What Causes Manufacturing Productivity to Vary from Place to Place?

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I. Introduction

What causes manufacturing productivity to vary from place to place? This study will attempt to answer that question. First, *does* manufacturing productivity vary from place to place? The places used in this study will be Metropolitan Statistical Areas (MSAs). In 1997, the highest MSA productivity rate was $323 per production worker hour and the lowest was $27 per production worker hour. The highest MSA was twelve times more productive than the lowest. This is a huge difference.

Why does this matter? An area that has a higher productivity rate will have higher incomes, which leads to a better economy. An area with a better economy will be a better place to live overall. The area's costs will be lower and local companies will obtain higher profit margins.

What causes productivity to vary? Through a literature review, many variables were found to affect productivity. The most important variables are capital stock, education, agglomeration economies, unionization, skill level, and industry mix. Data will be compiled for each of these variables and regression analysis will be used to determine the effects on productivity.

The first part of this paper will look at the theory behind the variables and the data used to measure the different variables. Next, descriptions of each variable will be discussed. The methodology used will be explained and the results examined. Finally the paper will conclude with policy implications and future research suggestions.

II. Theory and Data

A. Productivity

Productivity a measure of the amount of output produced per an input. This can also be stated as output divided by input or output/input. The most common productivity measure is labor productivity or output per worker hour. This is the measure of productivity used in this study.

The U.S. Bureau of Labor Statistics (BLS) is the major provider of productivity data. Their measure of productivity for the nation uses Gross Domestic Product for the output over a one year period. The input used by the BLS is the hours required to produce the output for that year.[1]

There are currently no data available on total output at the MSA level. The U.S. Conference of Mayors produces a measure of Gross Metropolitan Product for each MSA, but it is not separated into industry categories.[2] Since manufacturing output cannot be extracted from these data.

MSA level output data are available from the Economic Census, which the U.S. Census Bureau conducts every five years, years ending in two or seven. The most recent data available are for 1997. The census of manufacturing provide data at the sub-state level for various data, including value added, value of shipments, number of production workers, and hours worked.[3] A different measure of output must be used. It was determined that value-added would be the best measure of output. This is the dollar amount for which the manufacturer sold the product minus the costs of inputs needed in making the input. The measure of input used in this study is the same as that used for the BLS national data, the number of worker hours.

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[1] U.S. Bureau of Labor Statistic. "Overview" Available online at: http://www.bls.gov/lpc/lpcover.htm#Output

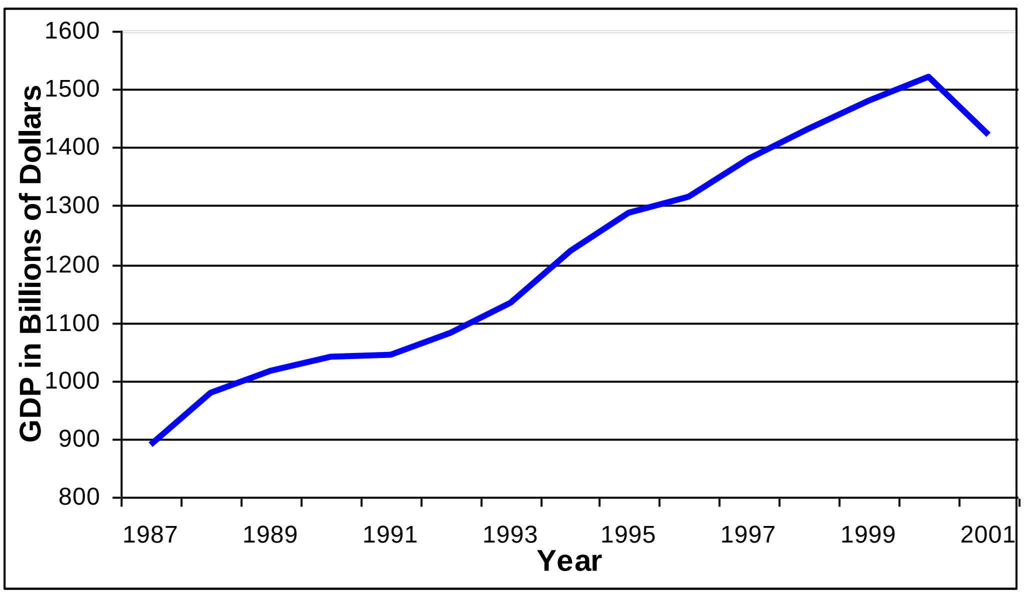
[2] Hammill, Mike. "Productivity Growth of Erie Manufacturing Through Time" (2003)

[3] U.S. Census Bureau. "Manufacturing General Subject Series EC97M31S-GS, Table 2-2, Industry Statistics for Metropolitan Areas – 1997. Available online at: http://www.census.gov/prod/ec97/97m31s-gs.pdf.

B. The Year 1997

The year 1997 was chosen for this spatial study because the crucial productivity data came from the 1997 Economic Census.[4] Data availability is the primary reason that 1997 was chosen. The 1997 manufacturing data were not released until 2001 and are the most current. Graph 1 presents data on GDP in manufacturing, to let us consider whether 1997 was a "typical" year or whether something unusual was happening that year. It shows that there were no unusual events, such as price shocks in 1997[5] and that year is also not at a peak or trough in the business cycle. Presumably 1997 data would be representative of other years, then.

Graph 1
GDP in Manufacturing



C. Education

One variable that is generally thought to be important to productivity is education level of workers in an area. It would be assumed that the more education an individual has, the more productive he or she would be. He/She would be able to learn quicker,

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[4] U.S. Census Bureau. "Manufacturing General Subject Series EC97M31S-GS, Table 2-2, Industry Statistics for Metropolitan Areas – 1997. Available online at: http://www.census.gov/prod/ec97/97m31s-gs.pdf.
[5] U.S Bureau of Economic Analysis. "Gross Domestic Product by Industry in Current Dollars, 1987-93." Available online at: http://www.bea.gov/bea/dn2/gpoc.htm

retain more information and be able to do more difficult tasks. This research project will attempt to determine if this is actually true. Does having a high school diploma make a manufacturing worker more productive? Also it will examine if higher levels of educational attainment, such as a college degree, affect productivity. Does it affect productivity more, less, or the same as a high school diploma? Have no effect at all?

Many of the previous research studies on productivity have used an education variable as a determinant of productivity. Beeson and Husted (1989) looked at the percent of population with a high school diploma at the state level using all industry categories. Beeson (1987) also used this measure in an earlier work. Brock (2001) examines the effect of education on productivity for the population over 25 years old with a high school degree and percent with a college degree. Moomaw and Williams (1991) used a different approach with the education variable; they determined the percentage of manufacturing workers with 12 or more years of schooling. All of the studies above have supported the idea that education does play a positive role in manufacturing productivity or productivity in general. Domazlicky and Weber (1998) stated that many researchers have used different types of variables to measure education and the results are all positively related to productivity. The only discrepancy to mention is Brock's study; he used two variables, high school diploma and also college degrees. Surprisingly, he found that a high school diploma increased inefficiencies.

Most of the educational data above were examined on the state level using all industry categories, although Moomaw and Williams were able to use education data for only the manufacturing industry. Unfortunately, the source of Moomaw and Williams' data is not clear from their article.

We hypothesize that the variable that would best measure the impact of education on manufacturing productivity would be the average years of education of manufacturing workers for a given MSA. Unfortunately, these data are not available. As a result, many different options were explored. The U.S. Department of Education website was examined but did not contain the data needed for this project. Also the *State and Metropolitan Area Data Book*[6] was reviewed, but the only data found there were the

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[6] U.S. Department of Commerce. "*State and Metropolitan Area Data Book, 1997-1998*." April 1998. Available online at: http://www.census.gov/prod/3/98pubs/smadb-97.pdf

number of people attending public school. These were not the data that would be most relevant for this project. The most useful data found were from the Census Bureau on their Fact Finder website at Census.gov. But the data located on this website are for 1990 and 2000, not 1997. Due to this date problem, the data will be interpolated using the 1990 and 2000 data. Table P060 was used for the 1990 data which is "Educational Attainment - Universe: Persons 18 Years and Over." The data set is 1990 Summary Tape File 3 (STF 3) - Sample data.   Table PCT25 was used for 2000 data which is "Sex by Age by Educational Attainment for the Population 18 Years and Over [83] - Universe: Population 18 Years and Over." The data set used is the Census 2000 Summary File 3 (SF 3) - Sample Data. The education variables used in this study will be: the number of people in an MSA that have less than ninth grade education, ninth to twelfth grade with no diploma obtained, a high school diploma, some college education but no degree, an associate's degree, a bachelor's degree and higher education. The data will be computed as the percent of each MSA's residents that have that particular level of education. The data are available for 273 MSAs for all the education variables. Also a variable will be calculated estimating the average number of years of education attained in a metro area.

D. Agglomeration Economies

A population variable will be used to approximate the effect of agglomeration economies or diseconomies on productivity. Agglomeration economies occur when firms locate near each other in order to lower costs or increase demand for their products. This would mean that several firms would locate in a central location, leading to a larger population. Agglomeration economies are expected to have a positive effect on productivity. If there are more people to choose from, a company can select the most productive workers and specialize its workers.

Previous studies have looked at this variable through state totals in MSA areas. Beeson and Husted (1989) used two variables to determine if agglomeration economies increase productivity. They used percent of the state's population living in MSAs and the total population of the state that is living in an MSA. They found that there was a positive effect between the percentage of the state's population living in an MSA and productivity. But there was a negative relationship between the total population of the state living in MSAs and productivity. For example, if the entire state's population was located in 20 MSAs and each MSA had 1 million people then it would be more productive than a state that had 10 MSAs and 2 million people in each one. These results are linked to the fact that large MSAs may have lower productivity due to overcrowding.

Brock (2001) used only one measure of agglomeration economies, the percent of population that lived in an MSA in the state. Moomaw and Williams (1991) tested for agglomeration using a dummy variable for whether the state had an MSA that was one of the 20 largest in the US. They found that if the state had one of the top 20 largest MSAs its productivity level was higher.

Fogarty and Garofalo (1988) also used MSA population to determine if agglomeration economies increase productivity. They found it to have a positive effect. Fogarty and Garofalo (1988) thought that at some population point, productivity would begin to decrease in an area due to Diminishing Marginal Returns (DMR). To capture DMR, Fogarty and Garofalo (1988) added a variable for the square of population. The results found that there was a positive relationship with productivity and population up to 2.9 million people, but after 2.9 million the effect on productivity was negative. Moomaw (1986) used two variables to measure agglomeration economies or localization. The first variable is the same as other studies, MSA population. The other variable is the employment in several separate industries in the MSA. Moomaw studies separate industries in manufacturing and the results are not consistent with the expectations of this project. The results found by Moomaw (1986) compare the different industry categories for the manufacturing industry with their population size and productivity. Moomaw's study is not directly comparable to this study because we are considering all manufacturing rather than separate industries.

Overall the studies find that agglomeration economies have a positive effect on productivity but this effect could be limited to a certain maximum population amount. This means that at some point, the population will become so large that diminishing marginal returns will take effect. Congestion may occur as an area grows larger causing costs to rise. Therefore this study will adopt Fogarty and Garofalo (1988) approach using variables for population and population squared.

The population data came from the Census of Population in the majority of these studies. The data for this study came from the U.S. Census Bureau webpage.[7]

E. Capital

Capital (physical machinery, place and equipment, not just funds) makes an important contribution to productivity. If a company has the latest technology and the best working machines, of course it is going to be more productive. Machines tend to make fewer mistakes than human labor and can work much faster without breaks. Accounting for capital is essential to understand the difference in productivity from one place to another. This study will attempt to see if this conclusion is really true. If there is more capital, will the productivity level be higher?

Capital is very important in manufacturing and determining productivity. Because of its importance almost every study has taken this determinant into consideration. Moomaw (1986) measured capital using the amount of capital per production worker hour. He found that this measure was positively related to productivity. Moomaw and Williams (1991) used aggregate stock of capital in plant and equipment and then used the perpetual inventory method to get reliable capital data. Their study determined that capital is positively related to productivity. Beeson and Husted (1989) used the same capital data as Moomaw and Williams (1991), which is for the state level. Beeson and Husted's (1989) research study used the data to determine which industry categories were most capital intensive. Because this study is using aggregate manufacturing data over many metro areas, the results of each individual manufacturing category are not relevant.

The majority of the capital data came from a study completed in 1972, which is quite outdated for this study. Another problem with the data is that they are for the state level and not the MSA level. These capital data were presented by the Federal Bank of

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[7] U.S. Census Bureau. "Population Estimates for Metropolitan Areas and Components: 1990 to 1999" Available online at: http://eire.census.gov/popest/archives/metro/ma99-03b.txt

Boston. This study supplied computed capital stock data for the years 1958 – 1976.[8] (citation) The capital stock data are computed by adding the investments of capital for prior years. For each of the investments in capital a deflator was used, so all dollar amounts are in the same base year. Deprecation and obsolescence were taken into consideration and capital stocks were calculated.

According to Domazlicky and Weber (1998), one study with unusual results for the capital variable was Mullen and Williams (1990), who found a negative relationship between capital and productivity. It is odd that capital would be negatively related to productivity. One explanation may be that firms are acquiring capital as a response to government regulations. Another explanation may be that this study used data from the 1970's when there were large increases in energy prices. The source for this data is also different because Mullen and Williams determine the capital growth during the years 1974 to 1978 instead of total capital that was used in previous studies.

The ideal measure of capital could be any one of many different measures. One ideal measure would be total dollars that an MSA has in capital stock. A second ideal measure of capital would be the average dollars of manufacturing capital for each manufacturing employee. Although it would be nice to have these data, they are currently not available at the MSA level.

A measure of capital that will be considered is total capital expenditure in 1997. These data are the measure of all new and used equipment expenditures for permanent additions and major alterations to manufacturing establishments and also machinery and equipment used for replacements and additions to plant capacity. These data, however, exclude some key measures, such as plant and equipment furnished to the manufacturer by communities or non-profit organizations. Another exclusion is the expenditures for land and repairs charged as current operating expenses. The capital data came from Table 2-2 in the Manufacturing General Summary (EC97M31S-GS) in the subject series.[9]

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[8] Federal Reserve Bank of Boston. "Calculation of State Stocks of Manufacturing Capital." *New* England Economic Review. (1980) p. 22-23.

[9] U.S. Census Bureau. "Table 2-2, Industry Statistics for Metropolitan Areas: 1997 (EC97M31S-GS)." Available online at: http://www.census.gov/prod/ec97/97m31s-gs.pdf

These data measure all new capital expenditures but do not count capital already obtained. Therefore if an MSA made a large purchase of capital only a few years prior and not as much in 1997 it will not be shown in this measure. These data are not the best measure for this research project but are the best that can be found.

In preparation for running the regressions, it was discovered that population and capital expenditures had a very high correlation. This implies that multi-colinearity could be present. In order to eliminate this problem, 1997 capital expenditures per capita, rather than the absolute amount, were used as a measure for capital. Capital per capita is the dollar amount of capital spent per person in the MSA in 1997 (capital expenditure/population of MSA).

F. Industry Mix

An analysis was conducted of the productivity of durable and nondurable manufacturing goods at the national level (BLS)[10]. The productivity measure used was output/input. Graph 2 shows that the productivity of durable goods has increased more rapidly than that of nondurable goods, in recent years. This implies that if a metro area has a concentration of durable goods manufacturing and very little nondurable goods manufacturing, it should be more productive.

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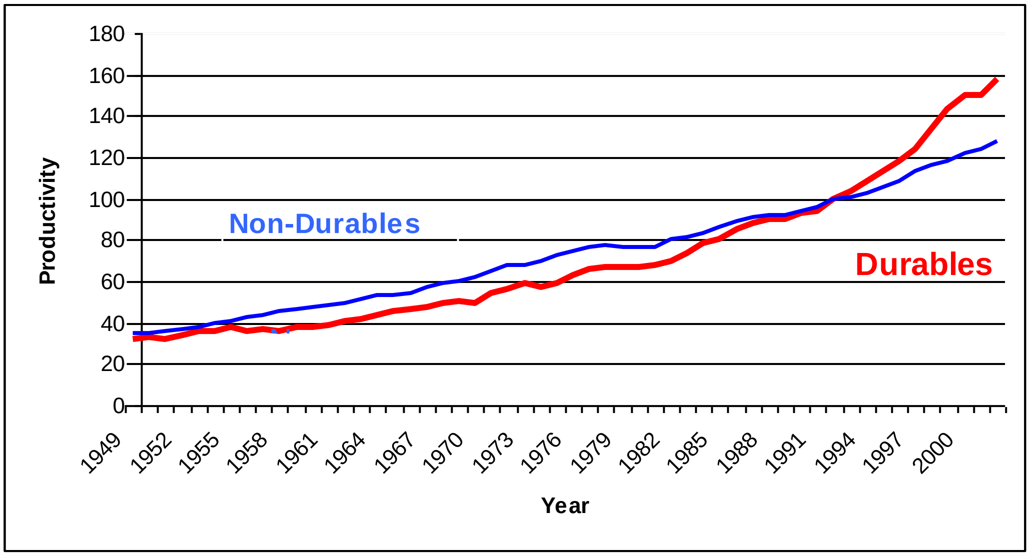
[10] U.S. Bureau of Labor Statistics. "Output per hour, Manufacturing, Durable Goods (PRS31006093)" Available online at: http://data.bls.gov/cgi-bin/srgate.
U.S. Bureau of Labor Statistics. "Output per hour, Manufacturing, Nondurable Goods (PRS32006093)" Available online at: http://data.bls.gov/cgi-bin/srgate.

Graph 2
Productivity



Several studies have looked at whether durable goods have an effect on productivity. Beeson and Husted (1989) used the percent of durable goods manufacturing and total manufacturing production and also used the capital intensity of the industry mix. They found a positive relationship between capital intensity and productivity, but they also found that durable goods have a negative effect on productivity. Because of the time period of this study, 1959 to 1972, this is to be expected. As can be seen in Graph 2 above, prior to roughly 1987 the nondurable goods industries were more productive than durable goods industries. Therefore it would be expected to find a negative relationship between productivity and durable goods industries. These results support the hypothesis of this study. Beeson (1987) also used the percent of value added in durable goods industries as a proxy for industry mix. It was found that the percent of durable goods industries was not a significant variable. According to Domazlicky and Weber (1998), McCoy and Moomaw (1995) used the unemployment rate and proportion of the labor force that is male as proxies for industry structure. McCoy and Moomaw found a positive relationship between male proportion and productivity and a negative relationship between unemployment and productivity.

There may be a question, however, about whether these variables really measure industry mix.

The presence of durable manufacturing does not appear to have a definite relationship to productivity. Although the United States has overall greater productivity advances in durable goods, it could be possible this will have no effect on regional studies.

Data for nondurables and durable manufacturing data were not easy to find at the MSA level. They can be found for each MSA separated into industry categories. Due to the time constraint on this research project, it was impossible to sum all category breakdowns for nondurable and durable goods industries for all 273 MSAs, so industry mix will not be considered in this study.

G. Skill Level

Skill level is a measure of job training. It differs from education because it is specifically job related, whereas education is general training. Skill level is expected to have a positive relationship with productivity. The higher a manufacturing worker's skill level, then the higher his or her productivity will be. This is due to the fact that highly skilled workers are more knowledgeable about their machines or skills needed.

There are no recent studies that have related productivity to skill level. Therefore it is not really known what effect this variable will have. This study had hoped to determine the effect of skill level on manufacturing productivity, but unfortunately, there are no data that would be a good measure of skill level. The ideal variable would be job tenure or years of experience. The closest variable to skill level is education, which is used as a proxy. Therefore there will be no measure of skill level in this study, although it could be an important variable.

H. Unionization

Unionization may be hypothesized to have a positive effect on productivity. Unionized workers tend to have higher skill levels and therefore better, more experienced workers. There also may be better worker morale which in turn increases productivity.

However, it can also be argued that unionized workers could cause a firm to be less productive. Unions could contribute to various types of restrictive work rules and featherbedding which hinders productivity.

Moomaw and Williams (1991) discussed unionization, but were unsure of what effect unionization would have on productivity. Their results found that unionization was positively related to productivity. Beeson and Husted (1989) find similar results to the previous study. Domazlicky and Weber (1998) who did an overview of previous research studies, state “Most previous research indicates a positive relationship between unionization and total factor productivity growth.”

The data used in all the previous studies was the percent of labor force that is unionized. This variable is available at the state level for most years. Currently there appear to be no data for percent of labor force unionized at the MSA level.

This study used the unionization variable at the state level. If an MSA is located in a state it will be assigned the percent of unionization for that state. If an MSA is located within the boundaries of two or more states the average of the two or more states’ percent of unionization will be used. These data can be found from the Statistical Abstract of the United States in 1998, No. 714, Labor Union Membership, by State: 1983 and 1997.

III. Descriptive Statistics

A. Productivity

In 1997 the most productive MSA was Albuquerque, New Mexico, with a productivity rate of $323 per production worker hour. The least productive MSA was Florence, Alabama having a productivity rate of only $27 per production worker hour. Albuquerque has a productivity rate 12 times higher than that of Florence, a huge difference. The average productivity rate for all 273 MSAs was $79 per production worker hour. Two hundred sixteen of the MSAs have a productivity rate less than $100 per production worker hour, while forty-two of the MSAs have a productivity rate greater than $100 dollars per production worker hour. The obvious question of this project, of course, is what causes productivity to differ from one MSA to another?

B. Population

The smallest MSA in this study is Enid, OK with a population of 56,799. The largest MSA is New York City which is to be expected. New York City has over twenty million people. Two hundred and twenty-five of the MSAs are smaller than a million people, while only two MSAs are larger than ten million.

C. Education

The average years of schooling for MSAs in this study range from 11 years of schooling to 14.4 years. The MSA with the least education, McAllen-Edinburg-Mission, TX, had an average of an 11th grade education. The highest education MSA, Iowa City, IA, had an average of 14.4 years or 2.4 years of college education. The average education level for all 273 MSAs was 12.9 years. The average education level is a high school diploma or greater in 246 MSAs. Only 12 MSAs have an average level of education less than twelve years of education.

The percent of the population with a bachelor's degree in an MSA ranges from six percent in Danville, VA to 22 percent in Iowa City, IA. Seventy-five MSAs have less than ten percent of residents with a bachelor's degree. One hundred and seventy MSAs have a percentage of residents with bachelor's degree between ten percent and twenty percent. Only thirteen MSAs have a percent greater than twenty.

D. Capital

The amount capital expenditures in 1997 varied widely across MSAs, from $4,920,000 in Casper, WY and $7,030,974,000 in San Francisco-Oakland-San Jose, CA. The average amount spent on capital in 1997 was $474,559,000. One hundred and ninety-nine MSAs spent less than $500,000,000 on capital in 1997, while 59 MSAs spent more than $500,000,000 ranging up to over $7,000,000,000. Most of the MSAs spent less than $500,000,000; there were very few that spend more than that.

E. Unionization

The unionization percentages were based on the state value as stated earlier, the averages in this paragraph are for the MSAs based on the state data. The average percentage of unionization for the MSAs was 12.5%. The highest was 26% and the lowest was 1%. Unionization was usually found to be similar in surrounding states. The majority of MSAs (190) have a union percentage between ten percent and twenty percent. Unionization tended to be very high in the northeastern states and lower in the west and south.

VI. Methodology

What causes manufacturing productivity to vary from place to place? That is the key research question of this project. In order to determine the causes, regression analysis was used. Through regression analysis the significance and the impact of the variables discussed previously were tested. Data were available on four of the six variables examined above. Table 1 gives a recap of the expected signs for the variables' effects on productivity.

Table 1

Expected Effect of Independent Variables on Productivity

Variable	Expected Sign
Education	+
Agglomeration Economies	+
Capital Expenditures per Capita	+
Unionization	+

All of the variables are expected to increase the productivity level of an MSA. A number of regressions were run to examine the impact of the variables used. For example, would using high school diploma have a greater impact on productivity than average years of schooling? Also by using numerous variables it was determined whether there were multi-colinearity problems with the variables.

Before running the regression it is necessary to examine a correlation matrix to determine if any of the independent variables are highly correlated with each other. If independent variables are highly correlated, a problem of multi-colinearity exists. Since the correlated variables move together, regression analysis cannot distinguish the effects of one variable from the other, leading to unreliable results. Table 2 presents the correlation matrix for the variables used in this study. For this study, we will consider a highly correlated value to be one greater than .40. This is a very conservative correlation value.

Table 2
Correlation Matrix

	Productivity (hrs)	Productivity (# workers)	Population	Population^2	Capital Expenditures 1997	Capital per capita	% High School Diploma	Percent Associate	Percent Bachelors	Ave Years of Schooling	% Union in state
Productivity (hrs)	1.00										
Productivity (# workers)	0.99*	1.00									
Population	0.07	0.07	1.00								
Population^2	0.01	0.01	0.90*	1.00							
Capital Expenditures 1997	0.16	0.17	0.85*	0.65*	1.00						
Capital per capita	0.25	0.29	-0.08	-0.05	0.12	1.00					
% High School Diploma	-0.11	-0.08	-0.21	-0.12	-0.20	0.22	1.00				
Percent Associate	-0.07	-0.08	-0.02	-0.02	-0.03	-0.09	-0.13	1.00			
Percent Bachelors	0.27	0.25	0.27	0.13	0.30	-0.07	-0.57*	0.24	1.00		
Ave Years of Schooling	0.23	0.22	0.15	0.06	0.17	-0.02	-0.38	0.36	0.88*	1.00	
% in Union	-0.10	-0.09	0.11	0.11	0.13	0.02	0.27	0.36	-0.03	0.13	1.00
	Productivity (hrs)	Productivity # workers	Pop	Pop^2	Capital Exp 1997	Capital per capita	% High School Diploma	Percent Associate	Percent Bachelors	Ave Years of Schooling	% Union in state

*Highly Correlated
*N = 273

Table 2 shows that most of the independent variables are not highly correlated with each other, meaning that it is acceptable to use them in the same regression equation. An exception occurs with the capital expenditures variable, however; it is highly correlated with the population variables. This is because both variables are scale variables, measuring the size of the place. As a result, we would expect there to be a high correlation between the two variables. Because of the multi-colinearity problems between the two variables, a different way of measuring capital must be used. Capital expenditure per capita is the most logical remedy. The population data are already compiled, so the capital expenditures data were divided by the population to get capital per capita. Capital per capita is not highly correlated with any of the other independent variable therefore it is a better variable to use.

Four different education variables were used in the study, each providing a different way of measuring the same thing. They cannot be used together in the same regression equation because this would cause multi-colinearity problems. Three different regressions were run to see which education variable had the greatest impact on productivity, as discussed below. As can be seen from the correlation matrix on the previous page, percent with a bachelor's degree and percent with a high school diploma have a negative correlation (-.57) with each other. The correlation is negative because if more residents only have high school diploma less can have a bachelor's degree. However, there is a positive correlation (0.88) between the average years of schooling and the percent of MSA with a bachelor's degree. One would suspect that if the population had a higher percent of residents with a bachelor's degree, the average years of schooling would also be higher for the MSA.

Notice that there is a high correlation (0.99) between productivity measured using production worker hours and productivity measured using the number of workers. This means that either variable should give about the same results; if data on the number of hours are not available to use as a variable, data on the number of workers could be used in its place. Data in other industries may not be as readily available as in the manufacturing industry. Data on production worker hours may not be available in other industries, but if data on the number of production workers are available the study can still be completed with reliability.

V. Results

After the correlation matrix was analyzed, the first of many regressions were run. Table 3 lists all important regressions run for this analysis with t-statistics reported below each coefficient. Each regression improved upon the previous regression, capturing something new or eliminating multi-colinearity.

Many different regressions were run in order to determine which variables had the greatest effect on productivity. Regressions seven and eight have the highest R-squared and most significant variables. These regressions are discussed first in section A. After the best regressions are discussed, the procedure on how they were determined is analyzed in section B.

Table 3
Regression Analysis

	Expected Sign	Regression 1	Regression 2	Regression 3	Regression 4	Regression 5	Regression 6	Regression 7	Regression 8
Intercept		96.441*	44.818*	-118.320*	54.007*	-123.161*	-147.598*	-134.410*	39.978*
		7.641*	5.348*	-2.120*	5.517*	-2.230*	-2.734*	-2.474*	4.066*
Population in 1997	+	-0.000005*	-0.000005*	-0.000005*	-0.0000047*	-0.000005*	0.000001	0.000005*	0.000004
		-2.108*	-2.167*	-2.060*	-2.163*	-2.085*	1.233	2.081*	1.339
Population squared in 1997	+							-0.0000000000003	-0.0000000000002
								-1.717	-1.233
Capital Expenditures (1000) For 1997	+	0.000013*	0.000011*	0.0000120*	0.0000115*	0.000013*			
		2.998*	2.570*	2.810*	2.700*	2.986*			
Capital per Capita	+						14.796*	15.048*	15.442*
							4.584*	4.675*	4.815*
Percent of MSA with High School Diploma (in Decimal Form)	+	-62.626							
		-1.556							
Percent of MSA With Bachelors Degree (in decimal form)	+		259.836*		249.714*				267.450*
			4.030*		3.856*				4.142*
Ave years of Schooling	+			15.250*		16.445*	17.644*	16.419*	
				3.508*		3.802*	4.180*	3.850*	
Union Membership	+				-65.321	-88.007*	-89.317*	-86.890*	-62.293
					-1.781	-2.400*	-2.484*	-2.424*	-1.754
R squared		0.049	0.098	0.084	0.108	0.085	0.145	0.155	0.163
Adjusted R squared		0.038	0.087	0.074	0.093	0.074	0.132	0.138	0.146

* significance at 5% level

*N = 273

* t-statistics are given below each coefficient

A. Major Results

Regression seven is the best regression for identifying the factors causing productivity differences. The R-squared value is .155 and the adjusted R-squared value is .138. This regression is used as the best regression in this study because in regression eight, when percent that obtained a bachelor's degree was introduced instead of average years of schooling, the unionization variable and the population variable become insignificant. The equation for regression seven follows:

$$\text{Productivity} = \underset{(-2.47)}{-134} + \underset{(2.08)}{0.000005}*POP - \underset{(-1.72)}{0.0000000000003}*POP^2 + \underset{(4.68)}{15.0}*CAP + \underset{(3.85)}{16.0}*EDUC \underset{(-2.42)}{-87.0}*UNION$$

R-squared = .155 N = 273

In the productivity equation above, the -134 is the constant or intercept term. The constant is used in order to scale the regression to the y-axis. The number in parentheses is the t-statistic, which is used to determine if the variable is statistically significant or different from a value of zero. A t-stat with an absolute value greater than two is statistically significant at the .05 level.

The second element on the right side is the linear population variable, Pop. Its coefficient indicates that it is positively related to productivity meaning that as the population increases, the productivity rate increases. The variable is significant because the t-stat is greater than two. The coefficient of the population squared variable is negative, and the t-stat is less than two and therefore is not significant at the .05 level. However it does have a significance level at .08 which is very close to .05. The population variables taken together imply that as the population of an MSA increases, productivity rises, but at a decreasing rate.

The fourth variable in the equation is capital. It also has a positive relationship with productivity. As the amount of dollars spent on capital increases, the productivity level increases. The t-stat of the capital variable is over four which is significant.

The education variable also has a positive relationship with productivity. As education increases, productivity increases as might be expected. As the average education increases by one year, the productivity rate will increase by sixteen dollars per production worker hour.

The final variable is unionization. Unionization has a negative relationship with productivity. As the percentage of unionization increases in an MSA, the productivity rate decreases contrary to findings in pervious studies. The t-stat for the unionization variable is greater than two and is statistically significant.

The number of observations is 273 for regression seven and the R-squared value is .155. This means that 15.5% of the difference in productivity levels across MSAs is determined by education, agglomeration economies, capital expenditures and unionization.

Regression eight has a higher R-squared than regression seven is regression eight. The difference in the two regressions is the education variable used. The education variable used in regression seven was average years of schooling, while regression eight uses the percent of the MSA's population with a bachelor's degree. The equation for regression eight follows:

$$\underset{(4.07)}{\text{Productivity} = 39.98} + \underset{(1.34)}{0.000004*POP} - \underset{(-1.23)}{0.0000000000002*POP^2} + \underset{(4.82)}{15.442*CAP} + \underset{(4.14)}{267.45*EDUC} \underset{(-1.75)}{-62.29*UNION}$$

R-squared = .163 N = 273

The population variable is not significant in this equation, and the population squared variable becomes even less significant. The capital variable stays roughly the same and the education variable also remains positive and has a higher significance level. And the unionization variable, while still negative, is no longer significant. Changing the education variable affects every independent variable except the capital variable. This implies that capital is a very important determinant of productivity, no matter what other variables are used. Because the population variables and the unionization variable change, they are not as reliable in determining productivity as is capital.

It is unclear why the percent with a bachelor's degree variable causes the other variables to become insignificant. One possible explanation for the change in unionization is because both the bachelor's degree variable and the unionization variable are measured in percent terms. Further studies should be done to determine the relationship between the education variables and the other independent variables used in this study.

Having looked at the key conclusions, let's consider some of the other regression equations that led to these results.

B. Other Results

1. Education

Education was determined to have a positive effect on productivity as it was hypothesized to have. The more education the residents of an MSA have, the higher the productivity of that area will be. It is clear from regressions one and two that having a high school diploma does not affect productivity as much as having a college degree. The R-squared doubles with the use of the college diploma variable rather than the high school diploma variable. The average level of education in an MSA was used in the third regression, and the R-squared value decreases slightly. Therefore the bachelor's degree variable captures the effects of productivity better than the average years of schooling variable. However, as can be seen in regressions four and five, the coefficients of the unionization variable and the population variables are affected by the use of the bachelor's degree variable. That is why in the final regression average years of schooling were used as opposed to college diploma.

2. Unionization

Unionization was expected to positively affect productivity because workers would have higher skills and higher worker morale in a union setting. But the opposite case was found; unionization caused a statistically significant decrease in productivity. The fact could be that unions may tend to establish restrictive work rules and featherbedding on the job which would decrease productivity, or that unions exist where a company has other managerial problems that will negatively affect productivity.

Through the different regressions, it was found that unionization became insignificant when different education variables were used. This could be due to the fact that both the unionization variable and the bachelor's degree variable are measured in percents. This also implies that the unionization variable is not as important to determine productivity as other variables in the regressions.

Although the unionization variable is not significant when percent with a bachelor's degree is included, the sign is negative in both regressions. This implies that unionization will most likely have a negative effect on productivity, no matter what variables are used.

3. Agglomeration Economies

It was expected that agglomeration economies would have a nonlinear effect on productivity, positive to a certain level of population, and then becoming negative. This can be tested using a quadratic form, with both population and population squared. Population had a statistically significant (t-stat greater than two) positive sign. This means an MSA that has a larger population will have a higher productivity rate. As stated previously this is due to the fact that the firms in the area can choose the most productive workers and also specialize the workers of the area to their industry. Although population squared is not significant at the .05 level, it is significant at the .087 level. The relationship of agglomeration economies is not linear because of the fact that the population variable is not significant when in the regression alone.

As with the unionization variable, when percent with a bachelor's degree variable is used population becomes insignificant. This also means that agglomeration economies are not as important to determining productivity as capital or education.

4. Capital

The expected sign for capital was positive. The more, newer, and better machinery and equipment that an MSA has the higher its productivity rate will be. This was confirmed by the regression analysis. The capital variable has a positive coefficient in the regression, and it has a t-stat greater than two, meaning that it is statistically significant.

In regressions one through four, the capital expenditures variable not the capital per capita variable was used as the capital variable, but as discussed above in the methodology section, capital expenditures were highly correlated with population making the results invalid. That is why in regressions five through eight, the capital per capita variable is used instead of the capital expenditures variable.

Capital has the highest t-stat of all the variables which means that it is the most likely not to be insignificant. Also the capital variable does not change in significance or value when different variables are entered in the equation. This also implies that capital is important to productivity.

5. Summary

Capital and education variables are the least likely to be statistically insignificant because they have the highest t-statistics. Agglomeration economies and unionization have lower t-stats and depending on which independent variables are placed into the equation may become insignificant. These variables cannot be said to have a non-zero value and more research should be done on these independent variables.

VI. Policy Implications

Does manufacturing productivity vary from place to place? The answer is clearly yes. There are great differences in productivity from one MSA to another. What causes productivity to differ? It is a combination of many things. Education, agglomeration economies, capital expenditures and unionization are only part of the picture. But they are four very important factors to productivity.

What can an area do to measure its productivity? An MSA could implement programs to increase the number of college graduates in the area. High school graduates could receive incentives to extend their education. A policy could be implemented allowing a local high school graduate choosing to go to college in the MSA and work in the MSA for a year or two after graduation to receive a partial grant. This would mean that the students would have a higher opportunity cost of going elsewhere to college and work after college.

An area could identify methods to help manufacturing firms finance increases in their capital stock. This study has shown that capital is a very important part of productivity. If the area spends more on capital, it is possible to become more competitive and an all around better place to live because of higher wages and incomes.

Although it might not be politically correct to say that an MSA should decrease unionization, the results of this study imply that if a decrease in unionization occurs, the area should become more productive.

VII. Further Research

Future studies could attempt to get data for workers' skill levels because this is thought to be an important variable to determine productivity levels. Also data on industry mix should be included in the model. If more time were available for this study, the durable goods industries and nondurable goods industries could have been added to the model. This proves to be a viable measure of industry mix in an area. The capital data used for this study were not perfect; a better measure of aggregate capital data could increase the accuracy of the model. To allow this project to go further, a more extensive literature review could also be undertaken. The four variables of this study are very important to productivity and account for 14 percent of the differences in it. There is still 86 percent to be explained. Other variables are the key.

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