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RENEWABLE PORTFOLIO STANDARDS: NORTH CAROLINA

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This report is an updated version of the original report from February 2015. It has been updated with more current data for labor force participation and personal income. Eight enactment dates were changed to reflect the dates the original RPS became effective rather than the dates the RPS legislation passed.

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EXECUTIVE SUMMARY

The U.S. has no federal mandate for “renewable” power production. Instead, a majority of states, including North Carolina, have created their own state laws called Renewable Portfolio Standards (RPS). These laws mandate that electricity generators and utilities provide a certain amount of their electricity from renewable sources. This report analyzes how the changes in electricity markets caused by RPS alter the functioning of a state’s economy and institutions, with a specific focus on North Carolina. Our report uses a theoretical model, an empirical analysis, and a survey of legal rules. The following are our key findings:

Our theoretical analysis found that North Carolina’s RPS will raise electricity prices significantly across all sectors, with the brunt of the costs falling upon the commercial sector. North Carolina’s cost caps will mitigate these effects, but even that will be at the cost of actually meeting North Carolina’s mandate. If the legislature lifts the cost caps for the purpose of meeting its mandate, electricity prices will skyrocket.

Our empirical analysis finds significant harmful effects on the economies of all states with RPS. States that have adopted an RPS have seen a drop in industrial electricity sales by 14.43 percent. Real personal income has fallen by almost four percent, which figures to a loss of $13.5 billion or $3,479 per family. Non-farm employment has declined by 2.52 percent. Lastly, RPS is correlated with an increase of 7.85 percent in a state’s unemployment rate, equaling a loss of 32,239 jobs.

Our analysis of the legal rules surrounding the RPS in North Carolina outlines several hindrances to compliance in its requirement for generation from poultry and swine waste, and also from its costs caps—a prediction our theoretical analysis substantiates. North Carolina’s RPS also may not embody the spirit of RPS in general, largely due to the burning of poultry and swine waste, which is not as environmentally-friendly as other sources of renewable generation.

BACKGROUND

North Carolina, a traditionally fossil fuel-heavy state (only 5 percent of their energy in 2005 came from renewable sources), first moved toward renewable energy incentives in 2003 with the formation of NC GreenPower. Formed and administered by Advanced Energy, and backed by investor-owned utilities, the non-profit runs a statewide program to promote renewable energy. Individuals and businesses can make donations to NC GreenPower, which will then invest three out of every four dollars they receive into some form of renewable energy production (they retain $1 for marketing and administrative purposes). NC GreenPower has supported nearly 20 million kWh of renewable production per year since its creation, an earnest effort but a meager result when compared to conventional energy sources.[1]

When Governor Mike Easley signed Session Law 2007-397 (SB 3) in 2007, North Carolina became the first state in the southeast to implement a Renewable Portfolio Standard. Before the bill was signed, the Environmental Review Commission of the North Carolina General Assembly requested that the North Carolina Utilities Commission (NCUC) undertake a cost-benefit analysis of the program. The NCUC contacted La Capra Associates to perform the analysis.

La Capra presented their findings to the Renewable Energy Committee in December of 2006. Their analysis outlined multiple benefits to the state such as augmented job creation, increased revenue from property taxes, and a reduction in the social costs of electricity from coal power plants.[2] The bill was passed the following August and implemented in February of 2008 after the NCUC issued its Order Adopting Final Rules.[3]

North Carolina's RPS, named the Renewable Energy and Efficiency Portfolio Standard (REPS), is not the most extreme in the nation—it requires investor owned utilities to produce a relatively scant 12.5 percent of 2020 retail electricity sales from eligible renewable resources in 2021. The requirements are even lower for municipal utilities and electrical cooperatives—they only have to meet a target of 10 percent by 2018, and they obey slightly different rules. The fact that utilities may use energy efficiency technologies to meet up to 25 percent of target production, and that they may use energy demand reduction technologies to meet up to 100 percent of target production, may also soften the blow.[4] The following technologies have been approved as appropriate renewable resources: solar-electric, solar thermal, wind, hydropower up to 10 megawatts (MW), ocean current or wave energy, biomass that uses Best Available Control Technology (BACT) for air emissions, landfill gas, combined heat and power (CHP) using waste heat from renewables, and hydrogen derived from renewables. Municipalities and cooperatives may produce up to 30 percent of their required renewable production using hydropower.

North Carolina policy makers have a unique approach to how they would like to see renewable energy produced. The RPS explicitly mandates specific amounts of production from the following resources by 2021: solar, swine waste, and poultry waste (the last two count as

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1 Cherry, D., Saha, S. (2008). Renewable energy in North Carolina. Popular Government, 73(3), p. 12-23. Retrieved from http://iei.ncsu.edu/wp-content/uploads/2013/01/renewableenergync.pdf

2 La Capra Associates (2006). Analysis of a Renewable Portfolio Standard for the State of North Carolina. Retrieved from http://www.ncuc.commerce.state.nc.us/reps/NCRPSReport12-06.pdf

3 North Carolina Utilities Commission. (2014). Renewable energy and energy efficiency portfolio standard. Retrieved from http://www.ncuc.commerce.state.nc.us/reps/reps.htm

4 American Council on Renewable Energy. (2014). Renewable energy in the 50 states: Southeastern region. Retrieved from http://www.acore.org/images/documents/Southeastern_Region.pdf

“biomass”). 0.02 percent production from solar is required beginning in 2010 and increasing to 0.2 by 2021; 0.07 percent production from swine waste is required beginning in 2014 and increasing to 0.2 percent by 2021. Mandatory poultry waste use begins in 2014 as well, starting with a requirement of 170,000 MWh and increasing to 900,000 MWh by 2021.[5] As with most other RPS, North Carolina utilities may trade or stockpile RECs.

The RPS in North Carolina has also faced opposition since its creation, most recently—and vociferously—from the American Legislative Exchange Council. They have targeted North Carolina as part of a nationwide campaign to rid consumers of RPS and the economic burdens they create. In 2013, with the support of ALEC, House Majority Whip Mike Hager introduced HB 298, the “Affordable and Reliable Energy Act,” but the bill was eventually killed.[6]

The fight over RPS in North Carolina is likely not over. The analyses in following sections of this report will be indispensable for predicting the effects of future bills that would either repeal or strengthen the RPS.

RESULTS

THEORETICAL ANALYSIS

Analysis Performed by the Beacon Hill Institute at Suffolk University

The North Carolina REPS requires that investor-owned utilities produce a total of 12.5 percent of their electricity from renewable energy, or reduce consumption through energy efficiency measures. Municipal owned utilities must meet at target of 10 percent by 2021.[7] As part of these mandates, specific “carve-outs” are included which require that specific percentages of electricity be generated from swine and poultry waste as well as solar power.

The REPS law contains provisions that enable electric utility companies to recoup these costs from customers by implementing a Cost Recovery Rider (CRR). The cost recovery rider is subject to a cap that peaks at annual cost of $34 for residential customers, $150 for commercial customers and $1,000 for industrial customers.

5 United States Department of Energy. (2014). Database of State Incentives for Renewables & Efficiency. Retrieved from http://www.dsireusa.org/

6 Voters Legislative Transparency Project. (2013). Bill to repeal North Carolina’s RPS passes House committee. Retrieved from http://vltp.net/bill-to-repeal-north-carolinas-rps-passes-house-committee/

7 North Carolina Utilities Commission. (2006, December 13). Renewable Energy and Energy Efficiency Portfolio Standard. Retrieved from http://www.ncuc.commerce.state.nc.us/r eps/reps.htm

Renewable energy such as wind and solar power cost more than conventional energy. Energy efficiency measures necessitate large investments that produce a return that is realized in small increments spread out over many years.

The return on energy efficiency investments also are subject to several factors that will diminish their effectiveness in reducing future electricity rate increases. First, energy efficiency investments are subject to diminishing marginal returns. After consumers exhaust the cheapest and most effective measures (e.g., efficient light bulbs), subsequent energy efficiency investments will be less effective and more costly. Second, energy efficiency investments are susceptible to the "rebound effect" and "free riders." The rebound effect occurs when consumers see their electricity bill decrease and, in response, increase their electricity consumption as supply and demand models predict. An example of a free rider would be a consumer who would have made the energy efficiency investments in the absence of any energy efficiency incentives, but now reaps the reward anyway. Finally, energy efficiency incentives simply transfer a portion of the investment cost from one electricity consumer who does not make the investment—maybe for financial reasons—to another consumer who does.

Table 1 displays the cost of the REPS for the years 2010 through 2014. The total for all six years is $276 million dollars. However, this is with a REPS mandate that only reaches three percent of total electricity sales in 2012. Moreover, the costs are concentrated on the industrial customer. For example, in 2013, industrial customers paid $38.8 million for the CRR, or $390 per customer, while residential customers paid $19.6 million, or $4.62 per customer. The cost increases will surge under the 2021 mandate of 12.5 percent, and as a result electricity prices will likely follow.

TABLE 1: THE COST OF THE NORTH CAROLINA REPS LEGISLATION TO DATE (MILLIONS OF DOLLARS).

Customer type	2010	2011	2012	2013	2014	Total
Residential	15.8	23.2	27.2	19.6	9.7	118
Industrial	12.1	17.6	20.9	38.8	33.4	140
Commercial	2.1	2.9	3.5	4.0	2.5	18
Total	30.0	43.7	51.6	62.4	45.6	276

Table 2 displays our cost estimates of the REPS legislation through its effect on retail electricity prices and, thus electricity consumers under two scenarios. The first assumes that the cost recover rider reaches the annual caps established by the legislation. In this case, electricity prices would rise by 2.3 percent for residential customers, 2.1 percent for commercial customers and 0.41 percent for industrial customers.

The second scenario assumes that policymakers raise the caps in order to reach the REPS mandates. In this case, electricity prices would rise by 2.2 percent for residential customers, 12.1 percent for commercial customers and 1.1 percent for industrial customers. Under this scenario, the residential CRR comes in under the price cap, while commercial and industrial CRRs would be well above their respective price caps. If policymakers were to strictly enforce the current cost caps for all customer types, the cost cap for commercial customers would effectively, though inadvertently, freeze the amount of renewable electricity produced at 6.75 percent in 2017, short of the 10 percent required by the following year.

TABLE 2: THE EFFECT OF THE REPS ON NORTH CAROLINA ON ELECTRICITY PRICES AND CONSUMERS.

Cost Cap	**Residential**	**Commercial**	**Industrial**
total annual cost ($ million)	149	94	9
Per customer ($)	34	150	1,000
Cents per kWh	0.27	0.19	0.03
Percentage increase	2.3	2.1	0.41
No Cost Cap			
Total annual cost ($ million)	142	533	25
Per customer ($)	32	847	2,679
Cents per kWh	0.26	1.10	0.08
Percentage increase	2.2	12.1	1.1

In each situation, the commercial electricity customer bears the brunt of the REPS costs and increase in electricity price increases, posing potential threat to the competitiveness of North Carolina's commercial business base. These results portend dire consequences for the state, and so we prudently turn to our empirical analysis to verify their validity.

EMPIRICAL ANALYSIS

Analysis Performed by Tyler Brough, Ph.D., at Utah State University

STATE COINCIDENT EVENT STUDY

In this section, we present the results of an event study for state coincident indices—a methodology first fashioned by the Federal Reserve Bank of Philadelphia.[8] The event study indexes the economic conditions of all states across multiple points in time, and assigns as "point zero" each state's economic conditions on the dates of their respective RPS implementations. The study then compares said economic conditions over a span of 48 months before to 48 months after that enactment date. We then average the results across the different states, which, given that RPS have been implemented in states over a long period, should minimize the effects of anomalies such as recessions and the enactment of other energy-related laws. The indices of each state RPS policy, while enacted in a different calendar month and year, can thus be lined up in this so-called "event time" and averaged. For these reasons, the event study has become a

8 Federal Reserve Bank of Philadelphia. (2015, January 29). State coincident indexes. Retrieved from http://www.philadelphiafed.org/research-and-data/regional-economy/indexes/coincident/

time-honored empirical methodology in finance and economics and a standard course of analysis for the Philadelphia Fed. It is a simple but powerful method for measuring the effect of an exogenous shock to an economic variable of interest. See Mackinlay for a more in-depth discussion of the event study methodology.[9] Table 3 presents the dates of 31 different states that have enacted an RPS policy.

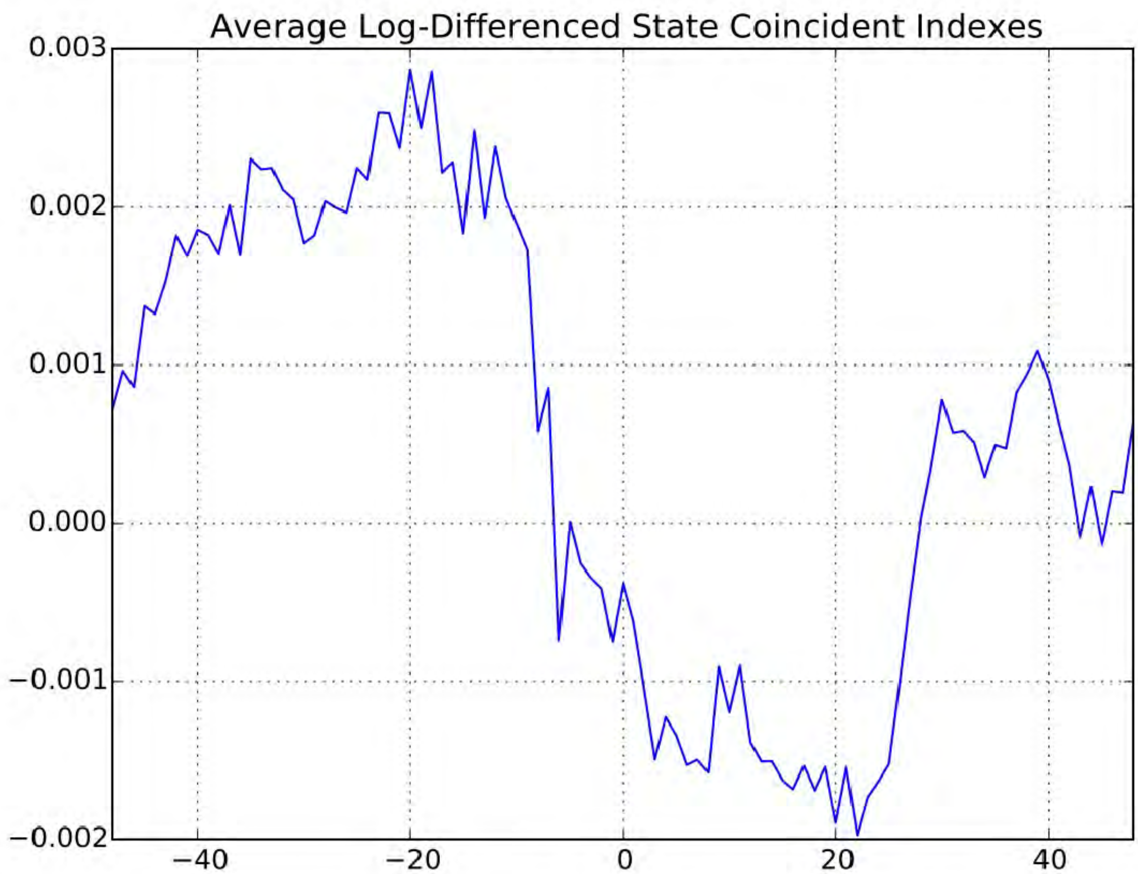
TABLE 3: THE DATES (MONTH AND YEAR) OF THE 31 STATES THAT HAVE ENACTED AN RPS POLICY TO DATE

State	RPS Enactment Date
Arizona	December, 1996
California	January, 2003
Colorado	December, 2004
Connecticut	July, 1998
Delaware	July, 2005
Hawaii	December, 2003
Iowa	January, 1983
Illinois	August, 2007
Kansas	July, 2009
Massachusetts	April, 2002
Maryland	January, 2004
Maine	March, 2000
Michigan	October, 2008
Minnesota	February, 2007
Missouri	November, 2008
Montana	April, 2005
North Carolina	January, 2008
New Hampshire	July, 2007
New Jersey	February, 1999
New Mexico	July,2004
Nevada	July, 1997
New York	September,2004
Ohio	July, 2008
Oregon	June, 2007
Pennsylvania	February, 2005
Rhode Island	June, 2004
South Carolina	June, 2014
Texas	September, 1999
Washington	December, 2006
Wisconsin	December, 2001
West Virginia	July, 2009

9 MacKinlay, A.C. (1997). Event studies in economics and finance. Journal of Economic Literature, 35(1), 13-39.

The results of the event study are presented in Figure 1, wherein we see the response of the state coincident index to the enactment of RPS policies. The coincident index is a measure of the strength of a state economy.

FIGURE 1: THE RESPONSE OF THE STATE COINCIDENT INDEX TO THE ENACTMENT OF RPS POLICIES.



The horizontal axis shows months before and after point zero (RPS enactment). The vertical axis shows an indexed scale measuring the average reaction of states in terms of several economic indicators.

As can be seen in Figure 1, the average effect on the state coincident index is a precipitous drop surrounding the enactment of an RPS policy. This evidence is suggestive of a negative effect of an RPS policy on a state economy. While suggestive, the evidence from the event study warrants further exploration into the effects, since state economies also appear to decline several months prior to the enactment of an RPS. The next section presents the structural panel VAR-X model, which provides further evidence of the negative economic effects of an RPS.

THE STRUCTURAL PANEL VAR-X MODEL

The VAR model takes into account the nature of the state macroeconomic variables that could provide unwanted feedback into the model, and considers their dynamic interactions. By including a panel dimension to the model we can include the data for multiple states in a single model. We include fixed effects to control for state-level heterogeneity. We impose a recursive causal ordering on the VAR-X model to allow for structural interpretation of dynamic multiplier analysis of the RPS policy variable. Table 4 presents the cumulative effects of an RPS on the state economy via structural policy simulations.

TABLE 4: THE LONG-RUN EFFECTS ON STATE MACROECONOMIC VARIABLES

State Economic Variable	Long-Run Effect
Electricity Sales	-14.43%
Real Personal Income	-3.53%
Non-farm Employment	-2.52%
Manufacturing Employment	3.53%
Unemployment Rate	7.85%

The cumulative effect of the enactment of an RPS policy on state electricity sales is a staggering 14.4-percent decline. This is, perhaps, not surprising as the RPS increases the cost of electricity generation. Real personal income declines in the long run by 3.53 percent, which figures to a loss of $13.5 billion in 2013, or $3,497 less per family.[10] Non-farm employment declines in the long run by 2.52 percent. Only one analyzed component of non-farm employment, manufacturing employment, does not experience a long-term suppression in response to an RPS policy, although as we see in the graphical analysis, it does still experience a sharp decline in the short term. Most significantly, the state unemployment rate increases by 7.5 percent. This means that, at the end of last year, North Carolina had 32,239 fewer jobs than it would have had without the RPS.[11] There can be no doubt that the combined economic effect on an RPS enactment, as measured by the structural panel VAR-X model, is a severe decline in the North Carolina economy. A graphical representation of the analysis, showing the changes over time that lead to these results, can be found in Appendix C.

CONCLUSIONS FROM THE EMPIRICAL ANALYSIS

We demonstrate strong empirical evidence that a Renewable Portfolio Standard has a lasting negative effect on a state economy. We present this evidence from both an event study of the state coincident index as measured by the Federal Reserve Bank of Philadelphia, as well as from

10 Bureau of Economic Analysis. (n.d.). Regional Data, Annual State Personal Income and Employment. Retrieved from http://www.bea.gov/iTable/iTable.cfm?reqid=70&step=1&isuri=1&acrdn=1#reqid=70&step=1&isuri=1

11 Bureau of Labor Statistics. (n.d.). North Carolina. Retrieved from http://www.bls.gov/regions/southeast/north_carolina.htm

structural policy simulations from a panel VAR-X model. The long-run effect of an RPS on state industrial production, as measured by electricity sales, is greater than a 14-percent decline. Real personal income declines in the long run after an RPS by 3.53 percent. The cumulative effect of an RPS on non-farm employment is a 2.52 percent decline. While the effect of an RPS on manufacturing employment is not as severe in the long run, it too demonstrates initial sharp declines lasting for several years. Finally, the state unemployment rate increases in the long run in response to an RPS by nearly 8 percent. These are strong and lasting effects in 4 of the 5 variables measuring the state economy. The combined econometric evidence makes clear that an RPS policy has a severely negative economic effect on a state that enacts such.

INSTITUTIONAL ANALYSIS

Our analysis of the legal rules surrounding the North Carolina's REPS suggests that the law may contain inherent hindrances to compliance. Considering these hurdles is important for judging an RPS on its own terms—even if we were to assume that RPS pose no economic threats, a statutory and regulatory structure that hinders compliance should call into question the propriety and efficacy of the law itself.

As discussed earlier, REPS carve-outs require 0.2 percent of North Carolina's renewable electricity must come from solar by 2019, another 0.2 percent must come from swine waste by 2019, and 900,000 MWh must come from poultry waste by 2016. Because both the swine and poultry waste requirements were originally statewide in nature, and not applied to each utility, we would expect this to have created a free-rider problem by which utilities, in assuming that their competitors will pick up the slack, feel less of an incentive to achieve compliance; this would ensure that utilities will generally not meet their goals across the state. Although the NCUC eventually corrected this problem, defining poultry and swine waste requirements for each individual utility, the negative effects of the original policy lingered. As a result, both the swine and poultry waste requirements were delayed in 2012[12] and 2013,[13] and the swine waste requirement was delayed yet again in 2014.[14] While in all cases, the NCUC has concluded that utilities "have made a reasonable effort to comply" with the mandates—given being constrained by fledgling technology—the NCUC also found that there are "additional factors contributing to

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12 North Carolina Utilities Commission. (2012, August 28). Docket No. E-100, Sub 113: Order modifying the poultry and swine waste set-aside requirements and granting other relief. Retrieved from http://starw1.ncuc.net/NCUC/ViewFile.aspx?Id=a3c753d4-0820-4961-890a-e594174146a9

13 North Carolina Utilities Commission. (2013, November 5). Docket No. E-100, Sub 113: Final order modifying the poultry and swine waste set-aside requirements and providing other relief. Retrieved from http://starw1.ncuc.net/NCUC/ViewFile.aspx?Id=84e6ed39-314a-41b0-bd8a-ac69c4ad0a84

14 North Carolina Utilities Commission. (2014, August 28). Docket No. E-100, Sub 113: Order modifying the swine waste set-aside requirement and providing other relief. Retrieved from http://starw1.ncuc.net/NCUC/ViewFile.aspx?Id=15b744a5-4826-4e56-8823-387cecffb33e

the inability to comply [including] interconnection issues, reluctance of farmers to sign long-term fuel supply agreements, uncertainty in contract fulfillment based on past lack of performance, and *the uncertainty caused by the previous delays to the swine waste set-aside requirement* [emphasis added], among others."[15] All these factors stem from previous and ongoing bureaucratic mismanagement, which are inherent to REPS—and government mandates for renewable electricity in general—and are unavoidable constraints on achieving compliance.

Even in the event that utilities meet their poultry and swine waste goals, we should view that accomplishment within a larger context: The stated central purpose of every RPS, and in the general promotion of renewable energy, is the mitigation of global climate change. Generating electricity from the combustion of swine and poultry waste, a process that emits pollution, seems to defeat that purpose. While proponents often tout the burning of poultry and swine waste for heat or power as good for reducing CO_2 emissions,[16] other pollutants may increase. As Baranyai and Bradley note, "due to the high concentration of nitrogen in the poultry manure, there may be significant fuel NO_x emissions. Nitrogen-oxides dissolved in the moisture of the atmosphere cause acid-rain and immediately end up in surface waters."[17]

Returning to its inherent legal barriers, the REPS contains several regulatory obstacles to generating renewable energy certificates (RECs) for the purpose of satisfying its mandates. The owner of a generator must first receive approval from the NCUC before RECs from their generator can be traded on the North Carolina Renewable Energy Tracking System (NC-RETS). In order to obtain this approval, the owner must consent to random, at-will, NCUC-audits of all his financial records.[18]

The regulatory hurdles don't end even once the generator owner receives registration to trade on NC-RETS. If the owner does not sell an REC produced at his facility within three years, then the REC may no longer be sold on NC-RETS; further, that REC must be retired within seven years from when their cost was recovered, or it is no longer valid. Utilities may use out-of-state RECs to meet up to 25 percent of the REPS mandates, and triple credit is given for every REC generated by the first 20 MW of a biomass facility located at a "cleanfields renewable energy demonstration park."[19] These parks must feature clean-energy facilities, laboratories, and

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15 Ibid.

16 Nicole, W. (2014, February 21). Pig poop powers North Carolina farm. Discover. Retrieved from http://discovermagazine.com/2014/march/17-pig-poop-powers-north-carolina-farm

17 Baranyai, V., & Bradley, S. (2008). Turning Chesapeake Bay Watershed Poultry Manure and Litter into Energy. Chesapeake Bay Program. Retrieved from http://www.chesapeakebay.net/documents/cbp_17018.pdf

18 North Carolina Utilities Commission. (n.d.). Chapter 8. Electric Light and Power, R8-66(b)(5) Registration of Renewable Energy Facilities, Annual Reporting Requirements. Retrieved from http://www.ncuc.net/ncrules/Chapter08.pdf

19 United States Department of Energy. (2014). Database of State Incentives for Renewables & Efficiency. Retrieved from http://programs.dsireusa.org/system/program/detail/2660

companies and include at least three renewable energy or alternative fuel facilities, one of which must be a biomass renewable energy facility.

Utilities are allowed to recover the incremental cost of renewable energy resources and up to $1 million in alternative energy research expenditures annually from consumers. Costs were capped at the following levels: For residential consumers, $10 in 2008, $12 in 2012, and $34 in 2015; for commercial consumers, $50 in 2008, $150 in 2012, and $150 in 2015; for industrial consumers, $500 in 2008, $1000 in 2012, and $1000 in 2015. Cost caps such as these, while sparing utilities and consumers from animosity and discontent, do create a further hurdle for the state in actually achieving its goal. As demonstrated in our theoretical analysis, adhering to the current cost caps would prevent utilities from meeting their goals for compliance beyond 2017.

Utilities must submit two annual reports to the NCUC. The first report is the Compliance Report, which documents how the utility met the renewable energy requirement of the previous year. The second report, the Compliance Plan, documents the utility's plan to meet future REPS requirements. The time and personnel it takes to take inventory of all a utility's actions toward this purpose pose a considerable drain on the activities that actually contribute to customer satisfaction.

RENEWABLE ENERGY DEVELOPMENT

While the REPS does not contain any specific restrictions on development, developers are still subject to environmental restrictions from the Department of Environment and Natural Resources, as well as local zoning laws. For example, interconnection with utilities is overseen by the NCUC but must carried out by the utility.[20]

Adherence to federal environmental regulations is also a criterion of compliance with REPS. According to the rules established by the NCUC, any owner of a facility that generates renewable electricity "shall certify in [that facility's] registration statement and annually thereafter that it is in substantial compliance with all federal and state laws, regulations, and rules for the protection of the environment and conservation of natural resources."[21] Given that there are innumerable state and federal laws and regulations regarding the protection of the environment, placing the burden of complying with them on utilities translates into heavily increased legal costs. Consequently, failure to comply with REPS causes not only a punitive response from the federal government for not meeting its expectations, but it also exposes utilities to the penalties of non-compliance with the REPS itself—a legal double-whammy.

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20 Ibid.

21 NCUC (n.d.), op. cit., R8-66(b)(2)

The cumulative effect of these institutional barriers to compliance threatens the efficacy of the entire program, even if all other economic factors were equal. This consideration of REPS on its own terms should give pause to those who take for granted compliance and enforcement with any law or regulation.

CONCLUSION

The evidence from these studies paints a clear picture about the effects of RPS. Both our theoretical and our empirical analyses point to a marked detraction from the economic health of states that enact such laws. Our institutional analysis further describes the barriers that make it difficult for utilities to comply and for bureaucracies to enforce the RPS. Any state currently deliberating on implementing a new RPS, or strengthening an existing one, should head these results as a warning of their harmful effects. Finally, states should refrain from following the fad of enacting such costly regulations, in spite of the policy's political palpability or expediency.

APPENDIX A

TECHNICAL CONSIDERATIONS OF THE BEACON HILL INSTITUTE'S STUDY IN NORTH CAROLINA

METHODOLOGY

Authored by the Beacon Hill Institute at Suffolk University

Since the CRRs charges are applied directly to the customers' bill to recover the cost of the REPS policy, BHI utilized recent CRR data to project future CRRs, and thus electricity price increases.

Table 5 displays the average of the approved annual CRRs for Duke Energy and Duke Progress Energy from 2010 to 2014 under the REPS mandate.[22] In the first three years, the CRRs for residential customers grew rapidly and then reversed for the remainder of the period. Commercial customers have experienced a similar pattern, except for the significant spike between 2012 and 2013. Finally, industrial customers pay the highest CRRs by far and thereafter face rapid growth in the first two years before significantly declining in 2013 with more modest growth resuming in 2014. The period of rapid reversals are likely to result from the frontloading of the RPS costs to 2010 and 2011, when the REPS mandate was negligible. This situation is unlikely to repeat itself in future years. We do not use the 2014 CRRs reported, because Duke Energy Progress have not been approved by the NCUC yet, and past CRR request have frequently been adjusted, up and down, by the Commission.

TABLE 5: AVERAGE ANNUAL COST RECOVERY RIDER FOR 2010 - 2014

Year	Residential	Commercial	Industrial
2010 ($)	3.78	18.84	188.70
2011 ($)	5.52	27.24	272.46
% growth	46	45	44
2012 ($)	6.42	32.04	335.40
% growth	16	18	23
2013 ($)	4.62	59.40	235.32
% growth	-28	85	-30
2014 ($)	4.92	37.68	263.46

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22 North Carolina Utilities Commission. (2014, October 1). Renewable Energy and Energy Efficiency Portfolio Standard (REPS), annual report regarding Renewable Energy and Energy efficiency Portfolio Standard in North Carolina, Years 2010-2014, p. 34-41. Retrieved from http://www.ncuc.net/reports/repsreport2014.pdf

% growth	6	-37	12
CAGR 2010 – 2015 (%)	6.8	18.9	8.7

The compound annual growth rate (CAGR) of the CRRs ranges from 6.8 percent for residential customers to 18.9 percent for commercial customers, with industrial customers in the middle at 8.7 percent. We also know that the REPS mandate will increase to 12.5 percent in 2021 and we need to account for that. We should expect that the demand for RECs should increase dramatically as the RPS mandates of the 31 RPS states will increase to over 20 percent, and some 30 percent in 2020. It is unclear if supply of RECs will be able to meet this surging demand. If so, REC prices would remain somewhat stable, if not REC prices would soar and the CRRs would follow. We assume that the demand for RECs will cause their prices to increase and that the supply response will lag the surge in demand creating a shortage of RECs. We use the CAGR to estimate price of the CRRs for 2021 by applying them to the average CRRs for the years 2012, 2013 and 2014—the years in which the 3 percent REPS mandate was in place.

We also account for the fact that the REPS mandate will increase to 12.5 percent in 2021, or by a factor of 4.17. Therefore, after growing the CRRs to 2021, we multiply them, by the factor or 4.17, assuming that the CRRs increase in a linear fashion from 2014 to 2021 to respond to the increase in the REPS mandate. As a result we get annual CRRs of $32 for residential, $847 for commercial and $2,679 for industrial customers.

We estimate the aggregate CRR revenue by multiplying our average annual estimate of the CRR by our estimate of the number of electricity customers in each group. We estimate the number of customers using past data from the U.S. Energy Information Administration (EIA).[23,24] For example, we multiply the average annual residential CRR of $37 by 4,392,206 million, the estimated number of residential customers in 2021. We rounded the numbers to the nearest million. The process was repeated for the other two types of retail customers.

We then divide the aggregate CRR revenue number by the estimated of retail sales in kilowatt hours (kWh) for each customer group. We estimate retail sales using the EIA regional forecast for the SERC reliability Corporation. For example, the $163 million in aggregate CRR revenue divided by 55 billion kWh equals 0.29 cents. We than divide the 0.29 cents by the projected state price of 11.86 cents to get our price increase of 2.5 percent. Again, the process was repeated for the other two types of retail customers.

23 Energy Information Administration. (2003, July 21). Supplement tables to the Annual Energy Outlook 2009, 2010, 2011, 2012, table 3: Top five retailers of electricity, with end use sectors. Retrieved from http://www.eia.gov/oiaf/archive/aeo03/supplement/suptab_82.htm

24 Ibid., Electric power projections by electricity market module region, SERC Reliability Corporation / Virginia-Carolina, reference case.

APPENDIX B

EXPLANATION OF EMPIRICAL STUDY METHODOLOGY

Authored by Tyler Brough, Ph. D.

In this technical appendix, I outline the details of the structural panel VAR-X model, its estimation, and its use for policy simulation.

0.1. The Panel VAR-X Model

The vector autoregressive (VAR) model is the standard work horse model in empirical macroeconomics. The basic p-lag VAR model can be written as:

$$y_t = a_0 + \sum_{j=1}^{p} A_j y_{t-j} + \varepsilon_t$$

where y_t for t = 1, . . . , T is an M vector of observations on M time series variables, ε_t is an $M \times 1$ vector of errors, a_0 is an $M \times 1$ vector of intercepts and the A_j are $M \times M$ matrices containing model coefficients.[25] This is the reduced-form VAR model. For the present study $y_t = (y_{1t},...,y_{Mt})'$, M = 5, and the y_{jt} are the five state macroeconomic variables presented in the main body of the paper, namely electricity sales, real personal income, non-farm employment, manufacturing employment, and the unemployment rate. Thus, the VAR model is a system of M equations, with one equation for each variable in the system. Each of the M = 5 variables is treated as endogenously determined.

The present model also includes an exogenous policy variable that represents the enactment of an RPS by a given state. Thus, we can now write the VAR-X (a VAR model with the exogenously determined variable) as follows:

$$y_t = a_0 + \sum_{j=1}^{p} A_j y_{t-j} + \sum_{k=1}^{q} B_{t-k} X_{t-k} + \varepsilon_t$$

where the X_{t-k} vectors contain the exogenous variables and their lags, and the B matrices contain the coefficients respectively. The variables in the X vector affect the state of the other variables, but are not themselves determined by the system of equations, and thus are considered exogenous.

25 Lutkepohl, H. (2005, Spring). New introduction to multiple time series analysis, Chapter 2.

In addition, the present model adds a cross-sectional dimension to the basic VAR(p) model by essentially stacking the VAR models for the different states on top of each other. In other words, the panel VAR-X model is:

$$y_{1,t} = a_{1,0} + \sum_{j=1}^{p} A_j y_{1,t-j} + \sum_{k=1}^{q} B_{t-k} X_{t-k} + \varepsilon_{1,t}$$

⋮

$$y_{M,t} = a_{M,0} + \sum_{j=1}^{p} A_j y_{M,t-j} + \sum_{k=1}^{q} B_{t-k} X_{t-k} + \varepsilon_{M,t}$$

See Canova and Ciccarelli for an excellent survey of panel VAR methods.[26] One thing of note is that in the present study I do not focus on estimating dynamic heterogeneities between the different state economies as is done in many panel VAR models for large macroeconomic studies. Instead I focus on the average effect of an RPS enactment on a state economy. To that end, I estimate the model with fixed effects to control for possible heterogeneities across states.[27] It is possible to recover the state fixed effects, though I make no effort to do so here as the focus of the study is on the average effect of an RPS and not on individual state effects.

0.2. Model Estimation

I use Bayesian techniques, namely the Gibbs sampler, to estimate the structural panel VAR-X model. See Ciccarelli and Rebucci for a review of Bayesian methods for VAR models.[28] See also Ocampo and Rodr´ıguez for a very practical tutorial.[29] I follow their Algorithm 3 for Bayesian estimation, which for simplicity I reproduce below.

Algorithm 1 Bayesian Estimation

1. Select the specification for the reduced form VAR-X, that is to choose values of p (endogenous variables lags) and q (exogenous variables lags) such that the residuals of the VAR-X (ε) have white noise properties. With this the following variables are obtained: T, p, q, k, where:

$$k = 1 + np + m(q + 1)$$

26 Canova, F., & Ciccarelli, M. (2013). Panel vector autoregressive models: A survey.

27 Greene, William. (2012). Econometric Analysis. Upper Saddle River, NJ: Prentice Hall.

28 Ciccarelli, M., & Rebucci, A. (2003). Bayesian VARs: A survey of recent literature with an application to the European monetary system.

29 Ocampo, S., & Rodríguez, N. (2012). An introductory review of a structural VAR-X estimation and applications. Revista Colombiana de Estadística, 3, 479-508.

2. Calculate the values of $\hat{\Gamma}$, S with the data (Y, Z) as:

$$\hat{\Gamma} = (Z'Z)^{-1}Z'Y \qquad S = (Y - Z\hat{\Gamma})'(Y - Z\hat{\Gamma})$$

3. Generate a draw for matrix Σ from an inverse Wishart distribution with parameter S and $T - k$ degrees of freedom.

$$\Sigma \sim iW_{pdf}(S, T - k)$$

4. Generate a draw for matrix Γ from a multivariate normal distribution with mean $\hat{\Gamma}$ and covariance matrix $\Sigma \otimes \ (Z'Z)^{-1}$

$$\Gamma | \Sigma \sim MN_{pdf}(\hat{\Gamma}, \Sigma \otimes (Z'Z)^{-1})$$

Repeat steps 2-3 as many times as desired, save the values of each draw.

The draws generated can be used to compute moments of the parameters. For every draw the corresponding structural parameters, impulse response functions, etc. can be computed, then their moments and statistics can also be computed. The algorithm for generating draws for the inverse Wishart and multivariate normal distributions are presented in Bauwens et al., Appendix B.[30]

Observe that in this notation

$$Y = \begin{bmatrix} y'_1 \\ \vdots \\ y'_t \\ \vdots \\ y'_T \end{bmatrix}$$

,

30 Bauwens, L., Lubrano, M., & Jean-Francois, R. (2000). Bayesian inference in dynamic econometric models. Oxford, UK: Oxford University Press.

$$Z = \begin{bmatrix} 1 & y'_0 & \cdots & y'_{1-p} & x'_1 \\ \vdots & & & & \\ 1 & y'_{t-1} & \cdots & y'_{t-p} & x'_t \\ \vdots & & & & \\ 1 & y'_{T-1} & \cdots & y'_{T-p} & x'_T \end{bmatrix}$$

,

$$E = \begin{bmatrix} \varepsilon'_1 \\ \vdots \\ \varepsilon'_t \\ \vdots \\ \varepsilon'_T \end{bmatrix}$$

and finally,

$$\mathbf{\Gamma} = \begin{bmatrix} v & A_1 & \dots & A_p & B_0 & \cdots & B_q \end{bmatrix}$$

Then the VAR-X model can be written simple as

$Y = Z\Gamma + E$
I set $p = 3$ and $q = 1$ for simplicity.

0.3. Dynamic Multiplier Analysis

During the Gibbs sampling simulation, which I run for 5, 000 replications with 500 burn-in steps, I also conduct dynamic multiplier analysis for the exogenous RPS policy variable. I follow Algorithm 2 in Ocampo and Rodrıguez to conduct this analysis.[31] This algorithm is as follows:

Algorithm 2 Identification by Long-Run Restrictions

Estimate the reduced form of the VAR-X model.

31 Ocampo, S., & Rodríguez, N., op. cit.

Calculate the VMA-X representation of the model (matrices ψ_i) and the convariance matrix of the reduced form disturbance ε (matrix Σ).

From the Cholesky decomposition of $\psi(1)$ and $\Sigma\psi(1)$ calculate matrix $C(1)$

$$C(1) = chol(\psi(1)\Sigma\psi'(1))$$

1. With the matrices of long run effects of the reduced form, $\psi(1)$, and structural shocks, $C(1)$, calculate the matrix of contemporaneous effects of the structural shocks, C_0.

$$C_0 = [\psi(1)]^{-1}C(1)$$

2. For $i = 1, \dots, R$ with R sufficiently large, calculate the matrices C_i as:

$$C_i = \psi_i C_0$$

Identification is completed since all matrices of the structural VMA-X are known.

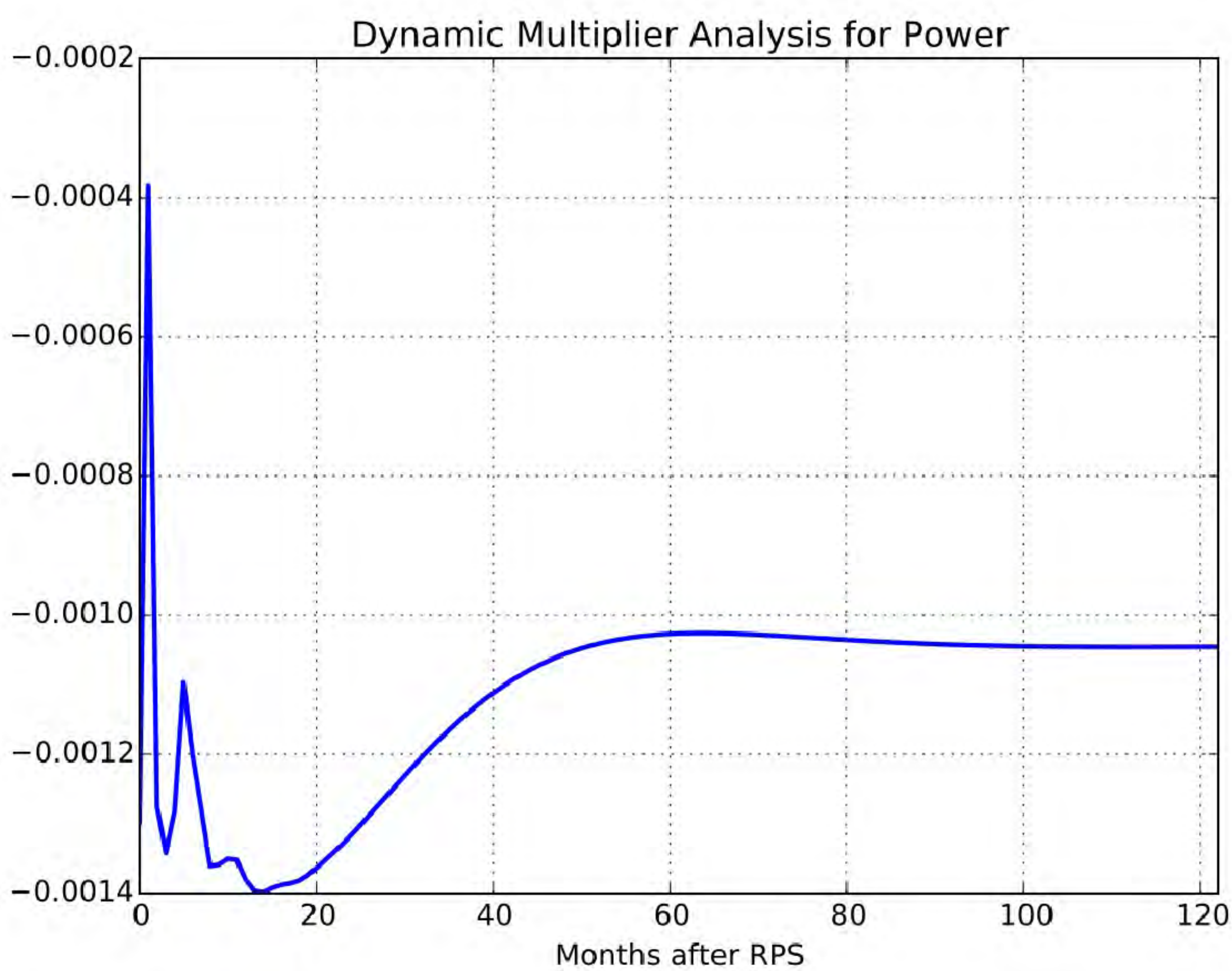
I set R = 120 months after an RPS to estimate the cumulative, or long-run effects of an RPS enactment for dynamic multiplier analysis.

APPENDIX C

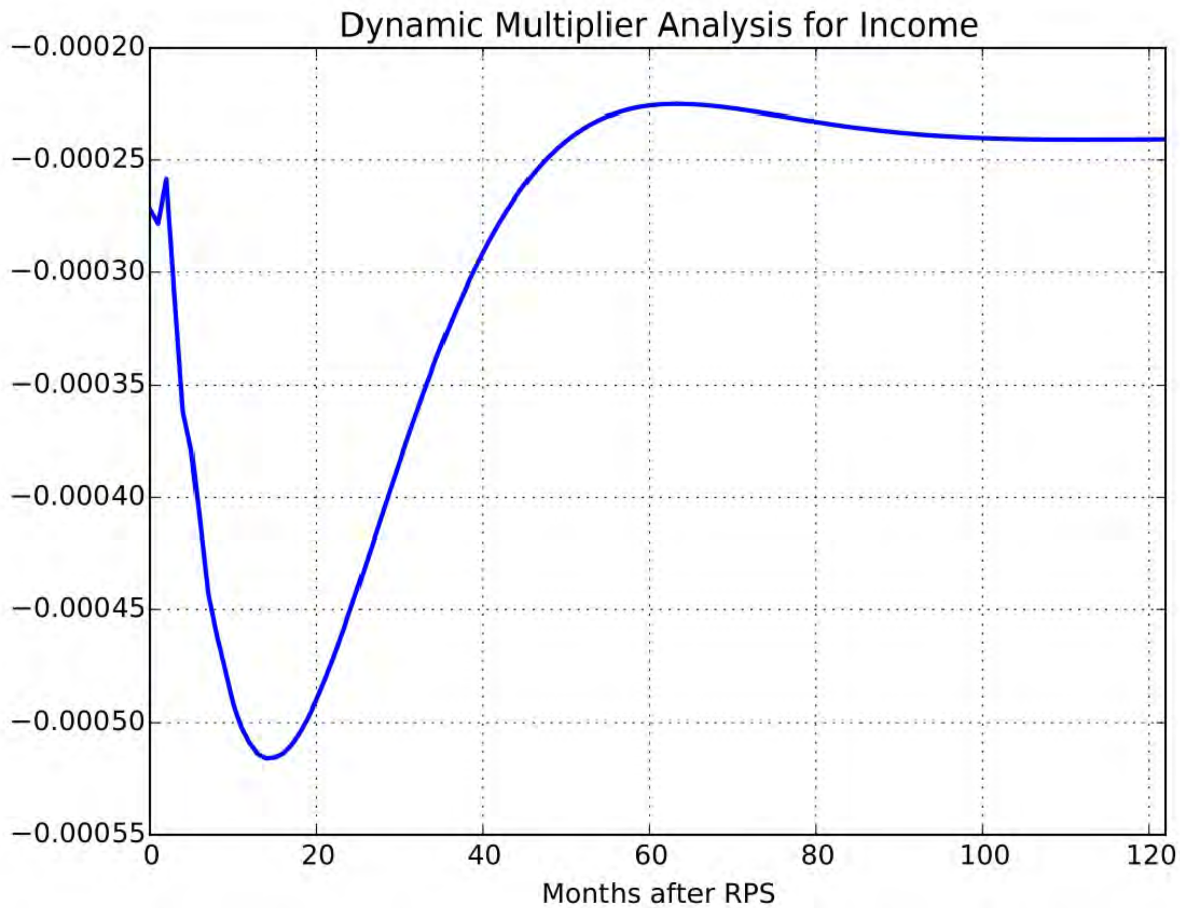
GRAPHICAL ANALYSIS OF THE DYNAMIC MULTIPLIER ANALYSIS

Analysis Performed by Tyler J. Brough, Ph.D., at Utah State University

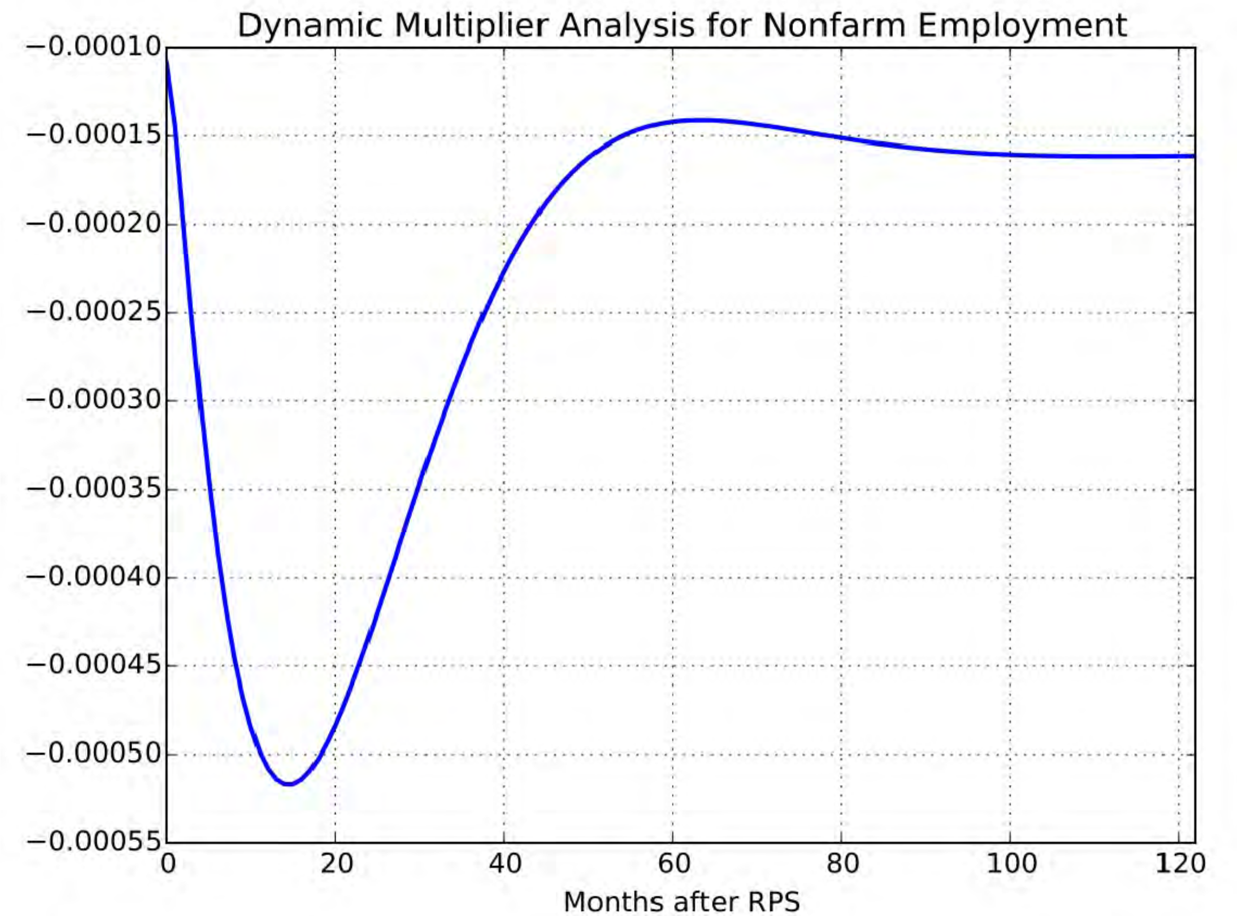
Below we present in graphical form the dynamic multiplier analysis for each of the five state macroeconomic variables. This analysis strengthens the evidence of a severely deleterious effect of an RPS policy. For electricity sales, real personal income, and non-farm employment the response to an RPS is an initial sharp decline lasting for several years and the long-run effect is a large and lasting decline. Manufacturing demonstrates the same initial sharp decline in response to an enacted RPS, but does show some recovery, after several years, though still never returns to levels prior to the RPS. However, the unemployment rate demonstrates a steadily increasing rate that cumulates into a large increase in state unemployment.



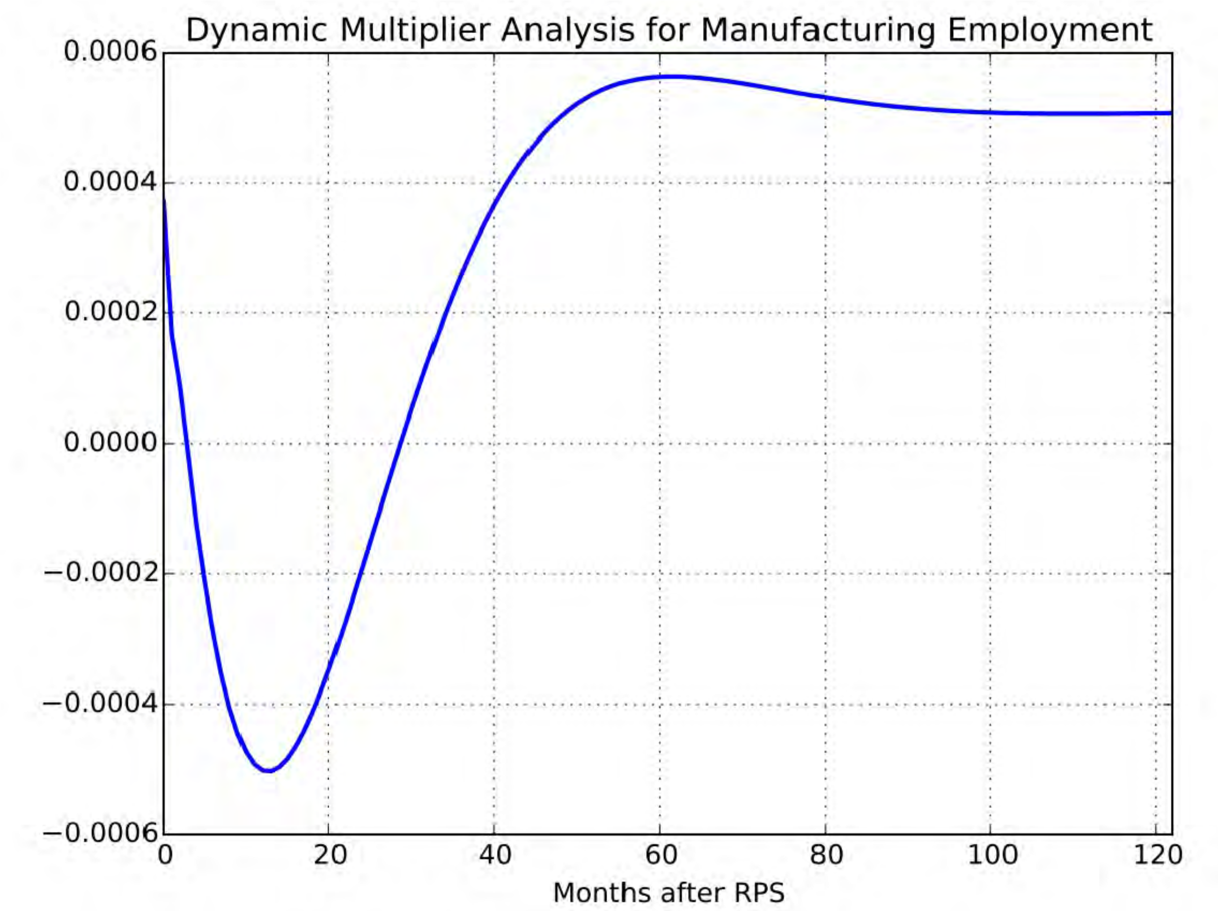
DYNAMIC MULTIPLIER ANALYSIS FOR ELECTRICITY SALES.



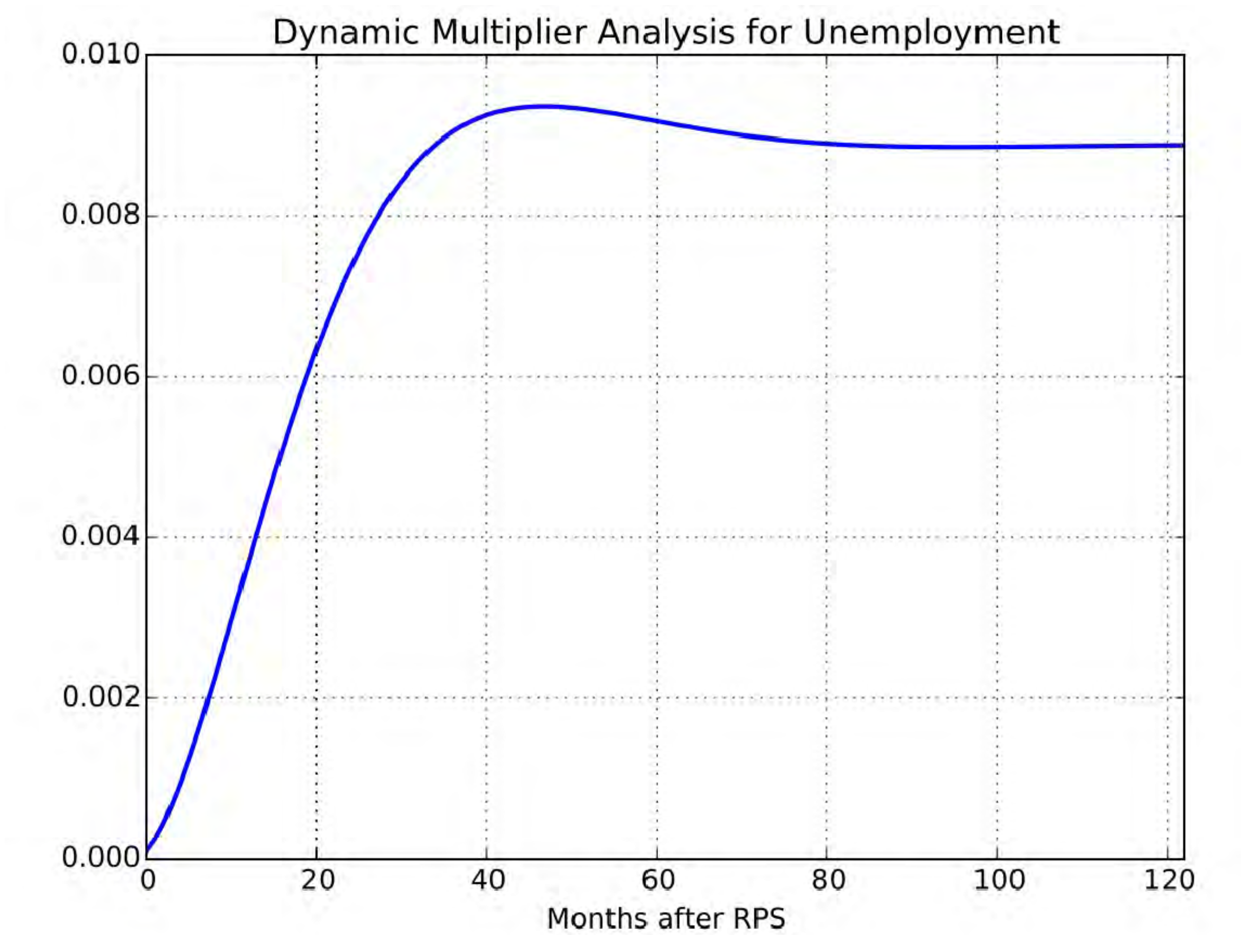
Dynamic Multiplier Analysis for Real Personal Income.



Dynamic Multiplier Analysis for Non-farm Employment.



Dynamic Multiplier Analysis for Manufacturing Employment.



Dynamic Multiplier Analysis for the Unemployment Rate.

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