least squares regression analysis. In my models, the dependent variables are the share of active registered apprentices per 1,000 workers in a state's labor force and the state's real gross domestic product per capita growth rate. The independent variable of interest in the models is whether the state had an apprenticeship tax credit in effect in that year.

The results of this research indicate that apprenticeship tax credits do increase the use of registered apprenticeship programs. The results from Model 1 indicate that the existence of an apprenticeship tax credit is associated with an increase in the share of apprentices in a state's labor force by 0.862 apprentices per 1,000 workers, controlling for other factors in the state's economy, demographics, and labor force characteristics. In the average state without an apprenticeship tax credit in 2017, this rise in the share of apprentices in the labor force would amount to a 28.72 percent increase if a tax credit were implemented. The results from Model 2 indicate that the existence of an apprenticeship tax credit is associated with an increase in the share of apprentices in a state's labor force by 1.129 apprentices per 1,000 workers, controlling for those same other factors in the state. Based on this larger effect, the share of apprentices in the labor force of the average state without an apprenticeship tax credit in 2017 would increase by 37.60 percent.

Apprenticeship tax credits do not appear to affect a state's economic growth. According to the results of Models 3 and 4, the existence of an apprenticeship tax credit is not associated with a statistically significant change in a state's real gross domestic product per capita growth rate, controlling for other factors in the state's economy, demographics, and labor force characteristics.

The finding that apprenticeship tax credits increase the use of apprenticeship programs provides compelling support for the creation of these tax credits. As states and the federal government consider policy options to raise the use of apprenticeship programs, my results suggest that implementing an apprenticeship tax credit is an effective strategy. This link between the tax credits and increased use of apprenticeships indicates that the costs to employers of forming a registered apprenticeship program, hiring apprentices, and providing training create barriers that limit the use of apprenticeship programs in the United States. Apprenticeship tax credits subsidize those costs and consequently appear to make the decision to create or expand an apprenticeship program profitable for some employers. If every state that did not have an apprenticeship tax credit in effect in 2017 implemented one, the results from Model 1 indicate this would increase the number of apprentices by nearly 120,000, a sizeable rise given that the United States had just 534,000 active apprentices in 2017.

The difference between the results of Model 1 and Model 2 illustrate the extent to which Hawaii is an outlier in its use of apprenticeship programs. Of the 357 state-years in my dataset, Hawaii accounted for each of the top seven figures in the share of apprentices in a state's labor force. By 2017, nearly 15 out of every 1,000 workers in Hawaii's labor force were apprentices, more than four times the average share of apprentices in the other states that year. Hawaii has achieved this extensive use of apprentices without implementing an apprenticeship tax credit. Thus, when removing Hawaii from the regression analysis in Model 2, the model finds a stronger relationship between the existence of an apprenticeship tax credit and the share of apprentices in a state's labor force. Without including Hawaii, the use of apprenticeship in states without an apprenticeship tax credit is far lower. In fact, the average share of apprentices in states without an apprenticeship tax credit drops from 3.002 to 2.766 apprentices per 1,000 workers if Hawaii is not included. Because Model 2 removes Hawaii, the state with the highest use of apprentices and a state without an apprenticeship tax credit, from the analysis, it is not surprising that this model finds the effects of apprenticeship tax credits on the use of apprenticeship programs to be stronger. Further research on the use of apprenticeship programs in Hawaii could provide insight into what policies, economic conditions, labor market characteristics, or other factors explain the state's high share of apprentices in its labor force.

The lack of evidence indicating that apprenticeship tax credits increase states' real gross domestic product per capita growth rates suggests that the effects of an apprenticeship tax credit on the overall economy of a state are too small to provide a significant stimulative effect. Even with the increased use of apprenticeship facilitated by the tax credit, apprentices still account for a very small share of a state's labor force. Thus, changes in this share have little effect on the economic output of a state. State governments seeking policies to provide a short-run stimulation to their economies should therefore pursue other policies instead of or in conjunction with an apprenticeship tax credit. Any sizeable effects of an apprenticeship tax credit on economic growth would likely be in the long run due to the increased productivity of workers after they have completed their apprenticeship.

An array of research has demonstrated that registered apprenticeships are profitable to apprentices by increasing their earnings and profitable to society by increasing tax revenue and decreasing use of social safety net programs (Hollenbeck and Huang, 2006; Reed et al., 2012). These findings have raised the question of why, if apprenticeship is so beneficial, is its use in the

United States so low, particularly in comparison to other countries with similarly advanced economies and labor forces. Without rigorous evidence of the costs and benefits to U.S. employers of creating registered apprenticeship programs, speculation has frequently focused on either that the financial costs of operating an apprenticeship program exceed its benefits or that the federal government's regulations of the registered apprenticeship system create too large of a burden on employers (King, 2018). State governments have attempted to address the financial costs on employers by implementing apprenticeship tax credits, but despite the increasingly common use of these tax credits, there had been a dearth of rigorous evaluation of their effectiveness. My research indicates that subsidizing the financial costs on employers by providing them an apprenticeship tax credit can significantly increase the use of apprenticeship programs. Although this increase still leaves the use of apprenticeship in the U.S. far lower than in other countries such as Germany, it nonetheless represents a sizeable spike in the share of apprentices in the labor force in U.S. states.

My results demonstrate that state and federal policymakers seeking mechanisms to increase the earnings and improve the labor market outcomes of workers without four-year college degrees should clearly consider apprenticeship tax credits part of their policy arsenal. Prior research has shown that apprenticeships improve earnings for workers in the short run and long run and do so in a net beneficial way for society (Hollenbeck and Huang, 2006; Reed et al., 2012; Clark and Fahr, 2001; Fersterer, Pischke, and Winter-Ebmer, 2008; Ecorys, Institute for Employment Studies, and Istituto per la Ricerca Sociale, 2013). This study reveals that apprenticeship tax credits significantly increase the use of apprenticeship programs. Taken together, the evidence indicates that apprenticeship tax credits effectively increase the use of a program with proven economic benefits for workers and society, improving labor market outcomes for workers without requiring a bachelor's degree.

In conducting my research, I use state-level data to control for a variety of state-specific factors that might affect a state's likelihood of implementing an apprenticeship tax credit and its use of apprenticeship in its labor force. This use of state-level data compels that I not utilize state fixed effects models because the inclusion of dummy variables for each state would introduce issues of multicollinearity. As a result, I am unable to control for qualitative factors that might impact the use of apprenticeship programs and the implementation of apprenticeship tax credits. For example, South Carolina, in addition to offering an apprenticeship tax credit, authorizes its state apprenticeship agency to provide robust technical assistance to employers to help them design registered apprenticeship programs and to partner with the state's technical colleges to help provide the related technical instruction to apprentices. This type of state assistance and other non-financial support for apprenticeships are not captured in my models. If states that offer apprenticeship tax credits are more or less likely to have other qualitative factors that increase or decrease the use of apprenticeship in those states, then my results could overestimate or underestimate the effects of apprenticeship tax credits on the share of apprentices in a state's labor force.

Among the states that offered an apprenticeship tax credit in the years within my dataset, each state structured its tax credit slightly differently. The credits vary by the size of the credit, the types of apprenticeships that are eligible (for example, specifically targeting youth apprenticeships), and the occupational fields that are eligible (for example, specifically targeting apprenticeships in manufacturing). Due to the fact that no two credits are structured exactly the same, I group all of the apprenticeship tax credits together to assess whether the policy idea as a whole is an effective method to increase the use of apprenticeship. However, this means that I cannot evaluate varying levels of effectiveness among the different structures of the tax credits. It is likely that the size of the tax credit would influence its effectiveness as would the other aspects that determine eligibility; nevertheless, my models cannot evaluate these questions. The take-up rate of the apprenticeship tax credits may also vary among the states that offer them. The effort a state makes to market its tax credit and the ease with which it allows employers to claim the credit would likely influence the percentage of eligible employers who benefit from the credit. If few employers are aware of the tax benefits their state offers for operating an apprenticeship program, then they would not be incentivized to create an apprenticeship program and thus the effects of the apprenticeship tax credit on the use of apprenticeship in the state would be reduced. However, due to a lack of data on the take-up rate of the apprenticeship tax credits, that factor is not included in my models. It is possible that the effects of apprenticeship tax credits are larger than my research found in states with a high take-up rate.

Despite these limitations, the results of my research indicate that apprenticeship tax credits can be part of a strategy to effectively improve the labor market outcomes of workers without four years of full-time college study. By increasing the use of apprenticeship, a program with proven economic benefits to workers, apprenticeship tax credits expand the pathways for workers to increase their earnings that do not require a bachelor's degree. These results show that an apprenticeship tax credit provides policymakers with an option to address the persistent wage stagnation of workers without a college degree. As more states implement apprenticeship tax credits that are structured in different ways, evaluations of these different structures may be possible to determine the most cost-effective way to increase the use of apprenticeship programs.

Rigorous evaluations of the costs and benefits to employers that operate apprenticeship programs could also help determine the ideal size of the tax credit.

APPENDIX

Table 1: Summary Statistics of Dummy Variable

Variable	Description of the Variable	Frequency of Occurrence	Standard Error
apprenttaxcredit	Whether state has apprenticeship tax credit in effect (1 = Yes)	.168	.375

Table 2: Summary Statistics of Continuous Variables

Variable	Description of the Variable	Mean	Standard Error	Median	Minimum, Maximum
apprentsharelf	Number of active apprentices per 1,000 workers	3.11	2.19	2.55	0.69, 14.74
stateGDPgrowth	Real GDP per capita growth rate	0.85	1.99	0.90	-6.50, 19.50
lagstateGDPgrowth	Real GDP per capita growth rate, lagged one year	0.90	2.11	0.90	-6.50, 19.50
percentpostsecondary	Percentage of state population with associate degree or higher	39.60	5.96	39.59	26.40, 59.70
percentbc	Percentage of state's labor force in blue-collar fields	21.96	4.33	22.18	5.42, 31.86
percentblack	Percentage of state population that is black	11.18	10.87	7.30	0.40, 51.90
percenthisp	Percentage of state population that is Hispanic	10.98	9.92	8.60	1.20, 48.20
percentasian	Percentage of state populations that is Asian-American	3.89	5.47	2.50	0.60, 38.90
percentunion	Percentage of workers in state who are union members	10.25	5.14	9.90	1.60, 24.70

Table 3: Mean Apprenticeship Share in States With and Without Tax Credit

	State does not have apprenticeship tax credit	State has apprenticeship tax credit
Apprenticeship share of state labor force (standard error)	3.00 (2.27)	3.63 (1.62)
Sample size	297	60

Table 4: Univariate Regression Results of Apprenticeship Share of State Labor Force

Variable	Coefficient	Significance level	t-statistic	p-value
apprenttaxcredit (standard error)	0.629 (0.309)	**	2.04	0.042
Constant (standard error)	3.002 (0.127)	***	23.73	0.000

Significance-level: one-percent --***, five-percent -- **; ten-percent -- *

Figure 1: Share of Apprentices in States With and Without Apprenticeship Tax Credits

Table 5: Mean Real GDP Per Capita Growth Rate in States With and Without Tax Credit

	State does not have apprenticeship tax credit	State has apprenticeship tax credit
Real GDP per capita growth rate (standard error)	0.98 (2.05)	0.21 (1.45)
Sample size	297	60

Table 6: Univariate Regression Results of Real GDP Per Capita Growth Rate

Variable	Coefficient	Significance level	t-statistic	p-value
apprenttaxcredit (standard error)	-0.773 (0.278)	***	-2.78	0.006
Constant (standard error)	0.980 (0.114)	***	8.58	0.000

Significance-level: one-percent --***, five-percent -- **; ten-percent -- *

Table 7: Correlation Matrix

	apprent sharelf	stateGDP growth	apprent taxcredit	lagstate GDP growth	percent post secondary	percent bc	percent black	percent hisp	percent asian	percent union
apprent sharelf	1.000									
stateGDP growth	-0.070	1.000								
apprent taxcredit	0.108 **	-0.146 ***	1.000							
lagstate GDP growth	-0.048	0.229 ***	-0.134 **	1.000						
percent post secondary	0.219 ***	0.099 *	-0.321 ***	0.091 *	1.000					
percent bc	-0.266 ***	0.046	0.044	0.078	-0.620 ***	1.000				
percent black	0.015	-0.144 ***	0.177 ***	-0.129 **	-0.019	-0.209 ***	1.000			
percent hisp	-0.148 ***	0.038	-0.089 *	-0.017	0.000	-0.364 ***	-0.118 **	1.000		
percent asian	0.597 ***	0.034	-0.076	0.014	0.226 ***	-0.353 ***	-0.088 *	0.204 ***	1.000	
percent union	0.385 ***	0.026	-0.119 **	0.029	0.314 ***	-0.355 ***	-0.250 ***	0.026	0.515 ***	1.000
year 17	0.080	0.017	0.031	-0.118 **	-0.026	-0.005	0.009	0.024	0.027	-0.025
year 16	0.002	-0.115 **	0.009	0.113	-0.076	0.002	0.001	0.015	0.009	-0.026
year 15	-0.052	0.130 **	0.009	0.068	0.087	0.017	-0.000	0.009	0.005	-0.003
year 14	-0.096 *	0.082	-0.012	-0.144 ***	0.051	0.013	-0.001	0.001	-0.003	-0.006
year 13	0.061	-0.143 ***	-0.012	0.012	0.028	-0.000	-0.002	-0.007	-0.008	0.007
year 12	0.090 *	0.023	-0.012	-0.004	-0.009	-0.009	-0.003	-0.017	-0.013	0.007

Significance-level: one-percent --***, five-percent -- **; ten-percent -- *

Table 7: Correlation Matrix (cont.)

	year 17	year 16	year 15	year 14	year 13	year 12
year 17	1.000					
year 16	-0.167 ***	1.000				
year 15	-0.167 ***	-0.167 ***	1.000			
year 14	-0.167 ***	-0.167 ***	-0.167 ***	1.000		
year 13	-0.167 ***	-0.167 ***	-0.167 ***	-0.167 ***	1.000	
year 12	-0.167 ***	-0.167 ***	-0.167 ***	-0.167 ***	-0.167 ***	1.000

Significance-level: one-percent --***, five-percent -- **; ten-percent -- *

Table 8: Multivariate Regression Results of Model 1

Variable	Coefficient	Significance level	t-statistic	p-value
apprenttaxcredit (standard error)	0.862 (0.248)	***	3.48	0.001
lagstateGDPgrowth (standard error)	-0.039 (0.042)		-0.94	0.348
percentpostsecondary (standard error)	0.017 (0.022)		0.79	0.430
percentbc (standard error)	-0.065 (0.034)	*	-1.91	0.057
percentblack (standard error)	-0.003		-0.34	0.730
percenthisp (standard error)	-0.068 (0.010)	***	-6.47	0.000
percentasian (standard error)	0.236 (0.018)	***	12.81	0.000
percentunion (standard error)	0.020 (0.021)		0.94	0.349
year17 (standard error)	0.769 (0.315)	**	2.44	0.015
year16 (standard error)	0.473 (0.311)		1.52	0.129
year15 (standard error)	0.143 (0.317)		0.45	0.651
year14 (standard error)	-0.101 (0.318)		-0.32	0.751
year13 (standard error)	0.767 (0.313)	**	2.45	0.015
year12 (standard error)	0.925 (0.312)	***	2.97	0.003
Constant (standard error)	2.977 (1.648)	*	1.81	0.072

Significance-level: one-percent --***, five-percent -- **; ten-percent -- *
N = 357, R^2 = 0.5082, F-statistic = 25.24

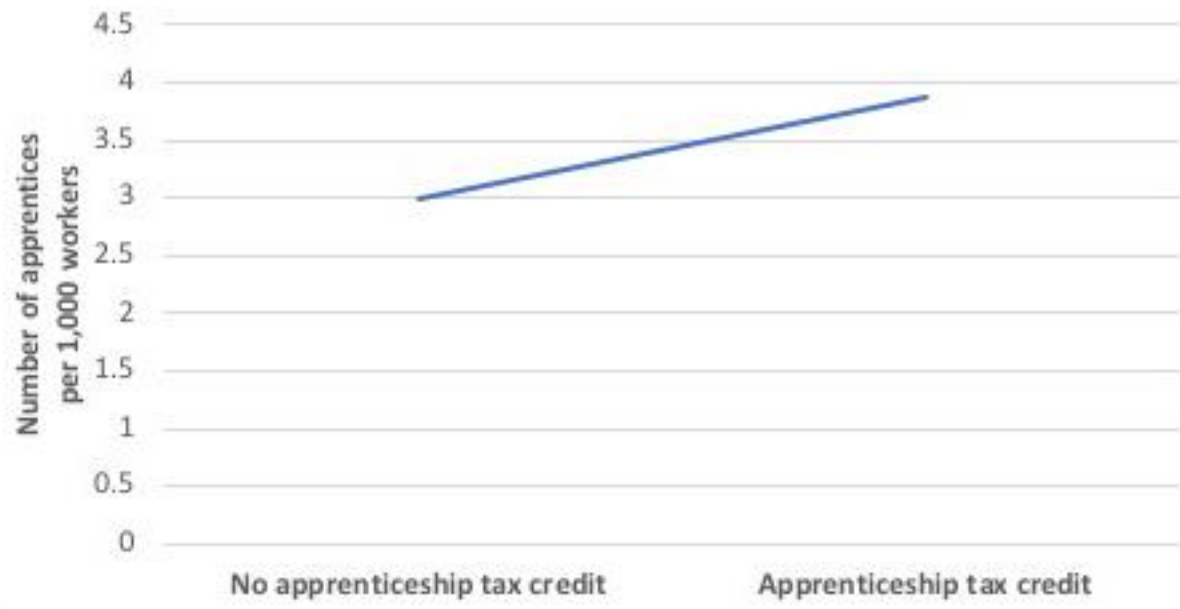

Figure 2: Estimated Effect of Implementing Apprenticeship Tax Credit

Table 9: Multivariate Regression Results of Model 2

Variable	Coefficient	Significance level	t-statistic	p-value
apprenttaxcredit (standard error)	1.129 (0.241)	***	4.68	0.000
lagstateGDPgrowth (standard error)	-0.034 (0.040)		-0.84	0.399
percentpostsecondary (standard error)	0.061 (0.022)	***	2.76	0.006
percentbc (standard error)	-0.028 (0.033)		-0.86	0.392
percentblack (standard error)	0.017	*	1.88	0.061
percenthisp (standard error)	-0.022 (0.013)	*	-1.77	0.078
percentasian (standard error)	-0.069 (0.053)		-1.29	0.199
percentunion (standard error)	0.102 (0.024)	***	4.18	0.000
year17 (standard error)	0.894 (0.306)	***	2.93	0.004
year16 (standard error)	0.587 (0.301)	*	1.95	0.052
year15 (standard error)	0.141 (0.305)		0.46	0.644
year14 (standard error)	-0.069 (0.307)		-0.22	0.823
year13 (standard error)	0.756 (0.302)	**	2.51	0.013
year12 (standard error)	0.927 (0.301)	***	3.08	0.002
Constant (standard error)	-0.271 (1.667)		-0.16	0.871

Significance-level: one-percent --***, five-percent -- **; ten-percent -- *
N = 350, R^2 = 0.2671, F-statistic = 8.72

Table 10: Multivariate Regression Results of Model 3

Variable	Coefficient	Significance level	t-statistic	p-value
apprenttaxcredit (standard error)	-0.383 (0.297)		-1.29	0.198
lagstateGDPgrowth (standard error)	0.207 (0.050)	***	4.15	0.000
percentpostsecondary (standard error)	0.032 (0.026)		1.23	0.219
percentbc (standard error)	0.044 (0.041)		1.07	0.285
percentblack (standard error)	-0.014 (0.011)		-1.32	0.188
percenthisp (standard error)	0.011 (0.013)		0.86	0.391
percentasian (standard error)	0.011 (0.022)		0.50	0.616
percentunion (standard error)	-0.009 (0.025)		-0.35	0.725
year17 (standard error)	0.230 (0.378)		0.61	0.543
year16 (standard error)	-0.643 (0.373)	*	-1.72	0.086
year15 (standard error)	0.517 (0.380)		1.36	0.174
year14 (standard error)	0.525 (0.382)		1.37	0.170
year13 (standard error)	-0.716 (0.375)	*	-1.91	0.057
year12 (standard error)	0.134 (0.374)		0.36	0.720
Constant (standard error)	-1.433 (1.975)		-0.73	0.469

Significance-level: one-percent --***, five-percent -- **; ten-percent -- *
N = 357, R^2 = 0.1405, F-statistic = 3.99

Table 11: Multivariate Regression Results of Model 4

Variable	Coefficient	Significance level	t-statistic	p-value
apprenttaxcredit (standard error)	-0.459 (0.304)		-1.51	0.132
lagstateGDPgrowth (standard error)	0.205 (0.050)	***	4.09	0.000
percentpostsecondary (standard error)	0.020 (0.028)		0.70	0.486
percentbc (standard error)	0.033 (0.042)		0.79	0.433
percentblack (standard error)	-0.020 (0.012)	*	-1.73	0.085
percenthisp (standard error)	-0.002 (0.016)		-0.15	0.882
percentasian (standard error)	0.098 (0.067)		1.46	0.145
percentunion (standard error)	-0.032 (0.031)		-1.04	0.297
year17 (standard error)	0.172 (0.385)		0.45	0.656
year16 (standard error)	-0.718 (0.373)	*	-1.89	0.059
year15 (standard error)	0.477 (0.385)		1.24	0.216
year14 (standard error)	0.542 (0.387)		1.40	0.162
year13 (standard error)	-0.721 (0.380)	*	-1.90	0.059
year12 (standard error)	0.115 (0.379)		0.30	0.762
Constant (standard error)	-0.473 (2.101)		-0.23	0.822

Significance-level: one-percent --***, five-percent -- **; ten-percent -- *
N = 350, R^2 = 0.1459, F-statistic = 4.09

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