DATA FOR *PROGRESS*

Introduction to the Data for Progress Jobs Model

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Introduction

In the summer of 2021, Data for Progress released a memo on the proposed Clean Electricity Performance Program (CEPP) and the 48C Advanced Manufacturing Tax Credit contained in drafts of the Build Back Better (BBB) Act, in which we made use of a technique for economic analysis known as *input-output (I-O) modeling* to assess the potentially synergistic effects of these two policies on GDP and job creation.[1]

Going forward, Data for Progress is eager to make more regular use of this approach to provide the progressive policy and advocacy communities with high-quality, evidence-based estimates of the likely output and employment effects of various legislative proposals as they work their way toward enactment.

To that end, this memo serves to reintroduce the Data for Progress Jobs Model, and to provide a basic outline of our methodology as well as the results of a "backcasting" exercise in which we use our model to analyze the American Recovery and Reinvestment Act (ARRA) of 2009. By demonstrating that our results are roughly in line with those obtained from economic studies of the ARRA by other authors, we hope to provide confidence in the practical utility and reasonableness of our approach.

"Backcasting" Exercise

In order to test the ability of our model to predict GDP and employment effects of legislative proposals with a reasonable degree of accuracy, we would like to be able to compare its predictions with *post hoc* assessments of the economic impact of legislation. However, such assessments are not routinely performed for most bills, so the first step is to identify a policy for which these kinds of studies have been conducted in order to obtain estimates that we can use as benchmarks.

An ideal candidate bill for this exercise is the ARRA, which was enacted by Congress and signed into law by President Barack Obama within weeks of the start of his first term.

The ARRA is a lengthy and complex piece of legislation. Its final text totals over 400 pages and appropriates funds to virtually every cabinet agency and branch of government, in addition to making significant changes to both the individual and corporate tax codes. To simplify the task of modeling its effects over time, we draw on the Congressional Budget Office (CBO)'s "score" of the fiscal impacts of the bill over a 10-year window.[2]

Since this document was available at the time the legislation was being debated and passed, we are not making use of any *ex post* information about its effects. In fact, the figures reported by CBO for the appropriations provisions of the bill can for the most part be computed by aggregating the numbers available in the text. Where this source is most helpful, though, is in its estimates of the cost of tax and revenue provisions, which are based on assumptions about how such changes would be expected to alter the behavior of individuals and firms.[3]

1 https://www.filesforprogress.org/memos/CEPP-amplifies-jobs-impacts-of-48c-tax-credit.pdf

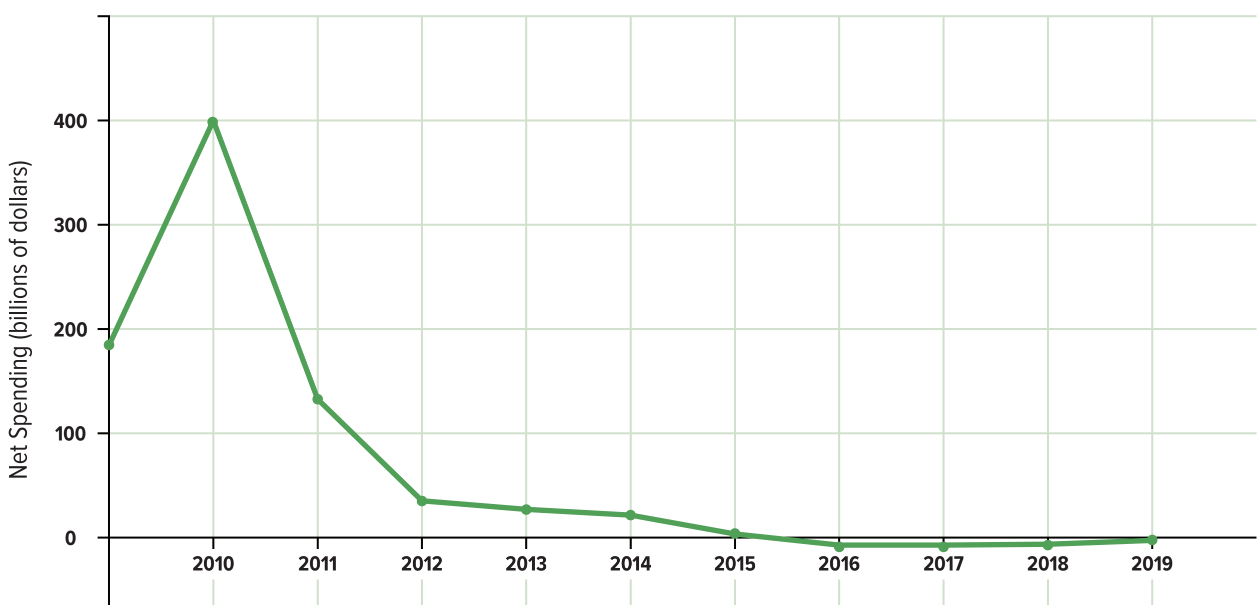
2 "Cost estimate for the conference agreement for H.R. 1," February 13, 2009. https://www.cbo.gov/publication/41762

3 When deploying our model to analyze bills involving tax changes going forward, we will either try to identify existing estimates of the fiscal cost of these provisions or will produce them ourselves. Given the complexity of the ARRA, however, we rely on the CBO numbers for the sake of tractability.

The following table shows the CBO's original projections for the change in net federal spending due to ARRA over the period 2009-2019. In total, the final budgetary impact was estimated at $787.2 billion over this period.

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Net spending (billions)	$184.93	$399.43	$134.43	$36.12	$27.58	$22.36	$4.70	-$7.31	-$7.53	-$6.10	-$1.37

Original CBO Projects of Net ARRA Spending by Year (in billions of dollars)



The next section presents the results of our baseline I-O analysis, followed by additional details on our methodology.

Results of Validation

The following table shows our estimates of the impact of ARRA on net employment and GDP by year. In total, we find that the law would have been expected to create 7.8 million jobs over this period and to increase GDP by $805 billion (in nominal dollars). Over the full implementation period, we calculate the cost per job created at $100,673.

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Net increase in employment (millions)	1.58	3.55	1.58	0.54	0.34	0.32	0.10	-0.06	-0.07	-0.04	-0.03
Net increase in GDP (billions of dollars)	164.51	350.99	158.15	61.36	42.33	37.87	12.12	-6.63	-7.49	-5.37	-3.16

However, since it can also be helpful to have a range of possible estimates, we perform two alternative model runs after considering different choices for the values of certain key parameters.[4]

In the first alternative scenario, which relies on choosing *lower* values for these parameters than in the baseline iteration, we find total job creation of 7.0 million jobs and increased GDP equal to $715 billion, as well as a cost per job created of $112,612.[5]

ALTERNATIVE SCENARIO 1: LOW PARAMETER VALUES

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Net increase in employment (millions)	1.38	3.12	1.44	0.51	0.32	0.30	0.10	-0.05	-0.06	-0.04	-0.02
Net increase in GDP (billions of dollars)	142.59	304.61	143.32	57.65	39.40	35.52	11.74	-5.77	-6.63	-4.66	-3.03

In the second alternative scenario, which relies on choosing *higher* values for these parameters than in the baseline iteration, we find total job creation of 8.7 million jobs and increased GDP equal to $900 billion, as well as a cost per job created of $90,583.

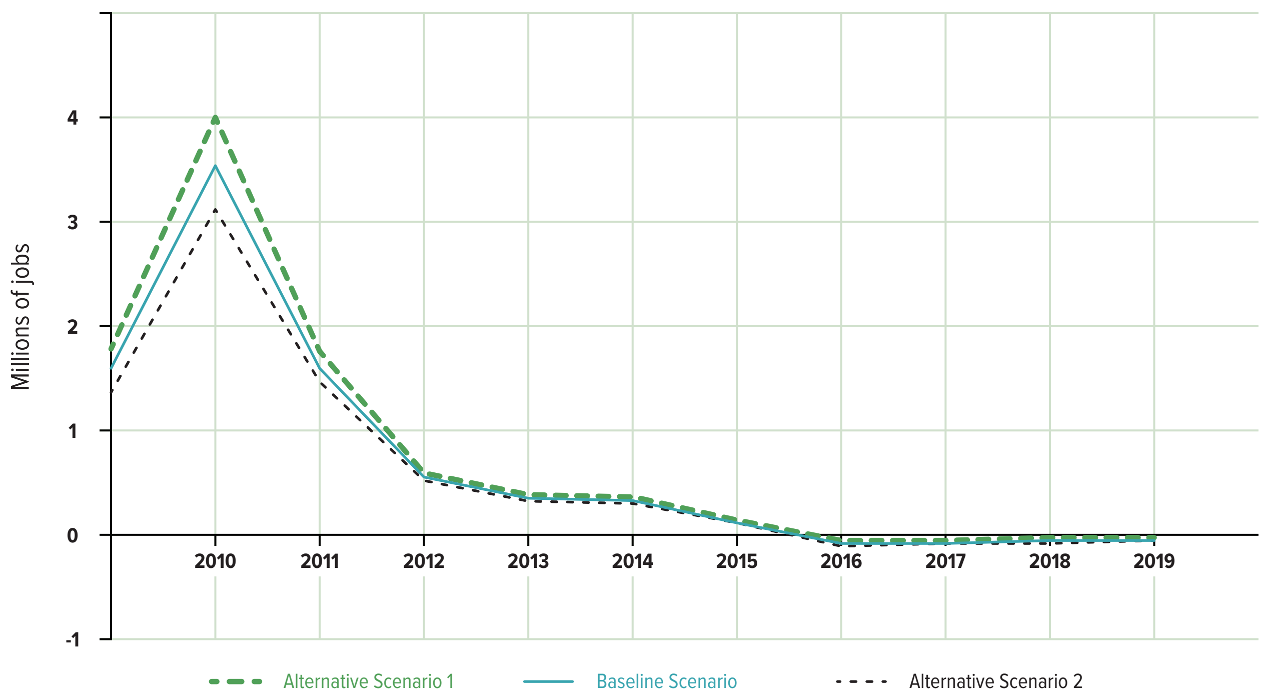
ALTERNATIVE SCENARIO 2: HIGH PARAMETER VALUES

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Net increase in employment (millions)	1.79	4.00	1.73	0.57	0.37	0.34	0.10	-0.07	-0.07	-0.05	-0.03
Net increase in GDP (billions of dollars)	188.00	400.65	173.53	64.98	45.24	40.18	12.43	-7.55	-8.40	-6.13	-3.28

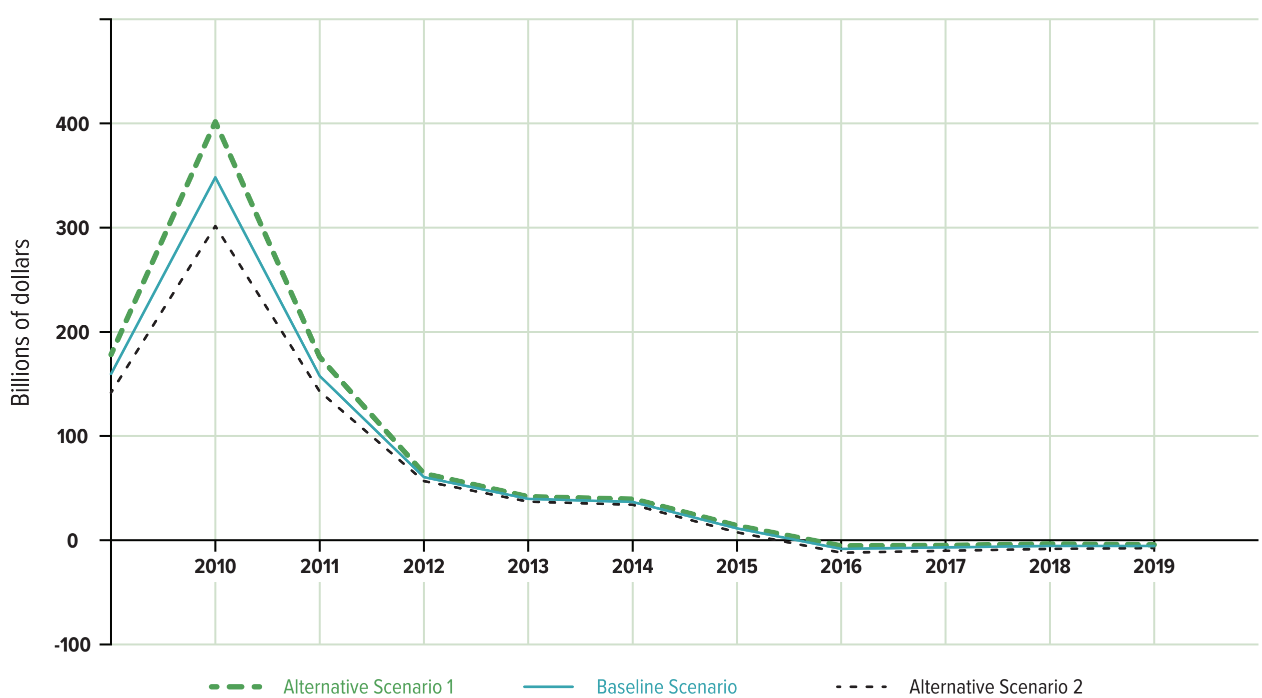
4 The subsequent sections explain the relevant parameters, but these are the marginal propensity to consume (MPC), the dollar increase in business investment in response to a $1 corporate tax cut, and the multiplier used to calculate the induced output/employment effects.

5 Cost per job created is equal to total ARRA spending divided by estimated job creation.

Model Predictions of Net Increase in Employment by Year (in millions)



Model Predictions of Net Increase in GDP by Year (in billions of dollars)



How do these estimates of job creation or the cost per job created compare to those from other sources? One of the most rigorous empirical studies of the ARRA was published by Wilson (2012),[6] who estimates that the cost per job created is $125,000, which is very close to our baseline estimate of approximately $100,000.

However, results from other authors using other methodologies vary widely. At the high end, Conley and Dupor (2013) put the cost per job created at $202,000,[7] and Feyrer and Sacerdote (2011) put it between $170,000 and $400,000 depending on the particular econometric methodology used. That said, the latter authors maintain that the true cost per job creation probably varies substantially for different categories of spending, and suggest that for non-education-related spending it was likely under $100,000.[8]

At the low end, Pollin *et al*. (2014) put the cost per job at $59,880. It is important to note, however, that not all studies look at every category of ARRA spending. For instance, Pollin et al. consider only spending programs administered through the Department of Energy.[9] Likewise, Chodorow-Reich et al. (2012) estimate that formula-based Medicaid spending boosted employment at a per-job cost of merely $26,000,[10] and Popp et al. (2020) also look at "green investments" within ARRA and find a cost per job created of $66,667.[11]

The Council of Economic Advisers' 2014 Economic Report of the President, which reviews much of this literature and also gives CEA's own assessment of job creation, estimates that the ARRA created or saved 1.6 million jobs per year from 2009 through the end of 2012, for a total of 6.4 million.[12] A 2013 Congressional Budget Office analysis reports a wider range of 1.6 to 8.3 million jobs over the same period.[13] Summing up our estimates for these years gives a range of 6.45 - 8.09 million jobs for the same period, and 7.25 million in the baseline scenario.

6 Daniel J. Wilson (2012). "Fiscal Spending Jobs Multipliers: Evidence from the 2009 American Recovery and Reinvestment Act," *American Economic Journal: Economic Policy*, 4(3): 251–282. Available at https://www.frbsf.org/economic-research/files/wp10-17bk.pdf.

7 Timothy Conley and Bill Dupor (2013). "The American Recovery and Reinvestment Act: Solely a government jobs program?," *Journal of Monetary Economics*, 60(5): 535-549.

8 James Feyrer and Bruce Sacerdote (2011). "Did the Stimulus Stimulate? Real Time Estimates of the Effects of the American Recovery and Reinvestment Act," NBER Working Paper No. 16759. Available at https://www.nber.org/papers/w16759.

9 Pollin, Garrett-Peltier, Heintz, and Hendricks (2014), Green Growth A U.S. Program for Controlling Climate Change and Expanding Job Opportunities, https://peri.umass.edu/fileadmin/pdf/Green_Growth_2014/GreenGrowthReport-PERI-Sept2014.pdf.

10 Gabriel Chodorow-Reich, Laura Feiveson, Zachary Liscow, William Gui Woolston (2012). "Does State Fiscal Relief during Recessions Increase Employment? Evidence from the American Recovery and Reinvestment Act," *American Economic Journal: Economic Policy*, 4(3): 118-145.

11 David Popp, Francesco Vona, Giovanni Marin, and Ziqiao Chen (2020). "The Employment Impact of Green Fiscal Push: Evidence from the American Recovery Act," NBER Working Paper No. 27321. Available at https://www.nber.org/papers/w27321.

12 Council of Economic Advisors (CEA) Economic Report of the President - Chapter 3: The Economic Impact of the American Recovery and Reinvestment Act Five Years Later, March 2014. Available at https://obamawhitehouse.archives.gov/sites/default/files/docs/erp_2014_chapter_3.pdf.

13 Congressional Budget Office, "Estimated Impact of the American Recovery and Reinvestment Act om Employment and Economic Output from October 2012 Through December 2012," February 21, 2013, available at https://www.cbo.gov/publication/43945.

As for the impact of the ARRA on GDP, here we also find results in line with the consensus of existing analyses. The same 2014 CEA report cited previously estimated that the ARRA "raised GDP by 2 to 2.5 percent between the fourth quarter of 2009 and the second quarter of 2011," while the 2013 CBO report gives values ranging from 0.4 to 4.6 percent of GDP over the same period. Blinder and Zandi (2010) consider only ARRA expenditures that took place in 2009 and find that these provisions increased GDP by 3.4 percent in the third quarter of 2009 and by 4.3 percent in the fourth quarter.[14]

According to the Federal Reserve, annualized nominal GDP for the fourth quarter of 2009 was approximately $14.65 trillion, so our estimates of the output effects of ARRA for that year range from about 1.0 to 1.3 percent of total output at the time. For the fourth quarter of 2010 the Fed reports annualized GDP of $15.31 trillion, which puts our estimates for that year at between 2.0 and 2.6 percent of GDP.[15]

All in all, our results for both job creation, including the cost per job created and the total number of jobs created, as well as for GDP impacts are for the most part well within the wide range of what can be found in the policy and peer-reviewed academic literature on the economic consequences of ARRA.

Discussion

Our hope is that the Data for Progress Jobs Model will be an important tool for providing progressive activists and policymakers with high-quality estimates of the likely employment impacts of proposed legislation. The simplicity and flexibility of the model will allow us to provide informed economic analyses in reasonably short order. Moreover, its ability to produce results in line with those from other reputable sources when tasked with evaluating a past policy (the ARRA) should give confidence in the soundness of our approach. We look forward to putting the model to work, and hope that it can help move our country forward by putting Americans to work in the good jobs of the future.

Appendix A: Background on Input-Output Modeling

In this section, we describe the basics of the I-O framework used to calculate our estimates, as well as some of the assumptions and methodological choices that are specific to our analysis. Appendix B contains even more detail about the mathematics underlying the model.

An I-O model is a simplified representation of an economy that uses data on the inputs that various industries require to produce their final outputs in order to illustrate the linkages among different sectors. Knowing what these linkages look like allows policy analysts to understand how an initial increase or decrease in spending by governments, firms, or consumers — what economists would refer to as a change in *autonomous spending* — will filter through the economy, and what will be its ultimate effect on certain macroeconomic indicators of interest, such as GDP or aggregate employment.

14 Alan S. Blinder and Mark Zandi, December 2010, "Stimulus Worked," IMF Finance & Development Magazine, available at https://www.imf.org/external/pubs/ft/fandd/2010/12/pdf/Blinder.pdf.

15 See Federal Reserve Bank of St. Louis: FRED Economic Data: Gross Domestic Product, available at https://fred.stlouisfed.org/series/GDP.

Input-output modeling assumes that such a change in autonomous spending has three types of effects on output and employment:

- **DIRECT EFFECTS —** the incremental economic activity and jobs created by the production of *final* goods and services brought about by the new spending;
- **INDIRECT EFFECTS —** the incremental economic activity and jobs created by the production of the *intermediate inputs* to those final goods and services; and
- **INDUCED EFFECTS —** the incremental economic activity and jobs created by the expenditures of workers who are paid to produce these final and intermediate goods and services.

To model direct and indirect effects, we can make use of data on industry-level input requirements made available by the Bureau of Economic Analysis (BEA), which publishes a variety of different tables that can be used to construct an I-O model.[16] One of these tables is known as the *direct requirements matrix*, which shows, for each of a specified set of industries, how many dollars of inputs are required to be purchased from each of the other industries in order to produce one dollar of its output.

Another is known as the *total requirements matrix* or the *Leontief inverse matrix*, after the economist Wassily Leontief, a pioneer of I-O analysis. This shows, for each industry, how many dollars of goods each of the other industries must ultimately produce in order for the initial industry to produce one dollar of its output, taking into account the production of intermediate inputs. Thus, the total requirements matrix allows one to isolate indirect effects by comparing to estimates that would be obtained from calculations based on the direct requirements matrix alone.

Induced effects result from the fact that a portion of the income earned by firms in a given industry when selling their outputs will be paid out as labor income for workers, who will then spend some of that income on purchases of consumer goods. The question of how best to model induced effects is itself a potentially complicated one, but for the sake of simplicity, we choose to follow the approach of Pollin, Garrett-Peltier, Heintz, and Hendricks (2014), who assume on the basis of relevant macroeconomic research that consumer spending has a multiplier of approximately 1.4. That is, each dollar of economic activity associated with the direct and indirect effects of a change in autonomous spending by governments or firms will ultimately generate total economic activity of $1.40. In alternative scenario #1 we reduce this to 1.3, while in alternative scenario #2 we increase it to 1.5.

The requirements matrices allow us to assess the impact of a change in autonomous spending on the *gross output* of every industry, including both intermediate goods sold to other producers and final goods sold to consumers. If we are interested in computing the total impact of an initial stimulus on GDP, we need estimates of *value added* in each industry, which subtract off the costs of intermediate outputs.

To that end, we obtain measures of both gross output and value added by industry from the BEA for each year, and use these to calculate industry-specific ratios of value added to output. Thus, we can take the gross output figures derived from our model and convert them into estimates of value added, which we can then sum across industries in order to obtain an estimate of the total impact on GDP in that year.

16 For our purposes here, all of the BEA tables that we use rely on an industry classification scheme involving 71 industries based on the North American Industry Classification System (NAICS).

Appendix B: Matrix Algebra of I-O Modeling

In algebraic terms, we let the direct requirements matrix be denoted by *A,* the dimension of which is 71-by-71. The entry in the *i*th row and the *j*th column of *A* indicates how many dollars of industry *i*'s output need to be purchased by industry *j* in order to produce one dollar of *j*'s output.

Suppose we want to consider the direct economic effect of spending a certain amount of money on purchasing the product of industry *j*. We can model this spending with a vector *X* consisting of a single column and 71 rows, where the entry in the *j*th row, which we denote by x_j, is the amount that we want to spend on product *j* (and the entries in every other row are zero, if we are not purchasing anything else).

Premultiplying *X* by the matrix *A* gives us the product vector *AX*, which shows how much input we require (in dollars) from each of the industries in order to produce x_j dollars of industry *j*'s output. (Simple matrix algebra shows that the entries of *AX* will be equal to the entries in the *j*th column of *A* multiplied by the scalar x_j.)

However, this calculation only provides us with a partial picture of the total impact that the initial influx of autonomous spending represented by vector *X* will have on the economy. This is because each of the industries that provide the inputs to allow industry *j* to produce its output will itself have to purchase inputs from other industries, and each of *those* industries will have to purchase *its* own inputs, and so on. The *direct* effect of the spending represented by vector *X* will be *AX*, but the inputs needed to produce *AX* will be given by A^2X, the inputs needed to produce A^2X by A^3X, and so on.

Therefore, the total effect on the economy, *direct* effects plus *indirect* effects, will be given by the infinite sum:

$$AX + A^2X + A^3X + A^4X + \dots$$

Through algebraic manipulation, it can be shown that this sum is equal to

$$(I\text{-}A)^{-1}X$$

where the matrix $(I\text{-}A)^{-1}$ is known as the *total requirements matrix* or the *Leontief inverse matrix*.

The entry in the *i*th row and *j*th column of the total requirements matrix gives the total amount of production (in dollars) by industry *i* that is brought about when industry *j* produces one dollar of final output. Thus, multiplying this matrix by the spending vector *X* gives the total economic impact of that initial stimulus.

Appendix C: Further Details About ARRA Modeling

The first step in analyzing the bill is to categorize the spending by industry so that it can be processed by the model. For the appropriations sections, we accomplished this by reading through the text and assigning to each provision that includes a reference to an amount of appropriated funds one or more industry codes on the basis of the activity or activities described in that provision. For example, Title II of Division A contains a series of allocations for the National Science Foundation (NSF). To an appropriation of $2.5 billion for "research and related activities" we assign an industry code of 5412OP ("Miscellaneous professional, scientific, and technical services"), while to one of $2 million to the inspector general's office we assign a code of GFGN ("Federal general government (nondefense))."

By contrast, we take an award of $400 million for "major research equipment and facilities construction" and split it in half, assigning $200 million to code 23 ("Construction") and $200 million to code 335 ("Electrical equipment"). In reality, these choices are likely to reflect only very rough approximations of how the money is ultimately spent, but the available details about the allocations constrain how detailed our modeling is able to be. In general, more specificity about the intended uses of an appropriation will permit us to be more refined in our analyses. We then allocate the CBO estimate of spending for each title of the bill across industries in proportion to the fractions that we calculate using this approach.

For tax provisions affecting individuals that are not structured as credits for specific types of spending, such as those involving the Earned Income Tax Credit or the Making Work Pay Credit, we allocate this spending first by multiplying the budgetary cost of the measures by an estimate of the marginal propensity to consume (MPC), which accounts for the fact that consumer expenditures increase less than one-for-one with increases in personal income. In the baseline model run, we use 0.2 as our estimate of the MPC. In alternative scenario 1, we reduce this to 0.1, while in alternative scenario 2, we increase it to 0.3.[17]

Making the assumption that extra income for individuals is spent on a representative basket of consumer goods, we then allocate this adjusted amount to industries on the basis of the industry composition of the basket used to construct the Consumer Price Index (CPI).[18]

For tax provisions relating to corporate taxes, we take a similar approach by first multiplying the budgetary cost of the provision by an adjustment factor to account for the fact that we expect only a portion of the tax benefits reaped by firms to translate into increased firm investment. While estimates of the elasticity of investment with respect to the corporate tax rate vary, one of the most rigorous empirical studies of this question that we are aware of finds this elasticity to be quite low, and in fact is unable as a statistical matter to rule out that there is no responsiveness whatsoever (Yagan 2015).[19] In our baseline model run, we set the change in business investment in response to a $1 corporate tax cut equal to 0.1, while in alternative run #1, we set it equal to 0, and in alternative run #2, we set it equal to 0.2.[20] We then allocate across industries in proportion to the shares of private fixed assets held in each industry as calculated using data from the BEA.[21]

17 Fisher et al. (2019) estimate the marginal propensity to consume by wealth quintile, and find values that range from around 0.002 for the higher quintiles to over 0.2 for the lowest quintile. Since programs like the Making Work Pay Credit were targeted at less-wealthy working people, we assume higher MPC's in our various modeling scenarios than would be calculated by considering the population as a whole. See Jonathan Fisher, David Johnson, Timothy Smeeding, and Jeffrey P. Thompson (2019). "Estimating the Marginal Propensity to Consume Using the Distributions of Income, Consumption, and Wealth," Federal Reserve Bank of Boston Research Department Working Paper No. 19-4. Available at https://www.bostonfed.org/home/publications/research-department-working-paper/2019/estimating-the-marginal-propensity-to-consume-using-the-distributions-income-consumption-wealth.aspx.

18 Historical data on the components of the CPI is available from the Bureau of Labor Statistics at https://www.bls.gov/cpi/tables/relative-importance/home.htm.

19 Danny Yagan (2015). "Capital Tax Reform and the Real Economy: The Effects of the 2003 Dividend Tax Cut," *American Economic Review* 105(12): 3531-63. Available at https://eml.berkeley.edu/~yagan/DividendTax.pdf.

20 Certain corporate tax provisions affect only specific industries — or even just one specific firm, as in the case of a change to a "loss limitation" rule that effectively only applied to General Motors. For more details see Saba Ashraf, "The Business Tax Changes of the Recovery Act: Provisions Make Loan Workouts Easier, Provide Tax Incentives for Small Businesses, & Address Treasury Notice Preserving Bank Losses," February 18, 2009, available at https://www.troutman.com/insights/the-business-tax-changes-of-the-recovery-act-provisions-make-loan-workouts-easier-provide-tax-incentives-for-small-businesses-address-treasury-notice-preserving-bank-losses.html. In these cases, we apply the same adjustment to account for the less-than-one-for-one increase in investment in response to a tax cut, but allocate to the specific industry or industries affected.

21 Private fixed investment data by industry is available from the Bureau of Economic Analysis at https://apps.bea.gov/iTable/index_FA.cfm.

Cover photo by Chris Grafton