

Team #143

M³ Challenge Sixth Place: First Honorable Mention Team Prize of \$2,500

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I. Summary of Results

To address the Congressional Budget Office's questions on the American Recovery and Reinvestment Act of 2009, we first investigated the relationship between the employment rate and the Gross Domestic Product (GDP), a measurement that represents the amount of money being spent on goods and services in the country. One of the major goals of the American Recovery and Reinvestment Act of 2009 is to provide the citizens of the United States with more opportunities for work—the idea is that by giving them more money, people will spend more, and ultimately generate even more money than the government originally handed out.

By analyzing U.S. government data from 1946 to 2008, we found a strong relationship between the amount of money spent in the United States (GDP) and the percentage of workers who are employed (employment rate). Therefore, in order to determine which part of the stimulus act would be most effective in saving and creating jobs, we calculated which part of the plan would increase national spending the most. We did this by investigating what percentage of their income Americans were likely to spend, since money that is put away into savings does not directly stimulate the economy. The stimulus plan is written such that the money would be given out in unequal portions on a yearly basis. Therefore, we also had to incorporate the schedule for when the government would be spending the money in the economy. Lastly, we used the numeric relationship between national spending and the employment rate and found that while the tax relief provided the most economic stimulation and created the most jobs, dollar-for-dollar, the expenditure on additional infrastructure projects was actually most effective at increasing the employment rate.

II. Introduction

With unemployment rates reaching record high levels and the national deficit in the trillions, Americans are growing increasingly anxious of the faltering economy and desperate for an opportunity to prevent another Great Depression. Recently, Congress approved a \$787 billion stimulus package, known as the American Recovery and Reinvestment Act (ARRA) of 2009, in “an unprecedented effort to jumpstart our economy, create or save millions of jobs, and put a downpayment on addressing long-neglected challenges so our country can thrive in the 21st century.”¹ The primary focus lies in creating and saving jobs, specifically three million jobs by the end of 2010.² Some have questioned the efficacy of the eleven-year agenda, especially given the tremendous scale of expenditure involved, and many others are asking how quickly this legislation will significantly affect the economy. Lastly, some are concerned whether the funding for this act will be sufficient to end the current economic crisis.

III. Assumptions

1) *All multipliers are constant with time.*

Given the complicated nature of predicting precise spending and tax multipliers, we made the assumption that the estimated multiplier stays constant throughout the eleven-year period. Consequently, the ratio involved in the geometric series for calculating the GDP multiplier effect was constant.

2) *Linear relationship between GDP and employment rate.*

We plotted the past data of real GDP and employment rates from 1949 to present. The correlation of the data proved to be a relatively strong linear and positive relationship, having a coefficient of correlation of 0.88 and a coefficient of determination of 0.77.

3) *Population is constant. (Some data are in per capita.)*

In order to keep the strong relationship between the employment rates and GDP, we had to assume the relative constancy of the population. Our forecasts of GDP growth after the year 2009 all assumed that the U.S. population remained at its January 2009 level of 3.05 million.

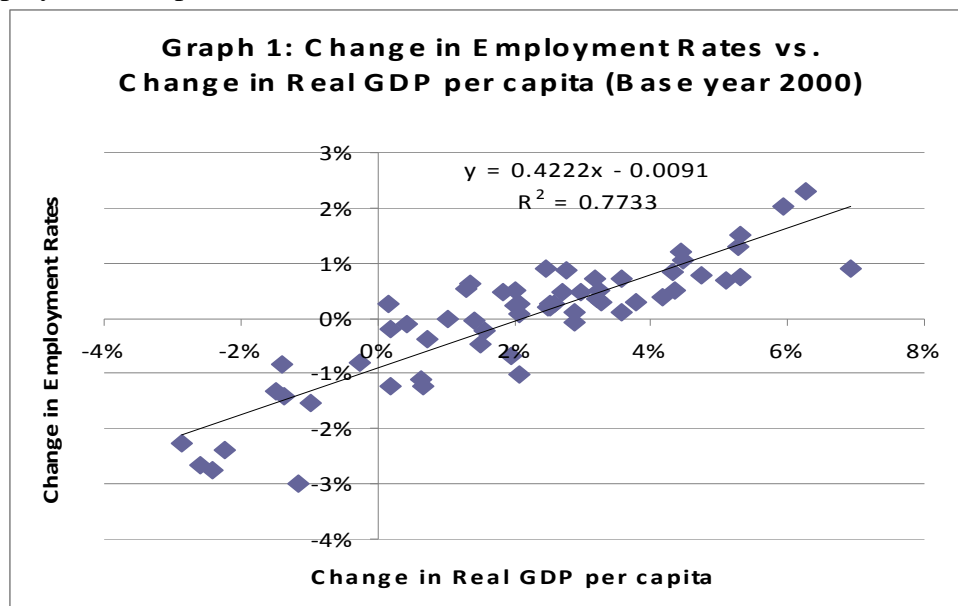
4) *GDP deflator remains constant for the base year of 2000.*

Since we could not perfectly model the inflation rate and effects of this increased government spending on the real value of money, we employed the existing GDP deflator from 2009 to make our data as accurate as possible. All values for GDP change were calculated using the base year of 2000.

IV. Design, Analysis, and Testing

1) *GDP vs. Employment Rate.*

The first step in determining the efficiency of the ARRA at improving national employment was to establish a correlation between the change in employment rate and the GDP. Analyzing this relationship allowed us to assess the precise impact an increasing GDP would have on reducing the unemployment rate. Data of the US real GDP per capita was collected from the website MeasuringWorth,³ and employment rate data came from the Bureau of Labor Statistics.⁴ These results are displayed in Graph 1.



We found a strong positive linear correlation between the annual percent change in employment rates and the annual percent change in per capita real GDP (base year 2000). The coefficients of correlation and determination for our linear regression are $R = 0.8794$ and $R^2 = .7733$. The Pearson product moment coefficient of correlation, R , is a measure of the strength of the linear relationship between two variables, and this relationship has a relatively strong positive value. More importantly, the coefficient of determination, R^2 , represents the proportion of the total sample variability around the mean annual increase of the employment rate that is explained by the linear relationship between the two variables. In other words, the linear relationship between the two variables accounted for 77.33% of the total sample variability around the mean annual change of employment rate.

2) *Proof of geometric series concept.*

According to the Keynesian model of aggregate expenditure, an increase in autonomous government expenditure should shift the aggregate expenditure line upwards. However, often this shift in GDP is several times the value of the injected government spending. This phenomenon is known as the multiplier effect, and is the amount by which a change in any component of autonomous expenditure is magnified or multiplied to change the real GDP.⁵ The multiplier effect is dependent on the concept of one's marginal propensity to consume (R_c) and marginal propensity to save (R_s). These variables and the value of the multiplier (M) are related as follows:

$$R_c + R_s = 1 \qquad M = \sum_{n=0}^{\infty} R_c^n = \frac{1}{1 - R_c} = \frac{1}{R_s}$$

The definition of the multiplier (M) follows an infinite geometric series with initial value 1 and ratio R_c . The following equations were used for calculating a generic finite and infinite geometric series for first term (a) and ratio (R):

$$\sum_{n=0}^x R^n = a \frac{1 - R^{x+1}}{1 - R} \qquad \sum_{n=0}^{\infty} R^n = \frac{a}{1 - R}$$

In order to fully assess the effect of government spending through ARRA on the GDP, we recorded the values of the spending multipliers involved in the various aspects of the plan. The multipliers for tax relief, infrastructure government spending, and noninfrastructure government spending were found to be 0.98, 1.75, and 1.30 according to a report conducted by the Council of Economic Advisors and Office of the Vice President-Elect.² This same source recorded the change in values of these multipliers over a period of 16 economic quarters. All these multipliers were maximized after 8 quarters, at which point they remained constant for the following 8. We calculated the values for the marginal propensity to consume as follows:

$$1.30 = \sum_{n=0}^8 R_c^n \approx \sum_{n=0}^{\infty} R_c^n = \frac{1}{1 - R_c} \rightarrow R_c = 0.231$$

$$1.75 = \sum_{n=0}^8 R_c^n \approx \sum_{n=0}^{\infty} R_c^n = \frac{1}{1 - R_c} \rightarrow R_c = 0.429$$

$$1.98 = \sum_{n=1}^8 R_c^n \approx \sum_{n=1}^{\infty} R_c^n = \frac{1}{1 - R_c} - R_c \rightarrow R_c = 0.495$$

For these calculations, we assumed that the sum of the geometric series of the first 8 terms was equivalent to the infinite geometric series sum because of the limited change in the multiplier after this period. This assumption allows us to conclude that the length of a single iteration of these series is one quarter.

In order to calculate the total change in GDP at any given quarter due to the separate parts of ARRA, we used the following formulas for a given quarter (x) for spending introduced in quarter (q):

$$\sum_{n=0}^x R^n = a \frac{1 - R^{x+1}}{1 - R} \qquad \sum_{n=4}^x R^{n-4} = a \frac{1 - R^{x-3}}{1 - R}$$

14: State Fiscal Stabilization Fund	6540	28377	16070	2363	250	0	0	0	0	0	0	
5: State Fiscal Relief	33881	43923	11847	88	-6	35	44	56	57	59	59	
2: Other	1697	2148	654	521	298	39	0	0	0	0	0	
9: Legislative Branch	8	15	2	0	0	0	0	0	0	0	0	
Total	42541	75293	29126	3387	1094	74	44	56	57	59	59	151790

Relief

Title: Specification	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total
12: Public Housing Capital Fund	80	1200	1200	800	640	40	40	0	0	0	0	
12: Other Housing Assistance	446	2068	3316	1973	1109	62	22	0	0	0	0	
12: HOME, Low Income Housing Tax Credit Program	1	3	8	12	14	16	17	18	18	18	18	
2: Unemployment Compensation	16976	20465	470	295	140	135	140	145	150	155	160	
2: Economic Recovery Payments, TANF, Child Support	14942	2125	713	187	49	14	4	1	0	0	0	
3: Health Insurance Assistance	14302	9206	1493	67	0	0	0	0	0	0	0	
2: Assistance for Unemployed Workers and Struggling Families	44	261	186	263	225	139	81	-34	-65	-105	-115	
3: Health Insurance Assistance	0	-52	-86	-93	-75	-46	-29	-10	-1	0	0	
Total	46791	35276	7300	3504	2102	360	275	120	102	68	63	95961

Infrastructure

Title: Specification	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total
1:Distance Learning, Telemedicine, Broadband Program	63	350	587	575	475	325	125	0	0	0	0	
1:Supplemental Nutrition Assistance Program	4812	6058	4362	3115	1639	5	0	0	0	0	0	
1:Other	816	1623	736	421	172	138	34	0	0	0	0	
2: Broadband Technology Opportunities Program	84	756	860	1250	1210	390	150	0	0	0	0	
3: Department of Defense	1679	2122	551	129	36	11	3	0	0	0	0	
4: Corps of Engineers	1171	1701	980	378	270	100	0	0	0	0	0	
5: Federal Buildings Fund	400	900	1000	1100	1000	500	300	150	50	0	0	
5: Other	220	662	339	67	19	0	0	0	0	0	0	
6: Homeland Security	506	591	857	457	230	93	10	0	0	0	0	
7: Clean Water and Drinkong Water State Revolving Funds	180	1380	1800	1240	600	320	120	68	36	42	0	
7: Other	988	2118	897	531	183	9	9	9	9	6	0	
8:National Institutes of Health	855	3286	3703	1505	249	118	27	0	0	0	0	

8: National Coordinator for Health Information	300	1280	360	40	0	0	0	0	0	0	0	0
8: Other Department of Health and Human Services	2173	3009	2358	1612	593	65	0	0	0	0	0	0
10: Military Construction and Veteran Affairs and 11: State, Foreign Operations and Related Programs	448	1564	1229	638	241	93	33	0	0	0	0	0
12: Highway Construction	96	180	162	114	50	0	0	0	0	0	0	0
12: Other Transportation	2750	6875	5500	4125	3025	2750	1925	550	0	0	0	0
4: Health Information Technology	2232	2511	3285	2910	3027	2672	1987	1051	400	320	116	
4: Health Information Technology	417	178	4741	6469	6463	14231	3848	-5535	-4980	-2780	-2233	
4: Health Information Technology	0	0	-120	-250	-360	-410	-435	-435	-425	-415	-410	
Total	20190	37144	34187	26426	19122	21410	8136	-4142	-4910	-2827	-2527	152209

Energy Efficiency

Title: Specification	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total
4:Energy Efficiency and Renewable Energy	4	2045	3340	3715	3300	2540	1048	267	100	0	0	
4: Innovative Technology Loan Gaurantee Program	60	1200	1500	1500	1200	540	0	0	0	0	0	
4: Other Energy Programs	1303	3943	5043	4275	2175	1910	1186	1050	1050	470	-30	
4: Other	180	500	200	120	0	0	0	0	0	0	0	
Total	1988	7688	10083	9610	6675	4990	2234	1317	1150	470	-30	46175

Human Capital

Title: Specification	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total
2: National Science Foundation	342	1266	794	349	162	63	12	0	0	0	0	
8: Employment and Training Administration	613	2226	1224	242	0	0	0	0	0	0	0	
8: Education for Disadvantaged	494	6210	5776	520	0	0	0	0	0	0	0	
8: Special Education	732	5734	5124	610	0	0	0	0	0	0	0	
8: Student Financial Assistance	917	14572	1056	15	0	0	0	0	0	0	0	
8: Other Education	207	1078	624	203	12	0	0	0	0	0	0	
8: Other	540	324	283	237	155	4	4	2	0	0	0	
Total	3845	31410	14881	2176	329	67	16	2	0	0	0	52726

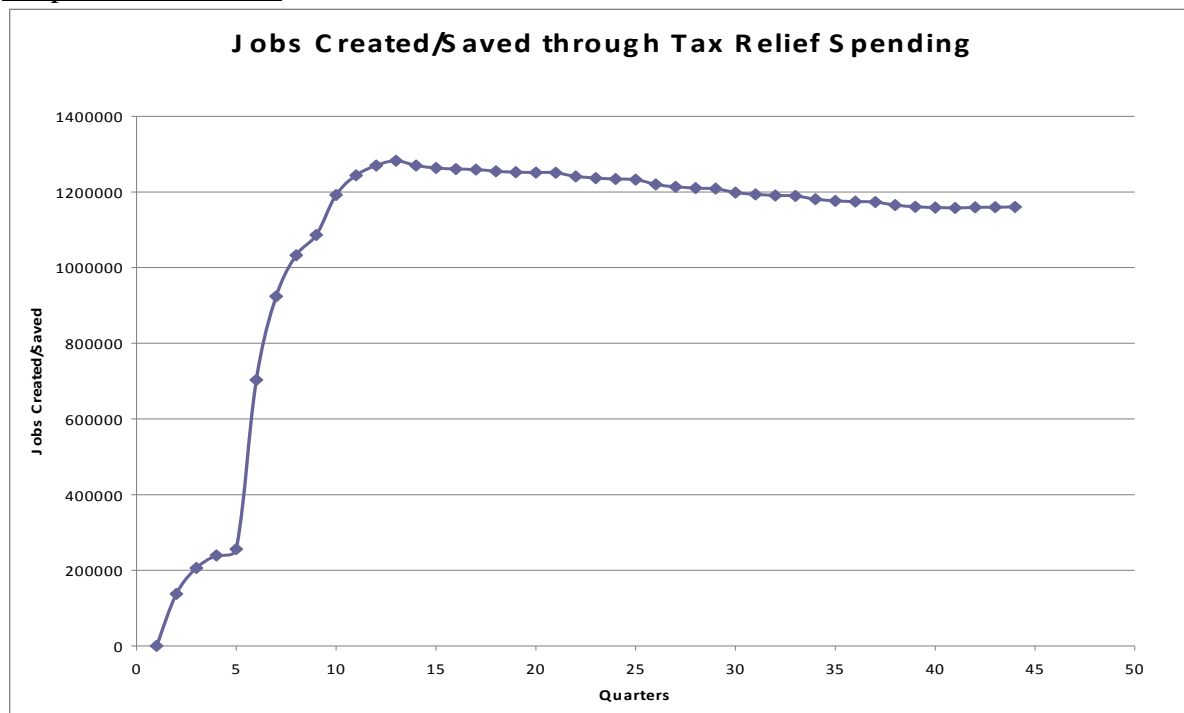
4) *Time frame for ARRA and long-term job effects.*

In his initiation of the ARRA, President Obama set forth the goal that by the end of the year 2010, 3 million jobs would be created or saved through the the stimulus package. In order to assess

if this package was “working,” we used our geometric series model of jobs created/saved through ARRA vs. time to assess if President Obama’s proposition would in fact achieve this goal by the said time frame. Using data from the Congressional Budget Office regarding the spending distribution of ARRA in tax cuts, aid for state & local governments, relief, infrastructure, energy efficiency, and human capital, we used the linear relationship from part 1) to interpret the change in GDP per capita in terms of employment rate and finally jobs created or saved. The present outline of ARRA allocates the \$787 billion as following: \$244 billion on tax relief, \$217 on aid for state and local governments, \$120 billion on relief, \$101 billion on infrastructure, \$59.5 billion on energy efficiency, and \$45.5 billion on human capital.

We made the assumption that the marginal propensity to consume (MPC) and all spending and tax multipliers are constant throughout an 11-year period, as justified in section 3). Additionally, our model is based on the assumption that the US population remained constant at 305,529,237, the GDP deflator from the base year 2000 also stayed constant at 112.41%, and no other factors impacted employment or the employment rate. Because of the small number of assumptions involved in this model, we are very confident in our predictions.

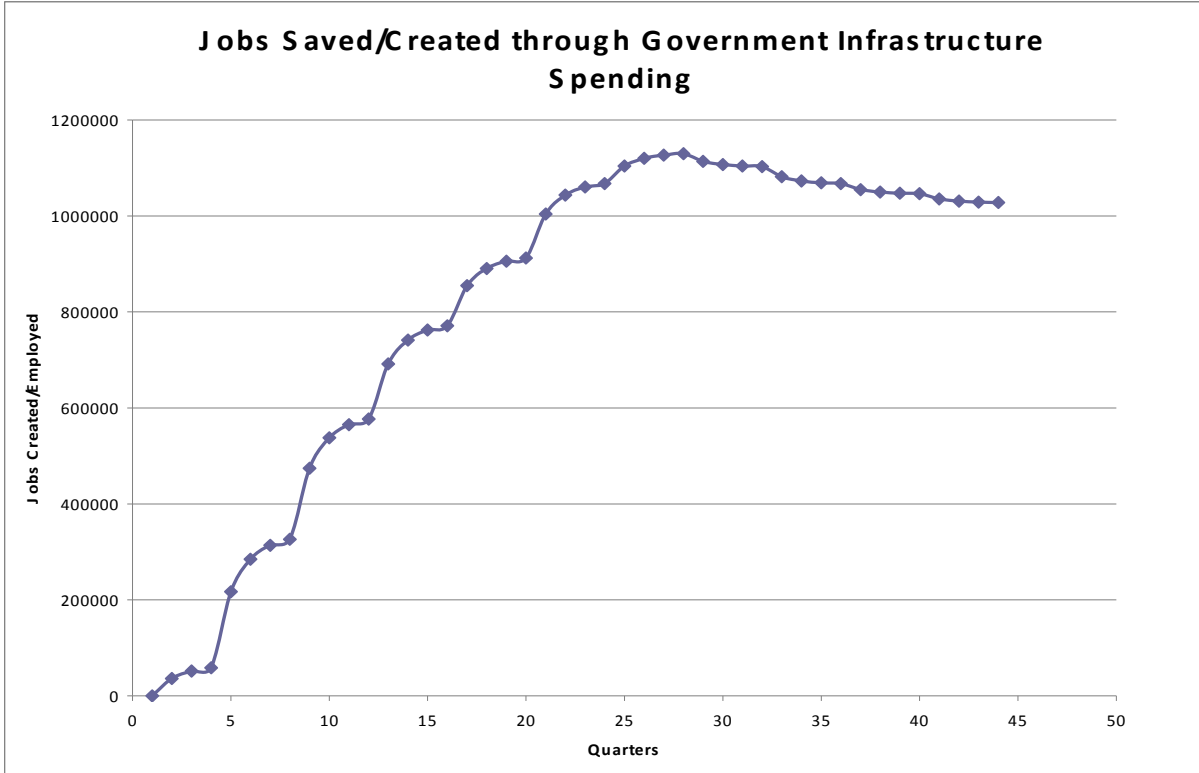
Graph 2a: Tax Relief



At the end of an 11-year period, our derivation from the expected spending of the ARRA suggests that 1.16 million jobs will be saved/created through just tax relief spending. This conclusion was made after calculating the increase in GDP from tax relief after factoring in the effects of the tax multiplier of 0.98 and MPC of 0.495. Consequently, the GDP increase was translated into change in the employment rate through the linear relationship established earlier.

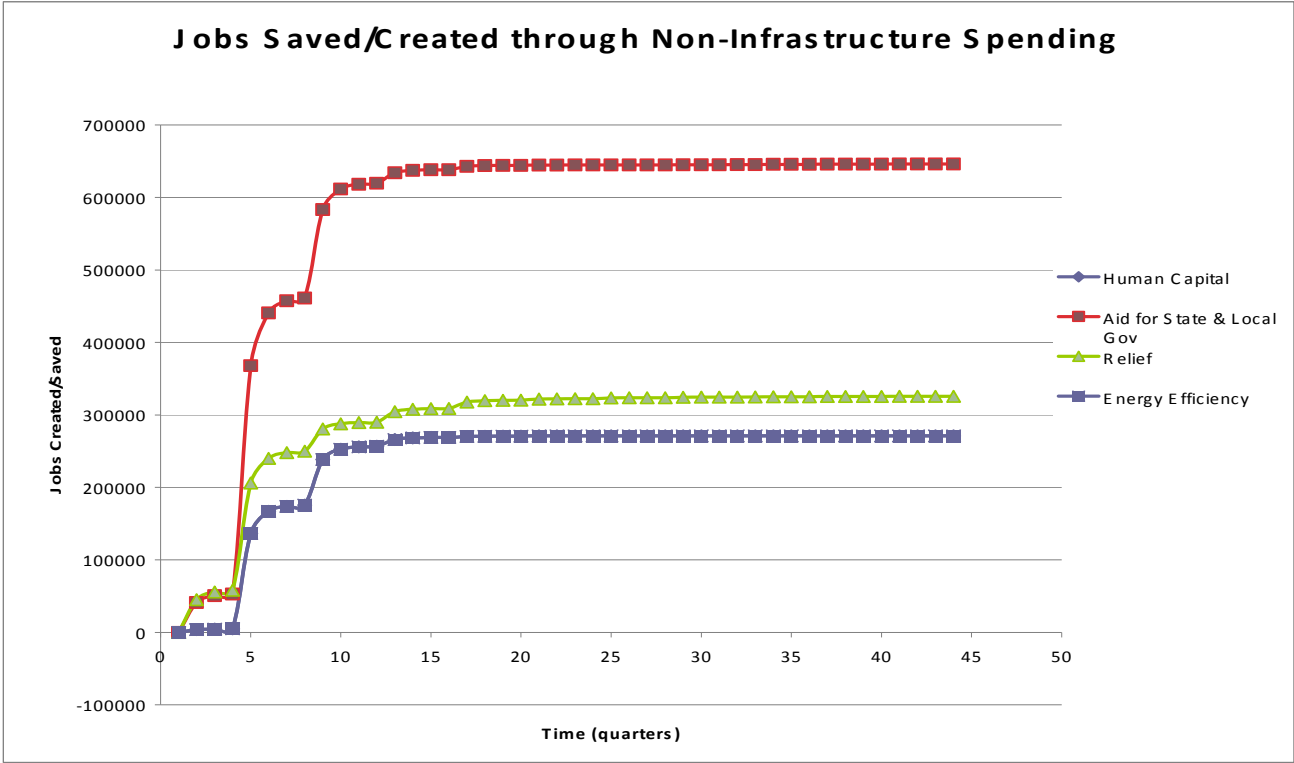
In order to determine the number of jobs created/saved in this sector of the ARRA, we incorporated the same technique described above for tax relief. The infrastructure spending multiplier employed was 1.75 and the MPC was 0.429. The results shown in Graph 2b indicate that 1.02 million jobs were saved/created by the end of 11 years.

Graph 2b: Infrastructure Spending

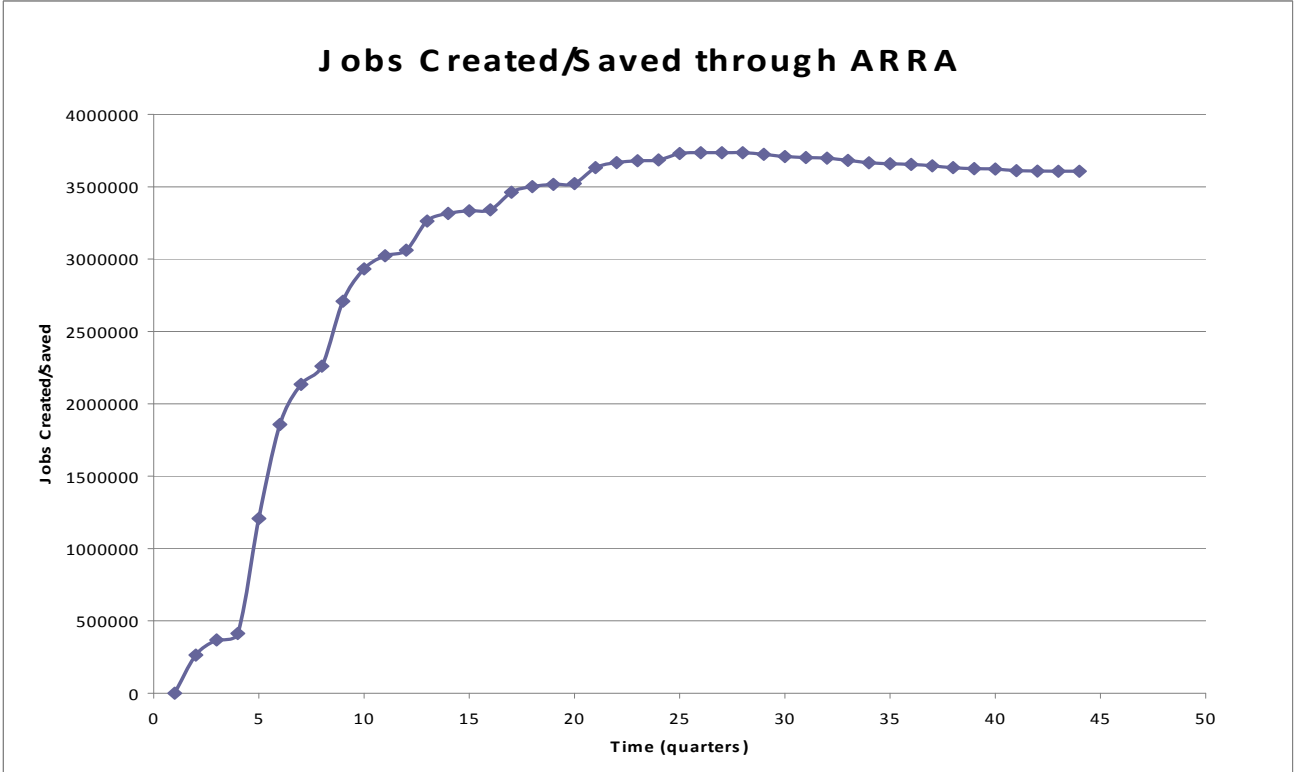


A similar approach was employed for analyzing job creation for the noninfrastructure spending portion of the ARRA. Job creation is plotted over time using a noninfrastructure spending multiplier of 1.30 and MPC of 0.231. Our results indicate that by 2020, 2.71 million jobs would be created/saved collectively through the four categories of noninfrastructure spending. Within noninfrastructure spending, Human capital accounted for 271,167 jobs, Aid for state & local government had 646,194 jobs, Relief had 325,724 jobs, and Energy efficiency led to 243,251 jobs after 11 years. See Graph 2c.

Graph 2c: Noninfrastructure Spending (energy efficiency, human capital, aid for state & local governments, relief)



Graph 2d: All ARRA Spending



Finally, we incorporated all the parts of the ARRA plan (tax relief, infrastructure spending, noninfrastructure spending) in this graph to determine the full effects of ARRA at any point during employment. Our data suggests that 3.61 million jobs would be created by the end of this time

period. Additionally, our model estimates that 2.26 million jobs would be created in total at the end of 2010, coming short of President Obama's expectations of 3 million jobs created/saved.

After analysis of all three components of the legislation, we concluded that tax relief accounted for largest number of jobs created among all 6 categories of ARRA. While infrastructure spending possessed the highest spending multiplier (1.75), the significantly larger amount of funds allocated for tax relief led to a greater effect than infrastructure spending for job creation.

5) *Optimizing the stimulus plan and other solutions.*

Our calculations show that President Obama's goal of creating or saving 3 million jobs by the end of 2010 will not be met by the current stimulus plan. Our models show that by the end of 2010, only 2.26 million jobs will have been created or saved. To meet President Obama's goal, 0.74 million more jobs must be saved or created during the first two years of the stimulus plan. We assessed two methods to achieve this goal. The first option would be to modify the spending timeline of the ARRA to increase spending in 2009 and 2010. Spending higher amounts during the earlier years of the program would allow the fastest rate of job growth, and could potentially allow the goal of 3 million jobs by the end of 2010 to be achieved. The current administration has already considered this option, and is attempting to spend the stimulus money as quickly as possible. However, the logistical challenges of spending the money are limiting this effort. The President's goal was to spend 75% of the money by September 30, 2010, but congress will only be able to spend 64% of the money by that time. These challenges show that expediting the spending of the ARRA is not a feasible way to create the extra jobs needed to meet President Obama's goal.

A much more realistic option to create a second stimulus package that will help to create the extra jobs needed to meet this goal. Using the relationship between GDP growth and increase in employment, we calculated that the increase in nominal GDP that would be required by the end of 2010 in order to create those extra jobs was \$176.21 billion. Our goal was to create a spending plan that would create the necessary GDP increase with the smallest stimulus package possible. Our goal is to spend the entirety of this additional stimulus package in 2009. The optimal way to increase GDP with minimal stimulation is to add additional funds to the sector with the highest multiplier, which is infrastructure spending. Adding \$103.7 billion to infrastructure spending would produce 0.74 million jobs with the highest efficiency. However, logistical challenges such as a lack of projects ready to be executed limit the government's ability to increase infrastructure spending. According to an article in the Wall Street Journal, in December 2008, the Conference of Mayors proposed 11,391 infrastructure projects that were "ready to go" and would be able to produce jobs in 2009 and 2010. The total cost of all of these projects was \$73.2 billion. Most of these infrastructure projects are a part of the ARRA's planned infrastructure spending, which is already approximately \$152 billion. Because of this, it is highly unlikely that an additional \$103.7 billion worth of infrastructure projects could be ready to go in 2009 and 2010. In our proposed secondary stimulus package, we will attempt to spend as much as possible in infrastructure. We will then attempt to spend the remainder of the money on noninfrastructure spending. However, like infrastructure, there are definite limits to how much spending is possible in 2009 and 2010. If we are unable to spend the remainder of the money in noninfrastructure projects, the rest of the stimulus money would be committed to tax cuts, which have the lowest multiplier of the three major categories.

We performed a hypothetical calculation for a secondary stimulus package that would help to meet the goal of creating 3 million jobs by the end of 2010. This calculation is based on rough estimates of possible increases in infrastructure and noninfrastructure spending over the first stimulus plan. We assume that both infrastructure and noninfrastructure spending could only be increased by 30% of the original stimulus money allocated to them.

a = tax spending

b = infrastructure spending

c = noninfrastructure spending

Total GDP gain = 176.2 = (0.98*a) + (1.75*b) + (1.30*c)

Total money spent = a + b + c

	Category	Spending (2009-2010)
ARRA spending	Infrastructure	\$57.3 billion
	Noninfrastructure	\$244 billion
Maximum secondary plan spending	Infrastructure	\$17.2 billion
	Noninfrastructure	\$73.4 billion

Plug in maximum secondary plan spending for a and b:

$$176.2 = (0.98*a) + (1.75*17.2) + (1.30*73.4)$$

Solve for a: a = 51.6 billion

In this hypothetical secondary stimulus plan, \$17.2 billion would be allocated to infrastructure spending, \$73.4 billion would be allocated to noninfrastructure spending, and \$51.6 billion would be allocated for tax cuts. The total cost for this stimulus plan would be \$142.3 billion.

If this secondary stimulus plan was passed, Congress would have to find actual the maximum possible spending for infrastructure and noninfrastructure spending, and use these data to calculate the proper allocation of the stimulus money.

V. Conclusion

It was found in our studies that at the end of the 11-year period of the ARRA, approximately 3.61 million jobs will be saved by the stimulus plan. 1.16 million of these will be saved/created through tax relief spending. Tax cuts will create more jobs than any other major category of the stimulus package. In spite of its inefficiencies in producing GDP, the sheer quantity of money allocated for tax cuts (\$283.5 billion) made it the largest contributor to job creation and saving. The most efficient producer of GDP was infrastructure spending, which had a multiplier of 1.75. However, only \$152.2 billion was spent on infrastructure, so its total effect on job creation and savings was less than that of tax cuts. From the studies performed, it was determined that the \$787 billion stimulus package will create and save approximately 2.26 million American jobs by the end of 2010, far short of President Obama's stated goal of 3 million jobs created and saved by the end of 2010. We analyzed two methods to help the stimulus package meet President Obama's goal. We concluded that the best option was a secondary stimulus package to help boost GDP by 176.2 billion, allocated with a priority on infrastructure and noninfrastructure spending. This plan will ensure that the US economy is able to recover quickly from this recession.

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