Team #58

**$M^3$ Challenge Champions**; **Summa Cum Laude Team Prize of $20,000**
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## SUMMARY

According to our models, the stimulus act will create about 3.2 million jobs in the US economy over the course of the next three years. We determined that tax breaks will produce the greatest increase in employment, creating approximately one million jobs (32% of total). The next runners up will be education and infrastructure spending, producing 600 thousand jobs and 500 thousand jobs, respectively (19% and 16%). To find these figures, we first estimated the number of jobs that would be immediately created in private industry to meet demand created by government contracts. These new jobs will represent additional income for the American consumer, and the tax breaks will also give Americans more income. That results in more job creation, as the money filters through the economy, being spent and re-spent by American consumers. We modeled the increase in employment using a combination of economic theories. We additionally found the ratio of jobs created to dollars invested in each section of the stimulus, so as to determine which parts were most cost-efficient. A complete breakdown of job creation by the stimulus act, as well as an explanation of the models used, is in the full paper.

We developed our own model to anticipate when we would see full effect from the stimulus bill. We looked at data from previous recessions in the United States in which expansionary fiscal policy was used to bolster the economy. Specifically, we looked at federal spending and unemployment data from the Great Depression of the 1930s, from the 1960s, and from the early 1980s. We found that within three years, increased federal spending had a powerful effect on unemployment rates. Based on projected federal spending for FY 2010, our model predicts that unemployment will fall to 6.22% by 2012. If unemployment falls to this level by 2012, then the stimulus bill will have effectively met its goal of bringing the economy back to normal levels. We used statistical error analysis to determine our degree of confidence in the model and the margin of error of the model.

Based on the results from our model, we determined a criterion for the success of the stimulus bill: we expect the unemployment rate in 2012 to be approximately 6.22%. If unemployment remains significantly above this anticipated figure, than the stimulus act has failed to behave as anticipated by our model. In this case, a new stimulus bill is warranted. We used figures from Moody's Economy.com to determine the most efficient makeup of a stimulus to gain maximum possible economic growth for dollar spent, concluding that a new stimulus should focus on unemployment benefits, food stamps, and aid to state governments. We then used Okun's law to calculate how large the stimulus bill would need to be to reduce unemployment in the economy to a desired threshold.

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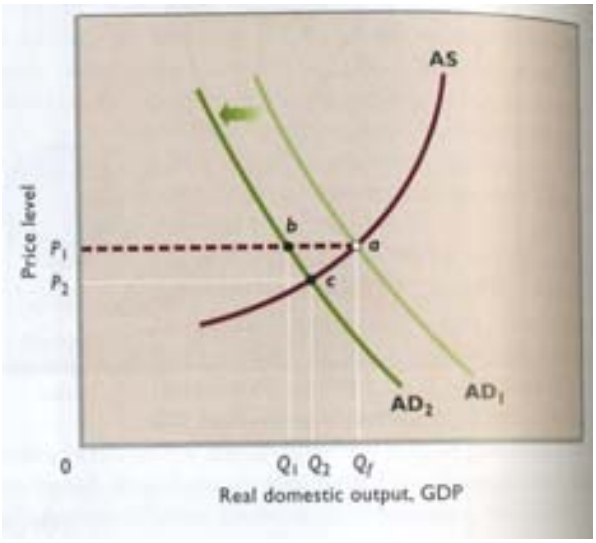
## INTRODUCTION

**Background.** What started in 2007 as the "subprime mortgage crisis" spread like wildfire to the global economy, creating a global recession. Crashing home and asset prices and a paralyzed financial system destroyed consumer wealth and confidence. The resultant drop in consumer spending pushed the US economy into a recession, while an underwater financial system struggled to survive. In response, the United States Government has launched its most ambitious economic interventions since the days of F.D.R.'s New Deal. The Federal Reserve has cut the intended federal funds rate all the way down to zero, the Treasury implemented a $700bn plan to recapitalize and rescue the nation's banking system, and Congress passed a $787bn stimulus package. The intent of this paper is to quantitatively evaluate what effect that stimulus package will have on the US economy; specifically, this paper will find how many jobs will be created or saved by the stimulus.

The roots of the current recession can be found in 2007, when the bursting of the housing bubble caused a crash in the subprime mortgage market. The damage quickly contaminated the larger financial system, as bank assets (particularly financial derivatives such as CDOs) crashed in value. Household wealth was devastated as home and asset prices fell, causing consumer confidence to fall to its lowest recorded levels. The result has been a sharp leftward shift in the aggregate demand curve, as illustrated in Figure 1 below. As price level is sticky downward, this has caused GDP to fall (from $Q_f$ to $Q_1$) without a change in price level, producing a recessionary GDP gap. The American Recovery and Reinvestment Act will shift the aggregate demand curve to the right, correcting for this gap and bringing unemployment down to the natural rate. This paper will examine the effectiveness of that act, and quantify changes in employment that will result.



[8]

**Figure 1 - Supply and Demand Curves with the Left Shift from the Recession**

**Restatement.** Specific questions that will be addressed in this paper include the following: What elements of the stimulus package are most likely to produce the greatest improvements in unemployment? How quickly will the stimulus package produce results? What will determine if the stimulus succeeds? Should there be a second stimulus, and if so, how large should it be? Are there better ways to stimulate the economy and increase employment?

**Global assumptions.** All of our models are based on the following assumptions:

**I.** Inflation will be close to or equal to zero. The effects will be negligible in the short term. Current inflation statistics from the Bureau of Labor Statistics suggest this will be true.
**II.** The "Buy American" clause in the American Recovery and Reinvestment Act of 2009 will keep all the stimulus money within the American economy without reducing foreign trade.
**III.** Okun's law accurately portrays the relationship between GDP and employment, even during radical fluctuations of either of those factors such as those have occurred recently.

## ELEMENTS OF THE STIMULUS

**Rationale.** The recent $787 billion stimulus package is expected to increase employment in two distinct ways. The primary effect, or first wave, of this plan will result from direct government spending through the awarding of contracts to private industry. All government spending will translate to increased revenue for companies awarded government contracts. This increase in revenue will cause companies to hire new workers to fulfill their contracts. At this point, an analysis was done of the stimulus package to determine the allocation of money to various industries within it.

Historical data was used to calculate revenue per employee ratios for the five sectors chiefly targeted in the stimulus package (Health Care, Science and Technology, Education, Infrastructure, and Energy). The inverse of this value was determined to be the number of jobs created by each dollar of revenue. The amount of the stimulus to each industry was multiplied by this ratio to determine the number of jobs that the increased revenue provided by the stimulus would be able to support in each industry. This portion computed the number of jobs directly created through government contracts.

The stimulus package is also expected to produce a macro effect on the US economy. All spending will translate to more income for American households and businesses; the tax breaks included in the plan will also be included in this second wave. This will shift the aggregate demand curve to the right, increasing GDP and decreasing cyclical unemployment. To calculate the size of the increase in employment, we used the GDP multiplier effect and Okun's law.

**Assumptions.** Our model is based on the following assumptions:

**I.** The marginal ratio of change in revenue to change in number of employees is constant for the foreseeable future. Furthermore, we assume that this marginal ratio is approximately equal to the overall ratio of revenues to employment within the industry.

$$\frac{d(employees)}{d(revenue)} = \frac{total\ employees}{total\ revenue}$$

**II.** The definitions of the industries examined are consistent throughout the sources of data used and stimulus package. This is reasonable because all of the classifications are at least indirectly based on the North American Industry Classification System.
**III.** Jobs created by the stimulus package will remain in the economy even after the immediate funding from the package has run its course.

**Design.** In order to determine the manner in which the stimulus package will improve employment, the sections of the bill were divided by immediacy of impact on the economy. The sections were grouped as "first wave" impact and "second wave" impact. Tax cuts were all sorted into the "second wave." This is because their effect is delayed until the individual receiving the tax cut spends the money. The main influential categories of the bill were identified as education, energy, health care, infrastructure, and science and technology [2]. Further, the money being allotted to each industry,

as outlined in the stimulus bill, was $16 billion for science and technology, $90 billion for infrastructure, $150 for healthcare, and $54 billion for energy [3]. From other sources, the stimulus apportioned to education was found to be $62 billion [5]. Because net revenue is associated with employment, and a relationship between employment and the stimulus bill was desired, the revenue per employee for various industries was found for the year 2008. For the short term, the revenue per employees was $ 997,393 for energy; $ 1,011,600 for healthcare; $228,636 for infrastructure; and $275,619 for science and technology [1]. The government spending per employee for education, using different sources, was $117,000 [4]. Working with the assumption that the money emanating from the stimulus bill would be treated by industries as revenue, the increase in the number of employees could be found by dividing the stimulus allocations by the revenue per employees. This yielded an increase of employees of 148,280 individuals in healthcare; 54,141 individuals in energy; 393,639 individuals in infrastructure; 58,051 in science and technology; and 529,915 individuals in education.

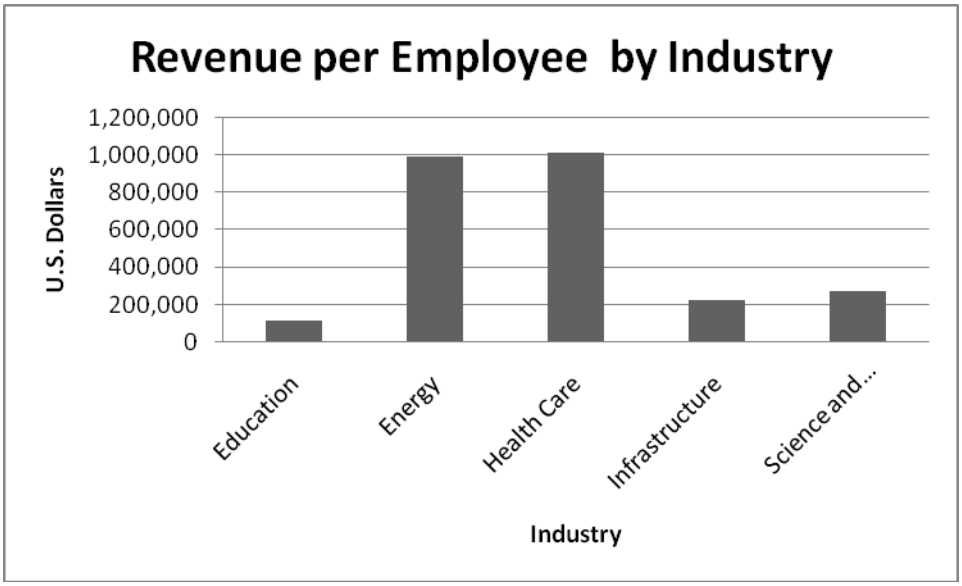



**Figure 2 - Revenue per Employee by Industry**

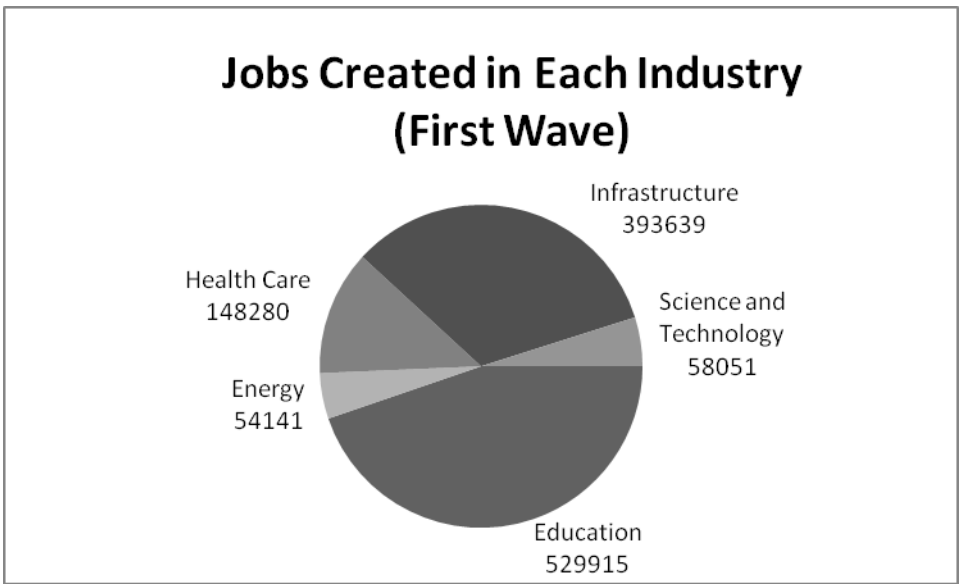



**Figure 3 - Jobs Created in Each Industry (First Wave)**

After the initial employment growth determined by examining the employee per revenue ratio of various industries, those employed will begin spending more money, leading to an increase in GDP. An increase in GDP may have many economic implications, but specifically Okun's law empirically suggests that this will generate even further job growth. Okun's law further allows us to calculate that change in employment, stating that the ratio of the change in GDP to the real GDP is equivalent to the difference of the average annual growth rate of full-employment output, $k$, and the product of the factor relating changes in unemployment to changes in output, $c$, and the natural unemployment rate, $\Delta u$. At the present, $k$ and $c$ can be taken to be 0.03 and 2, respectively. The increase in GDP will be equal to the increase in government spending and the decrease in taxes both multiplied by a factor, in this case referred to simply as the multiplier. The ideal formula for finding the increase in GDP is given by the infinite series in which the marginal propensity to consume is raised to the power of n.

$$\sum_{n=1}^{\infty} (\text{marginal propensity to consume})^n = \text{multiplier}$$

In this formula, $n$ is equal to 1 because the first term is already spent, and in the case of tax cuts it would begin with unity regardless. However, $n$ would start at zero if the entire effect of the stimulus bill—that is, both waves—should be taken into consideration. In any case, the velocity of money is not infinite, and some sources of money will be treated differently, so consumers will generally react to a temporary tax break with a lower marginal propensity to consume than a permanent act. The multiplier coefficients used for any of the following calculations were those generated by Mark Zandi, chief economist of Moody's Economy.com [6]. Job growth was calculated in the first wave of spending described previously, so 1 was subtracted from the multiplier coefficients for spending that has already been factored in to account for the fact that $n$ started at one rather than zero. For example, 1.4 becomes 0.4 to emulate the fact that the marginal propensity to consume to the zeroth power is equivalent to 1, which then would be subtracted from the infinite series. The multiplier coefficients, though, were defined for very specific aspects of the stimulus bill, and so estimates of these multipliers were made for the general categories of tax cuts and spending increases. The amount of spending done in the first wave, new spending, and tax cuts, based on research and results from previous calculations, was found to be $372 billion, $126.8 billion, and $284.4 billion, respectively [3]. These values were then multiplied against 0.4, 1.4, and 1.2, respectively, the sum representing the change in GDP.

**Table 1 - Fiscal Stimulus Multiplier Coefficients**

**Table 2: Fiscal Stimulus Bang for the Buck**
*Source: Moody's Economy.com*

| | Bang for the Buck |
|---|---|
| **Tax Cuts** | |
| Non-refundable Lump-Sum Tax Rebate | 1.01 |
| Refundable Lump-Sum Tax Rebate | 1.22 |
| Temporary Tax Cuts | |
| Payroll Tax Holiday | 1.28 |
| Across the Board Tax Cut | 1.03 |
| Accelerated Depreciation | 0.25 |
| Permanent Tax Cuts | |
| Extend Alternative Minimum Tax Patch | 0.49 |
| Make Bush Income Tax Cuts Permanent | 0.31 |
| Make Dividend and Capital Gains Tax Cuts Permanent | 0.38 |
| Cut in Corporate Tax Rate | 0.30 |
| **Spending Increases** | |
| Extending Unemployment Insurance Benefits | 1.63 |
| Temporary Increase in Food Stamps | 1.73 |
| General Aid to State Governments | 1.38 |
| Increased Infrastructure Spending | 1.59 |

Note: The bang for the buck is estimated by the one year $ change in GDP for a given $ reduction in federal tax revenue or increase in spending

[6]

As a result, the change in GDP is $667.6 billion, making a ratio of 0.05730 compared with the real GDP of $11.65 trillion. The unemployment change can then be determined as being -0.01365236. Based on a labor force size of 155.2 million individuals, approximately 1,947,220 new jobs will be created.

$$\frac{\Delta Y}{Y} = k - c\Delta u$$

$$\frac{\Delta Y}{1.165 * 10^{13}} = 0.03 - 2\Delta u$$

$$\Delta u = -0.01365236$$

This job growth, however, is calculated for all sectors and therefore has to then be distributed appropriately to determine the change in employment in each industry. To do this, the second wave employment increase was divided among the sectors proportional to the allotment of money by the stimulus bill. As a result, the total jobs in the education, energy, health care, infrastructure, and science/technology industries were, respectively, 602,250 jobs; 117,143 jobs; 323,285 jobs; 498,642 jobs; and 76,718 jobs. The total increase in employment, then, was 1,618,038 jobs.

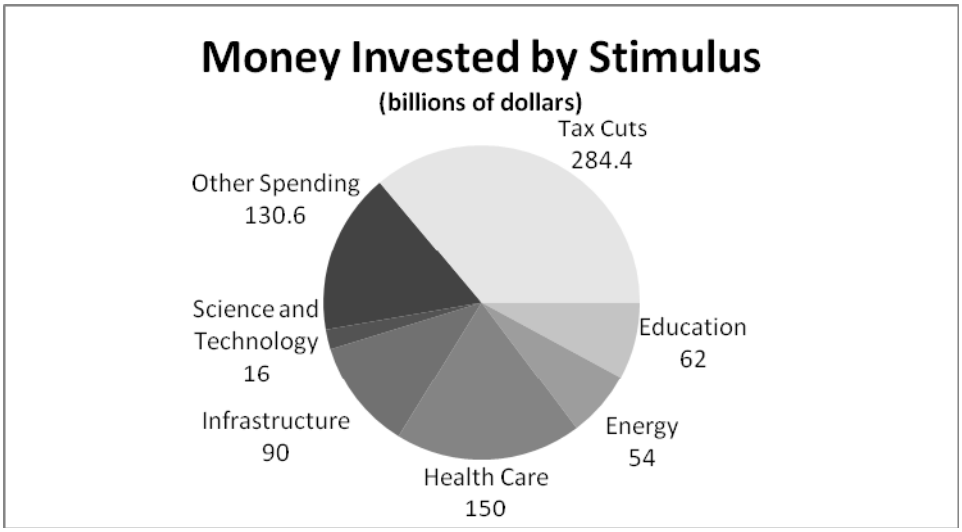



**Figure 4 - Breakdown of Stimulus Package**

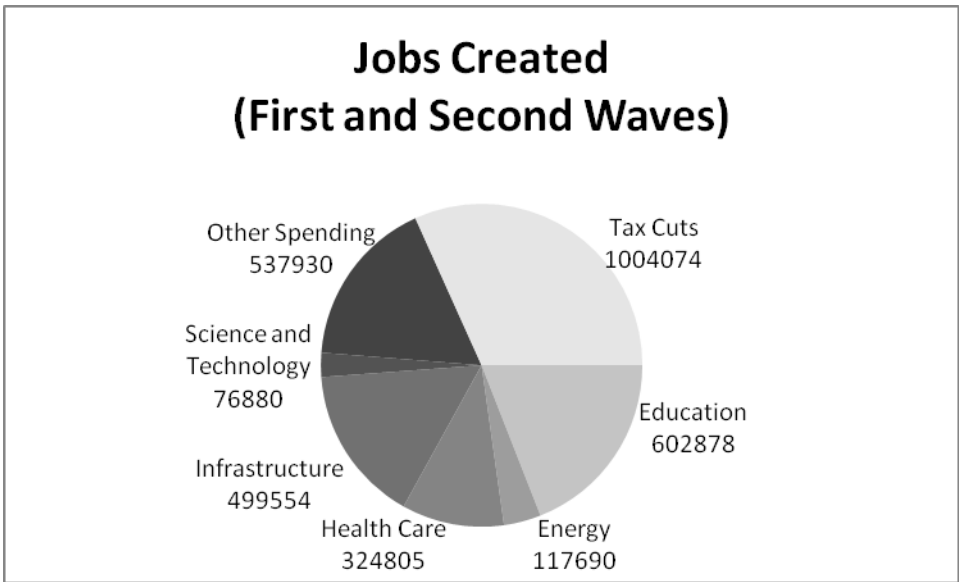



**Figure 5 - Total Jobs Created by Stimulus**

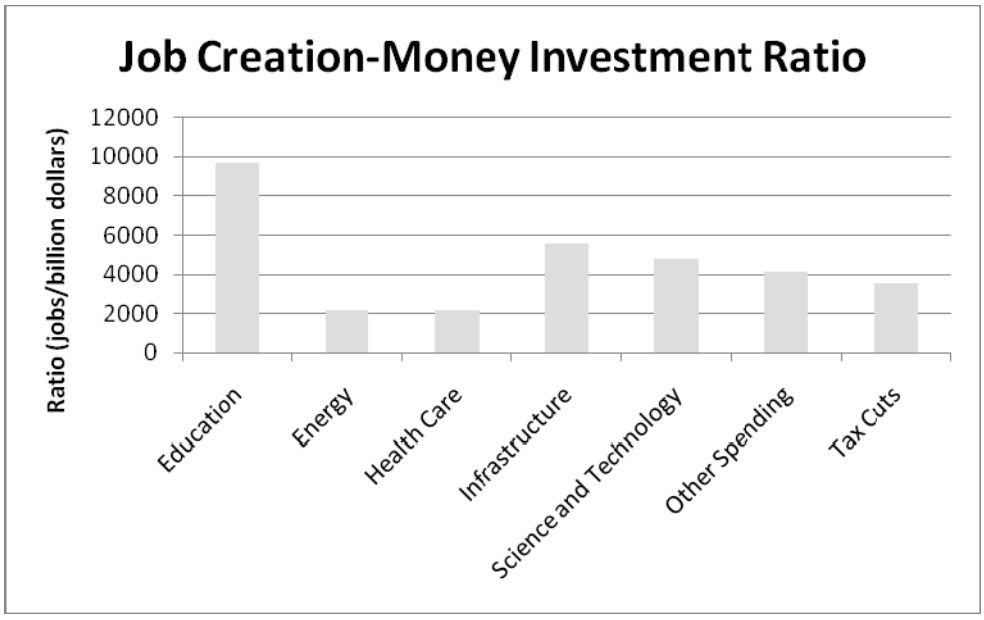



**Figure 6 - Ratio of Jobs Created per Stimulus Dollar**

Based on the actual amounts of money allotted to each industry and to each type of stimulus, it has been determined that the tax cuts in the stimulus will produce the most jobs, 1,004,074. The second largest source of employment from the stimulus will be education, with 602,878 jobs. The third largest source of employment from the stimulus will be infrastructure, with 499,554 jobs. Other sources will account for a significant percentage of jobs, but this is spread across many industries and is accounted for by countless small programs.

**Testing.** To test this model, an analysis could be done of the use of any money gained from the stimulus bill by an industry to verify that this money could be treated as revenue, as it was in the aforementioned calculations. Additionally, historical data could be gathered regarding the employment on a yearly basis in various industries over time and the revenue per year for those industries over a similar time span. The rate of change in each of these factors could be compared, and a regression could then be performed for each industry to determine values for revenue per employee, which would be the slope of the linear model.

Additionally, testing could be done to apply Okun's law to data from recent years for which there exists data regarding GDP, change in GDP, and natural unemployment rate. This data could then be entered into the formula for Okun's law to verify that the law can indeed be used to estimate the change in employment due to the stimulus bill. Similarly, the validity of the multiplier coefficients could be evaluated by manipulating the infinite series to produce a multiplier to which multiplier coefficients could be compared.

## EXPECTATIONS OF SUCCESS

**Rationale.** To determine how long it will take for the stimulus plan to have serious economic effect, we looked for precedents in US economic history where loose fiscal policy was used to bolster economic performance. We found three recessionary periods where Keynesian economic theories were aggressively implemented: the Great Depression of the 1930s, the recession of the early 1960s, and the recession of the early 1980s. We analyzed graphs of federal spending as a percent of GDP with respect to time, and graphs of unemployment rates with respect to time, and performed linear regressions on this data. We sought to find a temporal offset that would relate federal spending as a percent of GDP to future unemployment rates. We found an effective model using a

temporal offset of three years: we found that unemployment rates could be predicted by the federal spending as a percentage of GDP three years prior. Our model had a high correlation value and proved statistically significant. This model was created using data collected from recessionary periods in US economic history, and is only expected to function during recessionary conditions.

**Assumptions.** Our model is based on the following assumptions:

**I.** Correlations from the recessions of the 1930s, 1960s, and 1980s can be applied to current recession. These correlations are only applicable during times of recession.

**II.** In the short term, linear regressions can be used to correlate combinations of federal spending as a percent of GDP, unemployment, and year.

**III.** Models cannot be used to extrapolate significantly beyond the domains of the models (upper quartile + 1.5*interquartile range or lower quartile - 1.5*interquartile range)

**Design.** Data of the federal government spending as a percentage of GDP was analyzed following recessions in the 1930s, the 1960s, and the 1980s [10]. It was then compared to data on average yearly United States unemployment following these recessions [9]. First, the federal spending as a percentage of GDP and the unemployment were graphed separately as a function of year, as shown in Figures 7 and 8.

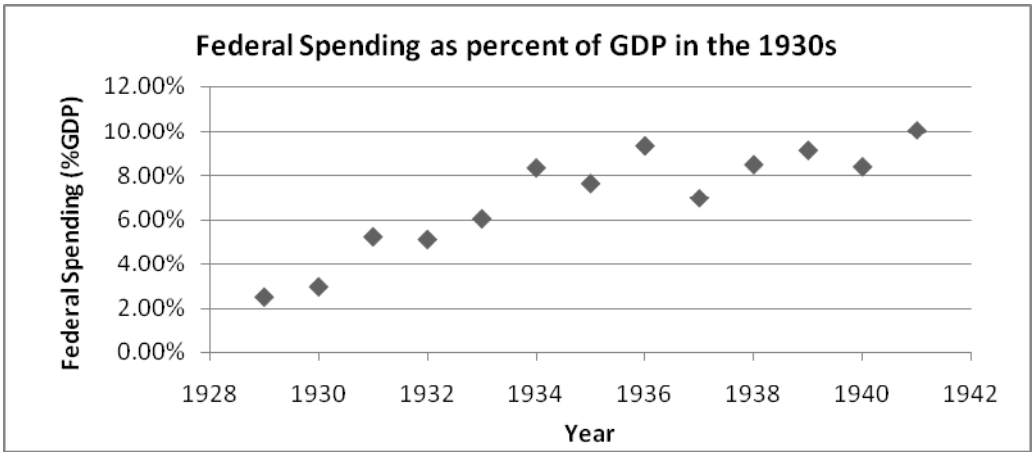



**Figure 7 - Federal Spending as Percent of GDP in the 1930s**


**Figure 8 - Unemployment in the 1930s**

The first marked increase in federal spending occurred in 1930 at the onset of FDR's New Deal. However, the first statistically significant decrease in what appeared to be piecewise unemployment trends occurred in 1933. This suggests that there is an offset of approximately 3 years before the federal spending "worked" in significantly increasing job opportunities. To test this analysis, best-fit linear regression lines were found from 1930 to 1938 in the case of federal spending and from 1933 to 1941 in the case of unemployment, as shown in Figures 9 and 10. The lines yielded Pearson's Correlation Coefficients ($r$) of 0.84 and -0.89, respectively, indicating strong correlations. The $r^2$ values of 0.71 and 0.81, respectively, confirmed that the majority of the variability in these variable was in relation to the models. Subsequent analysis of residual plots also showed that there was random scattering with consistent spread that could not be attributed to a systemic error source.

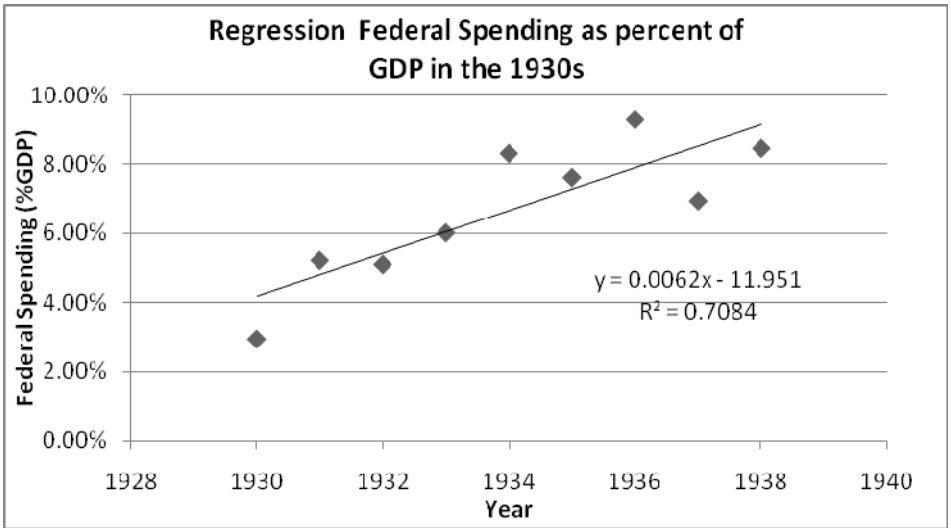



**Figure 9 - Regression Federal Spending as Percent of GDP in the 1930s**


**Figure 10 - Regression Unemployment in Regression Unemployment in the 1930s and '40s**

The data for federal spending as a percent of GDP starting in 1930 was then plotted against unemployment data starting 3 years later to yield a single plot that is shown in Figure 11.

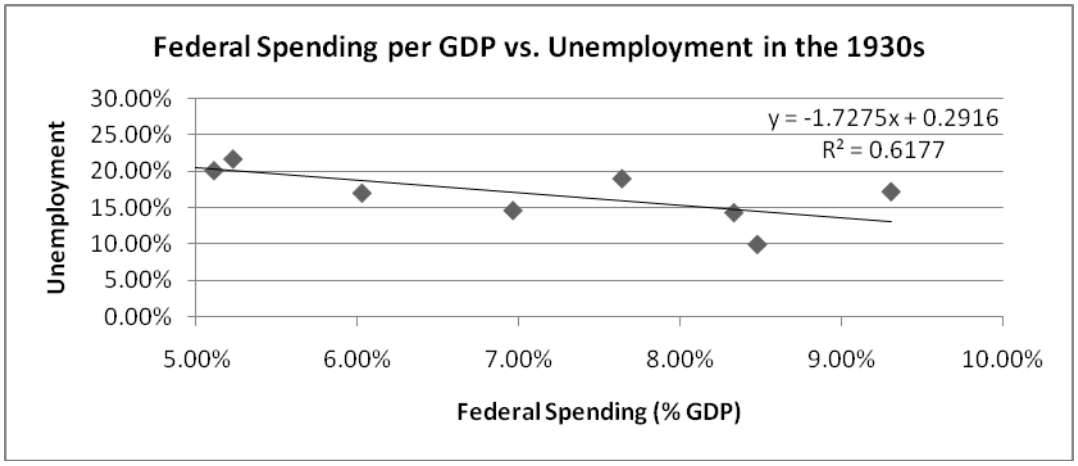



**Figure 11 - Federal Spending per GDP vs. Unemployment in the 1960s**

The line generated from the data chart yielded an *r*-value of -0.79, indicating a strong negative correlation. The $r^2$ value of 0.62 confirms that 62% of the variability in unemployment was in relation to federal spending as a function of GDP 3 years prior. Subsequent analysis of residual plots also showed that there was random scattering with only a slightly skewed spread that was not attributed to a systemic error source.

Despite this strong association between the two variables, it is also important to determine if the positive/negative correlation for the best-fit line is statistically significant; otherwise, the relationship may simply have occurred due to chance, which would give the model particularly weak predicting power. Therefore, a t-test was conducted with the null hypothesis of $H_0$: $r = 0$ and the alternative hypothesis of $H_a$: $r < 0$. It yielded a t of -3.361 and a p-value of 0.0060. This indicates that there would be a 0.60% chance of an *r*-value of -0.79 or less being found due to chance if the null hypothesis was true. Thus, one can confidently reject the null hypothesis and support the research hypothesis that the *r*-value is significantly less than 0.

Similar analyses of the 1960s and 1980s similarly showed the first statistically significant decreases in unemployment after 3 years. The final graphs of federal spending as a percent of GDP vs. unemployment are shown with best fit trend lines in Figures 12 and 13.

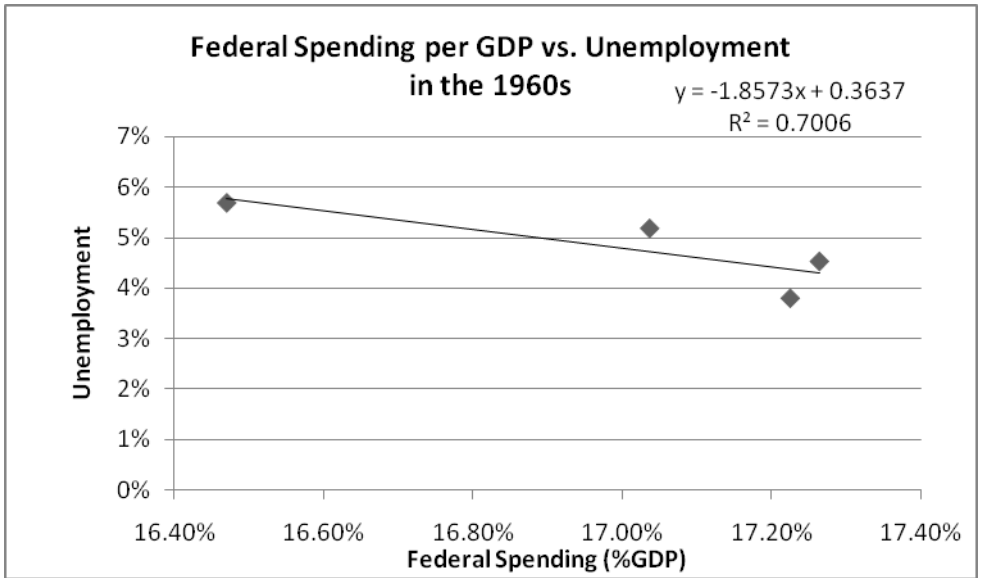



**Figure 12 - Federal Spending per GDP vs. Unemployment in the 1960s**

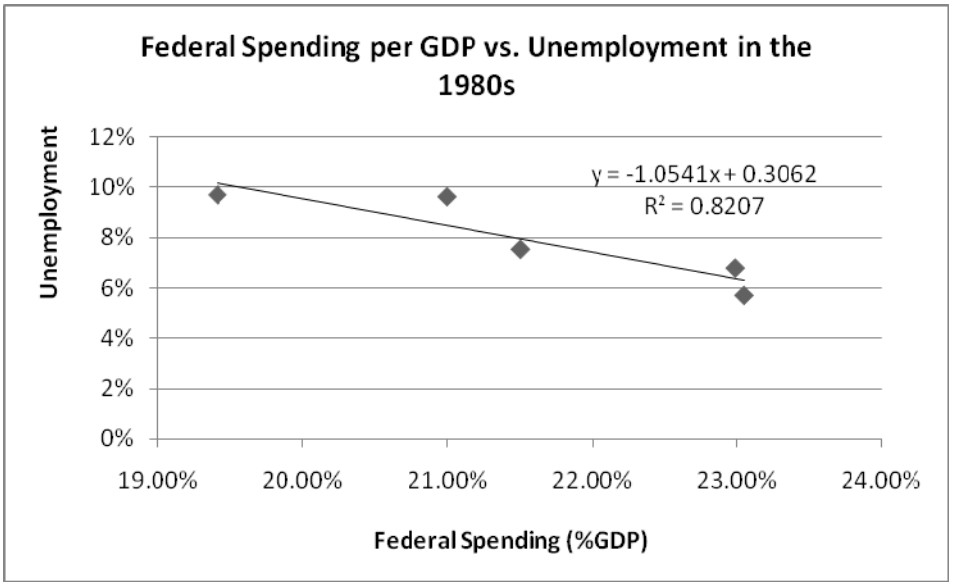



**Figure 13 - Federal Spending per GDP vs. Unemployment in the 1980s**

Throughout the process of graphing, it was noted that government spending as a percent of GDP was lower in the 1930s, which was lower than in the 1960s, which was lower than in the 1980s. Thus, the 3 data sets were combined to get a more accurate vision of how the percent of federal government spending was associated with the percent of national unemployment during times of recession in the long term. This yielded the data and the corresponding logarithmic regression shown in Figure 14.

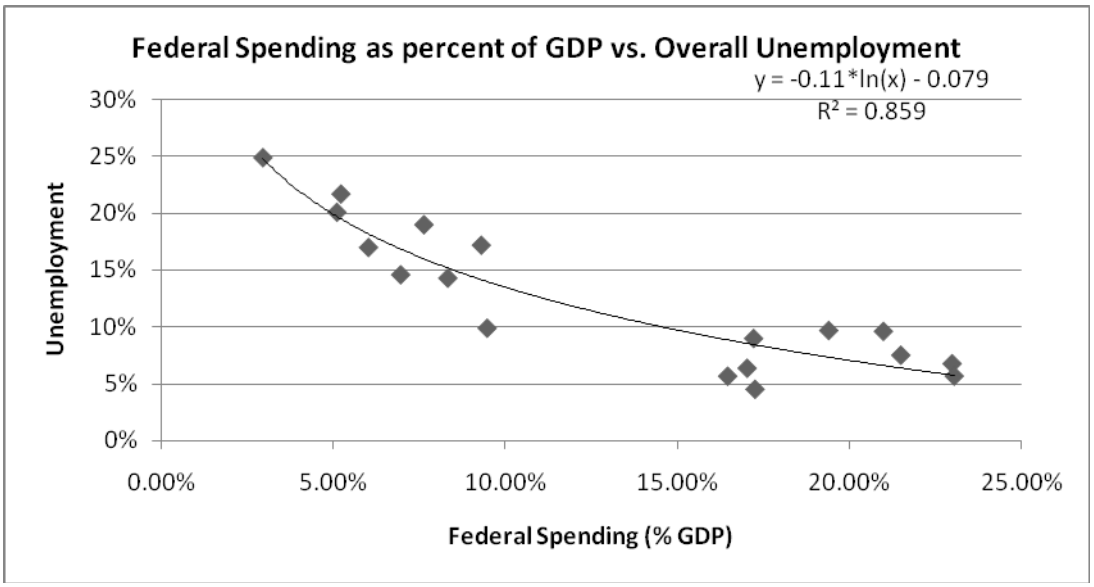



**Figure 14 - Federal Spending as Percent of GDP vs. Overall Unemployment**

The curve generated from the data chart yielded an *r*-value of 0.911, indicating a strong positive/negative correlation/association. The $r^2$ value of 0.830 confirms that 83.0% of the variability in percent federal spending of GDP is in relation to the model. Subsequent analysis of residual plots also showed that there was random scattering with generally consistent spread that could not be attributed to a systemic error source.

The absolute value of all *r*-values throughout the 3 regression analyses in the 1960s and the 3 regression analyses in the 1980s were greater than 0.83, since all $r^2$ values were greater than 0.70. All residual plots also showed random scatter and constant spread, and all linear regression t-tests

yielded p-values below 0.005, giving us high confidence in the models. Thus, there appears to be approximately a 3 year offset before unemployment decreases after increased federal spending. Therefore, for the entire economy, results will be produced after three years.

The projected 2009 federal spending divided by the projected 2009 GDP is expected to be [11]:

$$\frac{\text{federal spending}}{\text{GDP}} = \frac{\$3,945 \text{ billion}}{\$14,240 \text{ billion}} = .277$$

This number was plugged into the model from part 2, $\hat{y} = -0.11\ln(x) - 0.079 - 0.104$, where $x$ is unemployment percentage and $\hat{y}$ is federal spending as a percent of GDP.

$$.277 = -0.11*\ln(x) - 0.079$$

$$x = 0.0622$$

This means that if the model based on past financial crises can be applied to the current financial crisis, in 3 years the unemployment rate will decrease to 6.22%
Because the ideal unemployment rate is near 6% [12], this backs the conclusion that a new stimulus package will not be necessary

**Error Analysis.** For the primary Great Depression model, a level of significance (α) of 0.05 was utilized to calculate error. This model was used because we wanted to simulate conditions in a specific, severe recession and because this model had the lowest *r*-value and thus the greatest potential error of the three linear models. Since all the assumptions and conditions for the regression analysis were met, there is an approximately normal t-distribution for the slopes of the linear fit that approaches a normal Gaussian distribution as the degrees of freedom approach infinity. Thus, a 95% confidence interval for the true population slope ($\beta_1$) is the point-estimate for the slope from the sample ($b_1$) plus or minus 1.96 standard errors, such that

$$SE = s_{b1} = \sqrt{\left[\frac{\sum_i^n (y_i - \hat{y}_i)^2}{((n-2) * \sum_i^n (x_i - x_{\text{bar}})^2)}\right]} = 2.94,$$

where $y_i$ is the value of the federal spending as a percent of GDP *i*, $\hat{y}_i$ is the estimated value of the percentage of federal spending as a percent of GDP *i* according to the best-fit regression, $x_i$ is the observed value of the unemployment rate *i*, $x_{\text{bar}}$ is the mean of the unemployment rate, and *n* is the number of observations. Thus, the error in the slope for a 95% confidence interval is

$$\text{ME} = \pm 2 * SE * t_{n-2} = \pm 2*0.513*2.365 = \pm 1.215$$

When this error is plugged back into the linear equation $\hat{y} = -1.727x+0.291$, the corresponding error in $\hat{y}$ as a function of $x$ is

$$\hat{y} = 1.727*(x \pm 1.215)$$

This means that the total margin of error is 4.196 percent unemployment when federal spending as a percent of GDP is 1%, etc.

**Testing.** Moody's Economy.com projected unemployment to be 9.02% for 2009, 11.09% for 2010, and 10.53% for 2011 without a stimulus bill [6]. The workforce for 2009 is projected to be 156,293,000; 2010 is 157,695,000; and 2011 is 159,043,000 [7]. For the model, it was assumed no jobs would be added in 2009. The stimulus bill spending per year was examined, and it was assumed that job creation per dollar was constant. The total number of jobs from "Elements of Stimulus" was divided per quarter and per year with the assumption that job growth would occur within one year of the money being spent. This process was used to create Figures 15 and 16. It suggests that results from the stimulus will be noticed by 2010.

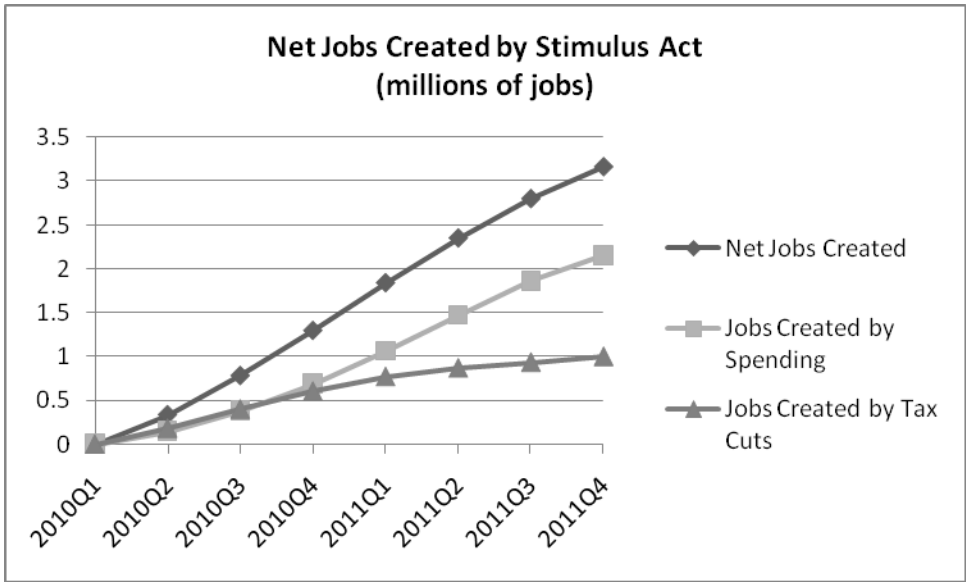



**Figure 15 - Net Jobs Created by Stimulus Act**

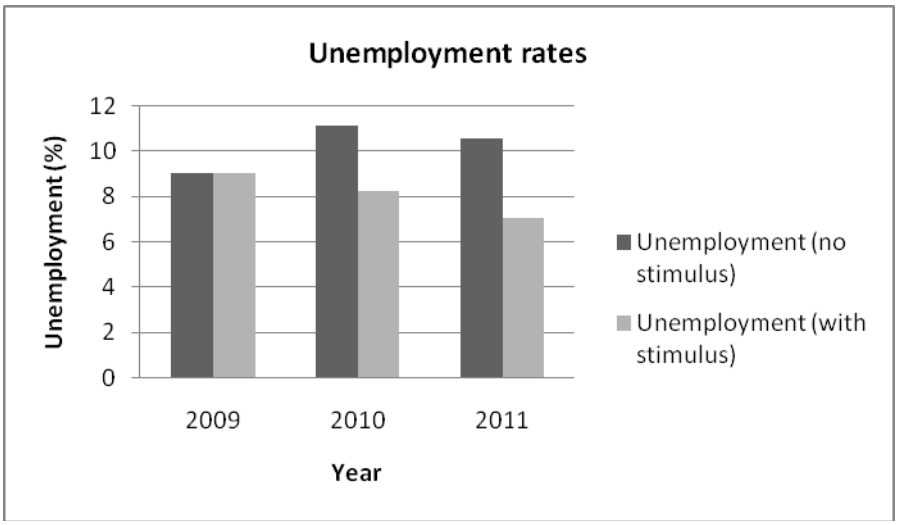



**Figure 16 - Unemployment Rates, 2009–2011**

As a sign of economic stability, unemployment rates should not accelerate. Moody's Economy.com predicts that without a stimulus, the unemployment rate will start to decrease beginning in 2011, which agrees with the model [6]. Furthermore, the model indicates that the rate of this rate should decrease beginning in 2010. These indicators are summarized as follows:

$$\frac{dU}{dt} < 0 \text{ for } t \geq 2011$$

$$\frac{d^2U}{dt^2} < 0 \text{ for } t \geq 2010$$

where *U* is the unemployment rate and *t* is the year. If unemployment continues to increase despite the model, this suggests that the economy has not been stabilized. If unemployment starts decreasing, however, this would be an indication that the stimulus is working.

## SECOND STIMULUS

**Rationale.** A second stimulus package would be necessary if the 6.22% target unemployment rate was not met in 3 years, as projected by the model in "Expectations of Success." If the rate is not met, it would be inferred that the model was inaccurate and a different model would have to be used. The alternative model is based on Okun's law and allows one to set stimulus spending based on the desired level of unemployment to reach. This model depends on GDP, change in GDP without the stimulus, the multiplier effect of the stimulus, and the desired level of change in unemployment.

**Assumptions.** Our model is based on the following assumptions:

**I.** The multiplier coefficients derived by Mark Zandi will be accurate.

**II.** The next stimulus bill (if needed) could be crafted purely for maximum short-term economic impact without regard to politics or other objectives.

**Design.** According to the estimate our model produced in the section "Expectations of Success," the unemployment rate in 2012 should be approximately 6.22%. If the 2012 unemployment rate is significantly above this figure, then the stimulus package has not succeeded according to our expectations. In this case, another fiscal intervention by Congress would be warranted.
If in the year 2012 the unemployment rate remains significantly above 6.22%, a new stimulus bill should be devised using Okun's law. (For this situation to occur, the model from "Expectations of Success" must have failed; therefore, it cannot be used.) Okun's law will tell us what change in GDP we need to increase employment.

$$\Delta U = .015 - \frac{\Delta GDP}{2GDP}$$

$$\Delta GDP = .03GDP - 2 * \Delta U * GDP$$

As mentioned earlier in the paper, 6% is a near ideal unemployment rate. A healthy economy will aim for this level, so $\Delta U$ should equal 6% subtracted from the current unemployment rate. However, to accomplish the target decrease in unemployment, the size of the stimulus must take into account the existing GDP growth, be it upward or downward. The size of the GDP change will take the form

$$\Delta GDP = GDP\ Growth \mid StimulusGDP$$

Therefore, to accomplish targeted unemployment of 6%

$$Stimulus\ GDP = .03GDP - 2 * (U - .06) * GDP - GDP\ Growth$$

Based on the multiplier effect,

$$Stimulus\ GDP = Stimulus\ Size * Multiplier$$

Based on data from Mark Zandi of Moody's Economy.com, the multiplier effect for the most effective areas of stimulus spending (Food Stamps and Unemployment Benefits) is over 1.6. As such, to produce the maximum boost to employment, the next stimulus bill would ideally be made up of primarily these maximum-impact spending categories. The necessary size of the next stimulus bill would therefore be modeled by:

$$Stimulus\ Size\ (\$) = \frac{.08GDP - 2 * (U - .06) * GDP - GDP\ Growth}{Multiplier}$$

Once a targeted change in unemployment rate $(U - .06)$ was determined, the size of the stimulus could be found as a function of the current GDP, the GDP growth rate, and the expected multiplier effect. The multiplier effect would be determined by the exact composition of the bill, but we believe a well-crafted bill focusing exclusively on maximum economic impact expenditures could attain a multiplier above 1.5.

**Testing the model.** Okun's law has been shown to work empirically in a variety of studies in order to test the model.

## CONCLUSIONS

Using several models to analyze the increase in employment according to the money allocated to each industry, tax cuts will generate 1,040,074 new jobs, education will produce 602,878 new jobs, and infrastructure will create 499,554 new jobs. The greatest increase in employment, then, is in tax cuts, followed by education, and then infrastructure. Regarding the ratio of jobs created to dollars invested by sector, education generated 9,714 jobs per billion dollars, followed by infrastructure with 5,540 jobs per billion dollars, making education the most efficient.

Referring to historical data, several regressions were made to identify a three-year period before a statistically significant decrease in unemployment after a statistically significant increase in spending. Based on projected federal spending, unemployment will fall to 6.22% by 2012, and so if unemployment reaches this level in actuality, the stimulus bill will have met its goals. Statistical error analysis supported the models produced.

The stimulus bill will be deemed effective if by 2012 unemployment is 6.22%. If this is not so, a second stimulus would be needed to set it to 6%. Based on information regarding the efficiency of a stimulus composition, a new stimulus should emphasize unemployment benefits, food stamps, and aid to state governments.

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