Economic Growth in US Metropolitan Areas: The Effect of College Major

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Abstract: A series of papers show a positive relationship between educational attainment and growth. Although it is clear that higher levels attainment (measured as the percentage of the labor force with a bachelor's degree or more) is positively associated with growth, undergraduate education quality may vary greatly across different fields of study. Indeed, average income varies considerably based on field of study. Moreover, the size of spillover effects may also vary by the type of training individuals receive. Consequently, we use panel data on US metro areas to examine the effect of degree type on growth. We correct for endogeneity using data from historical mines and 30-year lags on attainment.

I. Introduction

There is little debate about the importance of educational attainment for economic growth. A rather extensive literature supports the claim that higher educational attainment leads to more economic growth. Although there is a general consensus that higher average educational attainment causes faster GDP growth, there is little analysis of the impact of educational quality on growth. However, quality may be as important as quantity if it allows us to produce faster growth with lower investment. One key aspect of quality is the nature of training at the baccalaureate level. Indeed, the nature of training at the baccalaureate level varies dramatically by degree program.

A 2014 survey conducted by PayScale measured career earnings for college graduates, disaggregated by major. The survey found that all of the majors in the top 10 ranks on starting salaries and mid-career salaries were STEM majors. Although we may use individual-level wage data to identify the marginal product of labor by college major, individuals with higher educational attainment could produce knowledge spillover effects. Given these positive externalities, their contributions to economic growth would not be captured by wage data alone. In addition, some majors are more applicable to jobs that are in high demand than others. By measuring the impacts of major type on economic growth of the metropolitan area, we may capture the full benefit (including knowledge externalities) from varying degree types.

Because it is highly plausible that some majors provide more economic value than others, policymakers in states like Florida argue that tuition should vary by major. In 2012, Governor Rick Scott advocated that Florida state universities lower tuition for more “job-friendly” majors such as engineering or biotechnology, and raise tuition for humanities majors (Alvarez 2012). Scott argued that educational investment should be directed towards majors that are more productive because taxpayers are subsidizing the education costs. North Carolina Governor Pat McCrory made a similar argument, suggesting that subsidies to majors like gender studies should receive lower subsidies because of their weak employment prospects (Kingkade 2013). Even President Barack Obama joked about employment prospects for art history majors, explaining, “Folks can make a lot more, potentially, with skilled manufacturing or the trades, than they might with an art history degree” (Eliperin 2014). With both prominent Democrats and Republicans sharing skepticism over the economic value of non-STEM degrees, it is likely that legislation may be proposed to either increase subsidies towards STEM degrees, or decrease subsidies to non-STEM degrees.

Understanding the quality of education is vital in guiding the allocation of scarce resources towards sound education investments. With college costs rising rampantly, and states facing tightening budget constraints, the need for more productive higher education spending is a highly pressing issue. The ultimate goal of this paper is to quantify the impacts of differing college majors on economic growth. If the findings in this paper show that STEM majors have a much greater impact on growth than non-STEM majors, it could provide evidence supporting the claim that some degrees are a better investment for the public than others.

II. Review of Literature

Literature relevant to the research question includes the impacts of knowledge spillovers on growth, and the impacts of education quality on economic growth. Because students with different degree types will obtain different kinds of knowledge, different college majors should have differing levels of knowledge spillover effects. It is also important to understand the effects of college education on growth, however the literature on this topic largely analyzes levels of college attainment with no measures of education quality.

Lucas (1988) claims that economic growth is the result of human capital spillovers between workers. He argues that human capital improves marginal productivity through knowledge spillovers because workers learn from the methods of other workers in production lines. This kind of spillover effect is most noticeable in assembly-line production. Lucas realized that workers are faced with the regular introduction of new goods. Since firms may often implement new goods into production lines, spillover externalities may be cyclical. This means that the introduction of new products is correlated with an increase in knowledge about the production of that product and knowledge externalities associated with older products experience diminishing returns.

Glaeser et al. (1992) finds that cities with more diversity of industries with greater competition grew faster than others, suggesting that knowledge spillover effects from one industry to another were stronger than spillovers within one industry or one firm. Lin (2011) finds that younger, more educated workers are more likely to find new work than older, less educated workers. In addition, he finds that new work is most prevalently located where there is a greater proportion of college graduates and greater industry diversity. The findings in Lin (2011) seem to provide a link to the spillover benefits of diverse industry cities found in Glaeser (1992) and prior literature suggesting greater educational attainment in cities leads to greater spillovers. Essentially, it can be interpreted that college graduates allow for growth in diversity of industry due to their ease of adoption in new work, and the result is greater growth in cities.

Moretti (2004) attempts to measure these knowledge spillovers that may occur as a result of greater educational attainment of the labor force. In a cross-section of metropolitan regions, the paper analyzes the impacts of greater educational attainment on wage growth for those with less educational attainment. The results show that areas with higher proportions of college graduates experienced significantly greater wage increases than areas with lower levels of college graduates. Specifically, the analysis finds that a one percentage-point increase in the number of college graduates raises wages for high school dropouts by 1.9 percent, high school graduates by 1.6 percent, and college graduates by 0.4 percent.

Rosenthal (2008) attempts to capture wage spillover effects of higher levels of human capital based on geographic distances using geographic software to measure the spatial employment concentrations of higher and lower skilled workers. The paper concludes that wages of individuals in closer proximity to higher-educated workers experience greater wage growth, suggesting that there are benefits to high-skilled agglomeration and knowledge spill over effects are significant.

Just as spillovers may affect wages, they may also affect career choices. Ehrenberg (2004) analyzes the determinants of a student's college major choice. In addition to supporting the claim that spillovers benefit less-educated individuals, he shows that individuals decide on college majors based on local economic opportunities, and the gender composition of the opportunities.

A series of papers also examine the determinants of growth using cross-sectional data (Glaeser et al. 1995; Shapiro 2006; Hanushek 2007; Barro 2001; Lin 2004). Glaeser et al. (1995) attempts to capture the major drivers of economic growth in a cross-section of cities. The model assumes the utility of living in a city is measured by quality of life (traffic congestion, housing costs, etc.) and wage opportunities and allows free migration across cities. Under such conditions, Glaeser et al. (1995) shows that population growth may initially reduce the quality of life for migrants. This may occur because it takes time to build necessary public goods to accommodate the increased population growth. Glaeser et al. (1995) use lags of 1960 data for education quantity as an instrument to measure the effects of education quality on growth from 1960-1990. He finds that the percent of city populations with 16 or more years of schooling had a positive, significant effect on standard metropolitan statistical area (SMSA) output.

Shapiro (2006) uses panel data from 1940 to 1990 for U.S. metro areas to examine the impact of higher educational attainment on economic growth as measured by employment growth. Because areas that are growing faster may attract migrants, Shapiro controls for endogeneity. Shapiro uses an instrument to predict where migrants and firms will locate based on changes in land prices within SMSA's. In addition, Shapiro (2006) creates an instrument to predict higher education attainment in SMSA's based on indicator variables for regions that received college land grants for college institutions. The results show that a 10 percent increase in the number of college educated residents increased employment by 0.8 percentage points.

Hanushek (2007) takes issue with Shapiro and others who analyze the effects of educational attainment on growth and ignore the effects of education quality on growth. He claims that knowledge and skills are more important than the length time enrolled. Using panel data, Hanushek analyzes the effect of education quality, as measured by standardized test scores, on economic growth. Hanushek uses 1960 test score data as an instrument to explain changes in economic output from 1960-2000 across countries. He finds the effects of education quality are much stronger than the effect than education attainment. A one standard deviation increase in test scores resulted in a two percentage point increase in GDP per-capita.

In a similar analysis, Barro (2001) uses data from 100 countries over the period 1965-1995 to analyze the effects of education quality, as measured by test scores, on growth. A key concern is that faster growth may cause higher educational attainment or better quality. To prevent this endogeneity, Barro (2001) used lagged education levels as an instrument to explain the impacts of educational attainment on economic growth. The analysis also controls for GDP per-capita level, a rule of law index and government consumption as a share of GDP. The estimate predicts that for every additional year in educational attainment, economic growth will increase by 0.44 percent annually, before accounting for quality measures. When Barro (2001) includes independent variables for educational quality, the effects of education attainment become statistically insignificant. In addition, the effects of education quality on growth are significant and large in magnitude.

Lin (2004) analyzes time-series data for Taiwan to measure the impacts of educational attainment and the nature of post-secondary education (using college major data) on economic development. To account for the effects of different majors on growth, he regresses the change in growth on the changes in graduates, by degree type. The paper found that for every additional percentage point of higher education stock, the economy expanded 0.19 percentage points. In addition, the paper found that STEM majors had a greatest influence on growth as compared to the other majors, such as humanities, which had no significant correlation with growth. However, the conclusion is based on a time series analysis of only one location, and the endogeneity correction may be insufficient. Nonetheless, Lin (2004) is one of very few papers that disaggregate college graduates by type major in explaining growth, thus the results are worth noting.

Coughlin (2013) found that STEM majors had a significant, positive association with growth and per-capita income levels in metropolitan areas, while education majors had a significant negative association with growth. However, the data only spanned from 2009-2011, and the analysis included no correction for endogeneity.

III. Data, Methods and Hypothesis

The dataset is a panel from 285 SMSA's over five years. The dataset was constructed by extracting data on the percent of populations with bachelor's degrees, decomposed by degree type from 2009-2013 for each SMSA from the American Community Survey (ACS). Data on the unemployment rate, labor force participation rate, GDP, and GDP share of exports by SMSA is from the Department of Commerce, Census Bureau, and BEA, respectively. Finally, we collect 1980 census data on total bachelor's degree holders, and historic mine locations from Harvard Dataverse for use as instruments. We use these data as instruments because Glaeser (2013) found that the counts of mines within a fixed radii of SMSA centroids had long-lasting effects on industry composition. Since spatial counts of historic mines have long lasting effects on industry composition, they likely have a strong influence over the specific types of degrees that industries within SMSA's may attract.

Because we use changes in GDP growth as our control, we use changes as our independent variables. We begin by generating changes in total bachelor's degree holders, STEM degree holders, and non-STEM degree holders. We then lag these variables by one year to capture their effects on growth in the following year. Next, we generate changes in unemployment and labor force participation, as changes in employment and labor force participation are important determinants of growth. We then add per-capita GDP levels, which may be correlated with growth as explained by convergence theory, suggesting that SMSA's with lower per-capita income levels will grow faster than richer SMSA's.

Since variations in exports may also affect growth, we use export share of GDP as a measure to control for economic growth attributed to foreign trade markets. We also use an indicator variable for SMSA's in the east, including all MSA's within Maine, Florida, Pennsylvania, New Jersey, Massachusetts, Vermont, New Hampshire, Maryland, Virginia, North Carolina, South Carolina, and Georgia. We found that the "east" dummy variable was highly significant in most growth regressions. Since the estimates for the lagged changes in college graduates could be affecting the estimates in the following year for per-capita GDP levels, share of exports, change in unemployment rate, change in labor force and change in black population, we also lag the aforementioned control variables by one year. Finally, we include dummy variables for the year 2011 and 2012, as our final growth equation only includes 2011-2013.

Because the literature finds stronger associations with income and growth for STEM majors relative to non-STEM majors. We predict that the causal relationship between STEM majors and growth will be significant and stronger than the causal relationship between non-STEM majors and growth. Following neoclassical wage theory the marginal product of labor is equal to the wage, we expect STEM degree holders to be more productive because STEM degree holders tend to have higher wages. The higher productivity of STEM majors should result in greater effects on growth. This basic theory does not include knowledge spillovers, which will cause marginal product of labor to exceed the actual wage. Although knowledge spillovers may exist for non-STEM degree holders, these spillovers would have to be substantially greater than those of STEM degree holders to make up the difference in wages.

Although we expect changes in degree holders to have a causal effect on growth, strong growth prospects in SMSA's may cause migration of skilled workers. It is plausible that growth in SMSA's might have caused the changes in the levels of degree holders within SMSA's, thus raising concerns for endogeneity. This means that the uninstrumented results fail to show the causal relationship between changes in degree holders and growth. To correct for endogeneity, we use 1980 educational attainment data. We found that the 1980 levels of individuals with at least a bachelor’s degree was highly significant and positively correlated with current levels of bachelor’s degree holders. It appears that SMSA’s with greater levels of individuals with at least a bachelor’s degree in 1980 accurately predicts the levels of bachelor’s degree holders from 2009-2013.

Our method to correct for endogeneity is two-stage residual inclusion. We begin by predicting the levels of bachelor’s degree holders within SMSA’s by using the 1980 bachelor’s degree holders as the instrument. We add the other controls for economic growth in the regression to predict the levels of degree holders. We then generate the residuals from the first stage prediction equation. Since our key independent variable is changes in the percent of population with a bachelor’s degree, we then calculate the changes in residuals as our control for endogeneity. In the second stage, we first take the actual lagged actual changes in bachelor’s degree holders and add the change in the predicted residual to the regression. Finally, we add the additional growth controls to the equation, then regress it on GDP growth.

We follow up by disaggregating total bachelor’s degree holders into STEM and non-STEM majors. With the one-year lag of changes in STEM and non-STEM majors as our key independent variables, we regress them on GDP growth, including control variables listed above. In this case, we expect the lagged STEM degrees to have a significant, positive correlation with growth. We also expect non-STEM degree to be either insignificantly correlated with growth, or positively correlated with weaker effect than STEM degrees.

To correct the disaggregated model for endogeneity, we need two instruments to exogenously predict the levels of STEM majors and non-STEM majors within SMSA's. We use levels of 1980 bachelor's degree holders and the spatial counts of copper mines within 500 miles of SMSA centroids as our instrument variables. We regress the two instruments and growth controls on STEM majors and non-STEM majors, then predict the residuals from both equations. Finally, we calculate the changes in residuals for both STEM and non-STEM degrees, and use them as our controls for endogeneity in stage two.

IV. Results

From Table 1, we see that the dependent variable, GDP growth ($[GDP_{it}-GDP_{i[t-1]}] \div GDP_{i[t-1]}$) has a sizeable variation with a mean growth rate of 3.5 percent, and a standard deviation of 3.03 percent. The means for percent bachelor's, percent STEM and percent non-STEM levels also vary considerably across SMSA's. The variation in total bachelor's degree holders suggest that some SMSA's may have far higher human capital levels than others, and variation in STEM and non-STEM degree holders may be due to specialization of industries in SMSA's. We find that the mean changes in bachelor's degree holders, STEM and non-STEM majors was positive, indicating growing numbers of college-educated students over time. We also find that the changes in bachelor's degree holders are almost evenly split between the two degree types. We also see great variations in changes in unemployment and labor force participation rates. The changes in unemployment and labor force rates are likely to due the volatility of the economy from 2009-2013. Finally, we see large deviations in the spatial counts of mines because clusters of mines are located near natural deposits.

To determine the effect of educational attainment and degree type, we run two basic regression specifications. The first specification only includes changes in the percentage of the population with a bachelor's degree. The second specification disaggregates the percentage of the population with a bachelor's degree into changes in STEM degrees and changes in non-STEM degrees. As with the first specification, we run both instrumented and non-instrumented versions. In each specification, we also include controls for change in unemployment rate, change in labor force participation rate, per capita GDP levels, total bachelor's degree holders, export share of GDP, east dummy variable, year dummies for 2011 and 2012, and same year changes in degrees as controls for growth. We expect the sign for lagged changes in bachelor's degree holders to be significant and positive.

The results from the first stage regressions appear in Table 2 while the results for the second stage appear in Table 3. In column 1 of Table 3 we see that uninstrumented regression measuring the effect of the lagged changes in bachelor's degree holders on growth shows that the estimate for changes in bachelor's degrees is positive and significant at the .05 level (Table 3). The estimate shows that a 1 percentage-point increase in bachelor's degree holders increases GDP growth by an average of .112 percentage points one year later. Controls show insignificant estimates for change in labor force, change in unemployment, year dummy variables and GDP share of exports. SMSAs located in the "east" grew significantly slower SMSAs with higher per capita GDP levels grew faster.

Column 3 of Table 3 repeats the specification in column 1 but instruments for changes in bachelor's degrees. The first-stage estimates for this specification appear in column 1 of Table 2. To predict the levels of bachelor's degree holders within SMSA's, we use 1980 college graduate levels as our instrument, and we find it is strongly positively correlated with levels of college graduates. With a t-statistic of 36.2, we easily clear the rule of thumb for statistical significance of instruments. We also find that some of the growth controls are significantly correlated with the levels of college graduates. Strong positive correlations include per capita GDP, GDP share of exports and SMSA's located in the "east." A significant negative correlation exists for lagged change in unemployment rate. After generating the residuals from the prediction equation, we also generate the changes in residuals to match the nature of our key independent variable.

In the second stage regression, we ran the instrumented changes in bachelor's degree holders on growth. In this regression, we include the changes in predicted residuals as our control for endogeneity. We find that the lagged change in degree holders is still significant at the .05 level, with minimal change from the column 1 estimate. The estimate again shows that a 1 percentage-point increase in bachelor's degree holders increases growth by an average of .112 percentage points one year later. Estimates from the other control variables show little change compared to the uninstrumented estimates in column 1.

We then disaggregate degrees into STEM and non-STEM degrees. Column 2 of Table 3 reports the uninstrumented estimates for the effect of STEM and non-STEM degrees on growth. In each case (STEM and non-STEM degrees), the estimates are significant at the .05 level. The uninstrumented estimate for STEM majors indicates that every 1 percent increase in STEM majors leads to a .176 percentage point increase in GDP growth and the estimate for non-STEM majors is .143. It should be noted that the uninstrumented difference of STEM and non-STEM estimates on growth is not of a large magnitude, and not economically significant. Per-capita GDP levels, SMSA's in the "east" and the year dummy for 2011 were significantly correlated with GDP growth.

Although we obtained statistical significance in the uninstrumented regression, endogeneity may be weakening the causal estimates for STEM and non-STEM degrees. To test for this, we begin our two-stage residual inclusion by creating prediction equations for STEM and non-STEM degrees. We run first stage regressions using the counts of copper mines within 500 miles of SMSA centroids and the percentage of the labor force with a bachelor's degree in 1980 as instruments. The results appear in columns 2 and 3 of Table 2. In both equations, the estimate for 1980 bachelor's degree holders is positive and strongly significant; for STEM majors the t-statistic is 32.7 and for non-STEM majors it is 25.0. The copper mine instrument is also a strong predictor for both degree types. For STEM degree holders, it is positive and strongly significant with a t-statistic of 3.9, and for non-STEM degree holders, it is negative and strongly significant with a t-statistic of -5.0. In the case of both STEM and non-STEM prediction equations, many of the growth control variables were statistically significant as they did in the prediction equation for levels of college graduates.

After successfully generating prediction equations for total college graduate levels, STEM and non-STEM degree levels, we generate the residuals from each equation, and calculate the changes in predicted residuals for STEM and non-STEM. We then essentially run the same equation as we did in the uninstrumented case, but add the changes in residuals for STEM and non-STEM degree holders. The results appear in column 4 of Table 3. From column 4, we see that lagged changes in STEM degrees have a positive and significant effect on GDP growth at the 0.05 level. The estimate suggests that a 1 percentage-point increase in STEM degree holders, on average, increases growth by .197 percentage points in the following year. The results also show that while lagged changes in non-STEM degrees are not statistically significant, so that every 1 percent increase in non-STEM majors results in a .110 percentage point increase in economic growth. It appears that controlling for endogeneity has strengthened the estimate for STEM majors, and decreased the estimate for non-STEM majors. The difference in the instrumented STEM and non-STEM growth estimates is .0865. This suggests that a 1 percent increase STEM majors generates .0865 percentage points more in GDP growth than a 1 percent increase in non-STEM majors. Unlike the uninstrumented specification, the instrumented specification suggested that STEM majors had a greater positive impact on growth than non-STEM majors. Like the estimates for total degree holders reported in columns 1 and 3, the estimates for the growth controls did not change much from the uninstrumented specification.

V. Conclusion

The results in our paper are consistent with the findings in the literature for the effects of college graduates on economic growth. Increases in the percentage of the population with bachelor's degrees had a statistically significant, positive correlation with growth in both the uninstrumented and instrumented models. The effects for changes in degree holders also appears economically significant, as a 1 percentage point increase in college graduates led to a .112 percentage point increase in GDP growth in the following year. Although .112 percentage points may not seem like much on the surface, compounding and additional .112 percent of GDP growth over the course of several years can make a city richer. These results may also lack long-lasting gains from changes in college graduates, which can be captured over a greater time series. In that case, we would expect the estimates to show greater statistical significance.

The ultimate goal of this paper was to answer the question of whether or not STEM and non-STEM majors had varying education quality, based on growth estimates. In the uninstrumented model, both STEM nor non-STEM degrees appeared to had a significant effect on growth, however those estimates may have been affected by endogeneity. However, after we control for endogeneity, we found the estimate for lagged changes in STEM degree holders was positive and significant at the .05 level, while lagged changes in non-STEM degree holders was insignificant. The estimate of the effect of STEM majors on growth was of far greater magnitude than that of non-STEM degree majors. We believe this difference in magnitude is economically significant. The findings of positive statistical significance for STEM majors lines up with our hypothesis. Our hypothesis was also accurate in predicting a greater effect for STEM majors on growth than non-STEM majors.

The findings in this paper may not come as a surprise to politicians who claimed that STEM degrees are far more economically beneficial to society than non-STEM degrees. We found that the instrumented effect of an STEM majors was over 75 percent greater than that of non-STEM majors. This paper provides evidence that STEM majors have a more economically significant effect on growth than non-STEM majors, and thus these results may support claims that subsidies for higher education ought to be directed away from non-STEM degrees and towards STEM degrees. The findings of this paper do not conclude that non-STEM degrees are not at all useful, but rather the economic benefits of non-STEM degrees are less than that of STEM degrees. Some may argue that non-STEM degrees help individuals become more fluid readers, or more eloquent writers, and that may be true. Although non-STEM degrees may hold some immeasurable values, it should also be noted that economic growth is the ultimate determinant of our living standards.

It is highly plausible that education quality varies greatly from one STEM degree to another, or one non-STEM degree to another. There appears to be great heterogeneity for both, as STEM degrees include everything from engineering, to social sciences, to mathematics, and beyond, while non-STEM degrees may include communications, education, business, and philosophy. The fields of study mentioned above vary greatly in terms of the type of training students may receive. As data becomes more readily available, it may be possible to measure the effects of more specific degrees. If we were able to disaggregate even further, we may find that some of the non-STEM degrees have a stronger effect on growth than some of the STEM degrees, or, perhaps that a few less productive non-STEM degrees are pulling down the estimate for all non-STEM degrees on growth.

Another constraint was the lack of years in the data of disaggregated college degrees within SMSA's. The American Community Survey currently only has this data from 2009-2013. Once we difference years to find changes, and lag the changes by one year, we are left with only three years of panel data. It is possible that a longer time series of panel data could strengthen the estimates, or perhaps allow for a different method of statistical measurement to get stronger results. In addition, studies like Moretti (2004), which analyzed spillovers of college graduates onto lesser skilled workers, may be conducted for disaggregated degrees to capture the magnitude of the spillovers from one degree type to another.

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VII. Tables

Table 1: Summary Statistics of Key Variables from 2009-2013

Variable Name	Obs	Mean	Std. Dev.	Min	Max
GDP Growth	1320	1.868344	3.334831	-8.589676	43.03458
GDP	1671	37838.56	101899.6	1918	1471170
Percent Bachelor's	1391	26.44472	7.989127	11.3	59.1
Percent STEM	1391	11.44185	4.555202	4.31461	34.07839
Percent Non-STEM	1391	15.00169	3.844004	5.775528	29.48893
Change Labor Force	1751	-0.3373501	1.882791	-17.7	9
Change Unemployment	1751	-0.236265	2.627243	-11.1	9.000001
Change Percent Bachelor's	1106	0.2845389	1.688595	-7	5.5
Change STEM	1106	0.1250565	1.119545	-10.2617	4.552084
Change Non-STEM	1106	0.1613492	1.289564	-4.937118	6.497267
1900 Copper Mines	1391	307.563	303.2993	1	1557
Percent Bachelor's 1980	1391	9.245725	2.943116	4.430593	20.68802
GDP Share of Exports	1669	8.195572	9.423459	.1342517	86.92171

Variable Name	Explanation
GDP_{it}	GDP in Millions of 2014 dollars for Metro Area i in Year t (BEA)
GDP $Growth_{it}$	GDP Growth for Metro Area i in Year t $(GDP_{it} – GDP_{i[t-1]}) \div (GDP_{i[t-1]})$ (BEA)
Percent $Bachelor's_{it}$	Percent of Population with at least a Bachelor's Degree for Metro Area i in Year t (ACS)
Percent $STEM_{it}$	Percent of Population with a STEM Degree for Metro Area i in Year t (ACS)
Percent $Non\text{-}STEM_{it}$	Percent of Population with a Non-STEM Degree for Metro Area i in Year t (ACS)
Change Labor $Force_{it}$	Change in Labor Force Participation Rate for Metro Area i in Year t (ACS) (Labor Force $Rate_{it}$ - Labor Force $Rate_{i[t-1]}$)
Change $Unemployment_{it}$	Change in Unemployment Rate for Metro Area i in Year t (ACS) (Unemployment $Rate_{it}$ - Unemployment $Rate_{i[t-1]}$)
Change Percent $Bachelor's_{it}$	Change in Percent Bachelor's for Metro Area i in Year t (ACS) (Percent $Bachelor's_{it}$ - Percent $Bachelor's_{i[t-1]}$)
Change $STEM_{it}$	Change in Percent STEM for Metro Area i in Year t (ACS) (Percent $STEM_{it}$ - Percent $STEM_{i[t-1]}$)
Change $Non\text{-}STEM_{it}$	Change in Percent Non-STEM Degree for Metro Area i in Year t (ACS) (Percent $Non\text{-}STEM_{it}$ - Percent $Non\text{-}STEM_{i[t-1]}$)
1900 Copper $Mines_{it}$	Total Count of Copper Mines in 1900 within 500 mile radius of MSA centroid for Metro Area i (Harvard Dataverse)
Percent Bachelor's 1980_{it}	Percent of Population with at least a BS degree for Metro Area i in year 1980 (ACS)
GDP Share of $Exports_{it}$	Exports as a Share of Metro Area GDP for Metro Area i in Year t (Commerce Department)
$East_{it}$	Dummy Variable for Metro Areas in ME, FL, PA, NJ, MA, VT, NH, MD, VA, NC, SC or GA for Metro Area i

Table 2:

Stage 1: Prediction Regressions for Total Bachelor’s, STEM, and Non-STEM degree Holders
Independent Variables in Top Row

Variable	Percent Bachelor's	Percent STEM	Percent Non-STEM
Change Unemployment Lag	-0.0786832**	-.0359591*	-0.0442759**
	(0.0334175)	(0.0192130)	(0.0204154)
Change Labor Force Lag	0.0613888	.0262081	0.0339248
	(0.0723173)	(0.0441580)	(0.0419436)
Per Capita GDP Lag	0.0001478***	.0000599***	0.0000872***
	(0.0000172)	(0.0000095)	(0.0000104)
Year 2011 Dummy	-0.0397895	-.0368237	-0.0026612
	(0.2672151)	(0.1635167)	(0.1614560)
Year 2012 Dummy	0.1003286	.0633329	0.0364744
	(0.2825997)	(0.1675717)	(0.1665749)
East	1.113831***	.7825196***	0.3050984***
	(0.22)	(0.1332628)	(0.1330539)
GDP Share of Exports Lag	.03196807***	.02763793***	.003621851
	(1.0153020)	(0.5867173)	(0.6431178)
1900 Copper Mines		.2208529***	-0.3317373***
		(0.0562439)	(0.0663478)
Percent Bachelor's 1980	2.103721***	1.234606***	0.8757424***
	(0.4081519)	(0.0377365)	(0.0350162)
Constant	4.0349588	-4.016855***	4.988136***
	(0.6386587)	(0.5862760)	(0.5508914)
R^2	0.7826	0.7790	0.8220
N	1080	1080	1080
* >= 90% Statistical Significance ** >= 95% Statistical Significance *** >= 99% Statistical Significance			

Table 3:

Effects of Total Bachelor’s Degree Holders, STEM and non-STEM Majors on Growth
Independent Variable of GDP Growth

	Uninstrumented		Instrumented	
Variable	GDP Growth	GDP Growth	GDP Growth	GDP Growth
Change Percent Bachelor's Lag	0.1124053**		0.1122896**	
	(0.0522303)		(0.0522068)	
Change STEM Lag		.1765033**		0.1965216**
		(0.0859649)		(0.0925966)
Change Non-STEM Lag		.1434400**		0.1100202
		(0.0692392)		(0.0790074)
Change Unemployment Lag	-0.0659925	-.059641	-0.066309	-0.0666089
	(0.0539478)	(0.0542186)	(0.0542428)	(0.0541857)
Change Labor Force Lag	-0.0143163	-.0132241	-0.019969	-0.0161385
	(0.0489480)	(0.0486030)	(0.0493681)	(0.0488851)
Per Capita GDP Lag	0.0000215**	.0000205**	0.0000222**	0.0000222**
	(0.0000100)	(0.0000100)	(0.0000099)	(0.0000100)
Year 2011 Dummy	-0.6039319	-.6323561*	-0.5928627	-0.5835257
	(0.3696906)	(0.3723703)	(0.3704650)	(0.3709782)
Year 2012 Dummy	0.4526343	.4294499	0.4478527	0.4567058*
	(0.2763644)	(0.2781037)	(0.2758912)	(0.2761443)
East	-1.036924***	-1.058008***	-1.020822***	-1.029954***
	(0.2209397)	(0.2215665)	(0.2194158)	(0.2210881)
GDP Share of Exports Lag	.02217791	.02213356	.02217475	.02208457
	(1.6233570)	(1.6290820)	(1.6139460)	(1.6246210)
Constant	1.047875*	1.112064**	1.012067*	1.000792*
	(0.5469573)	(0.5502718)	(0.5462715)	(0.5485205)
R^2	0.0753	0.0785	0.0750	0.0782
N	802	802	801	801
* >= 90% Statistical Significance ** >= 95% Statistical Significance *** >= 99% Statistical Significance				