A Sectoral Level General Equilibrium Analysis of Washington State Initiative 732 - A Revenue-Neutral Carbon Tax Policy

Washington State Initiative 732 is a proposed revenue-neutral carbon tax policy for the state of Washington, which will be on the November 8, 2016 ballot. The policy proposes a tax on carbon pollution from fossil fuels. The revenues raised from this tax will be used to offset two types of tax payments: a sales tax reduction across all sectors and a business and occupation tax reduction in the manufacturing sector. Some of the revenues will also be used to fund the Working Families Tax Rebate program that aids low-income households.

There are two objectives in the first study which relate to the first two years of the proposed policy. First, we determine the sectors in the economy that will carry the burden of the tax and the sectors that will enjoy the benefits of the policy. We find that three sectors that generate approximately 80% of total carbon revenues are the fossil fuel sector, the household sector and the service sector. Since agriculture is largely exempt, it is the smallest contributor. Benefits from a reduction in the sales tax are relatively more evenly distributed across the different sectors in the economy, with the service sector benefiting the most. The manufacturing sector also enjoys a reduction in the business and occupation tax. Second, we measure the welfare effects of implementing the policy. We estimate Gross Domestic Product (GDP) and Green GDP which is GDP net of pollution damages. GDP and Green GDP both increase after the policy is implemented which indicates that aggregate welfare increases. However, we find that low-income households that do not receive aid through the Working Families Tax Rebate program may incur a decline in welfare. Thus, to increase welfare for all households, the Working Families Tax Rebate program is important.

The second study analyzes the effect of the proposed policy on two important sectors in Washington State: the agricultural and forestry sectors. We find that the value of output in the agricultural and forestry sectors increases by 1.77% and 0.13%, respectively, during the second year of policy implementation. Even though the carbon tax reduces fossil fuel use in both sectors, the influx of labor and capital from the reduction in sales tax offsets this effect leading to a net increase in output value in both sectors. The impact on total exports is small but positive in the agricultural sector with an increase of 1.45%, and exports in the forestry sector see a negligible drop of 0.03%.

The final document in this volume provides a technical detail of the model. This includes the structure of the model, data sources, sectoral components, assumptions and functional forms used in the simulations and calibrations.

The studies summarized in this volume provide important information for voters in Washington State. Also, our study may be of value for other states proposing similar types of carbon-reducing policies, as our model can provide a template for sectoral level analysis and welfare evaluation of a revenue-recycling tax policy.

Who Pays and Who Benefits from a Revenue Neutral Carbon Tax? The Main Contributors and Beneficiaries from Washington State Initiative 732[1]

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Introduction

Washington State Initiative 732 (I-732), a citizen-led initiative currently proposed in Washington State, seeks to implement a statewide revenue-neutral carbon tax. The initiative was devised by the lobby group Carbon Washington (CarbonWA)[3]. A revenue-neutral carbon tax taxes commodities that create carbon dioxide during the consumption or production process and uses the revenues to offset an existing tax distortion in the economy by reducing the tax rate in that sector. Here, total additional government revenue from the instrument is zero. Taxing in such a manner can potentially create a double-dividend where the first benefit is a reduction in carbon dioxide emissions and the second benefit is an increase in efficiency in the market where the current distortionary tax exists (Pearce, 1991; Parry, 1995).

The objective of I-732 is to incentivize the adoption of cleaner fuel sources and reduce market inefficiencies by reducing the sales tax across a broad set of sectors and reducing the business and occupation (B&O) tax for the manufacturing sector (CarbonWA, 2015). In particular, I-732 imposes a tax of $25 per metric ton (MT) of carbon dioxide emitted from the use of fossil fuels in the state of Washington. Farm diesel and public transportation are partially exempt from full taxation during the first 40 years of the policy. The revenues are used to fund a 1% reduction in the sales tax, from 6.5% to 5.5%, and a reduction in business and occupation tax in the manufacturing sector from as much as 0.484% to 0.001%. Some revenues from carbon taxes are also used to provide a tax rebate of up to $1,500 per year for low income families (CarbonWA, 2015).

Two studies have estimated whether the policy is truly revenue neutral. CarbonWA (2015) and an independent study by the Washington State House Finance Committee used the Carbon Tax Assessment Model (CTAM) to show that the policy is approximately revenue-neutral (OFM, 2016). CTAM measures the greenhouse gas levels and fiscal impacts of a carbon tax from five sectors: industrial, commercial, residential, electricity and transportation sectors. A variety of fuels can be used within each sector such as natural gas, coal, gasoline, distillate fuel and diesel fuel. The model also allows for changes in output price given a policy shock to determine the effect to changes in consumption and output of fuel within each sector. However, such changes are partial equilibrium in nature, neglecting adjustments in equilibrium supply and demand across sectors. Furthermore, CTAM does not consider the changes from electricity imports and changes to the tax base. Finally, CTAM analyzes the Washington State economy

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[3] For more information, refer to www.yeson732.org.

as a whole and very few implications are drawn on policy impacts to specific sectors in the economy such as agriculture, forestry and the manufacturing sectors.

This paper uses a general equilibrium approach to measure the effect of I-732 on different sectors in the economy. In particular, we calculate each sector's contribution to total carbon tax revenues and each sector's reduction to total sales and business tax revenues. In addition, we evaluate the policy's potential for achieving revenue neutrality in a general equilibrium context. Unlike the CTAM model, our general equilibrium model allows for spillover effects across sectors as well as changes to electricity imports and changes to the tax base. We also conduct robustness checks on our estimates to determine how slight changes in the policy affect revenue collected. Finally, we assess the welfare effects with and without the policy to determine if it is welfare improving or not. Our analysis focuses solely on the first two years of the project during the gradual phase-in of the sales tax reduction and carbon tax while the agricultural sector is mostly exempt.

Policy Background

There are four main policy changes proposed by I-732, and each policy change is introduced in different phases. We focus our analysis on the first two years of the policy because it is in those years that our analysis is most reliable given our model and assumptions.

During the first year of the policy, a $15 tax per ton of carbon dioxide will be implemented before rising to $25 per ton in the second year. During the subsequent years, the carbon tax rate rises by 3.5% plus the rate of inflation to account for the predicted carbon tax revenue drop as emissions decline. The carbon tax will be capped at $100/ton in 2016 US dollars which is expected to occur after 40 years (CarbonWA, 2015). The rise of the carbon tax rate in the agricultural sector, or more specifically the use of farm diesel, and the public transportation sector will occur more slowly. These sectors face a rising carbon tax rate that will converge toward the level imposed on the rest of the economy by year 40 (OFM, 2016).

The revenues from the carbon tax are used to finance the reduction in both the business tax in the food and general manufacturing sector and the sales tax across a broad range of sectors. The sales tax will decrease by 1% from 6.5% to 5.5% but it will decline gradually in that the first half-percent reduction occurs in the first year and the second half-percent occurs a year later (CarbonWA, 2015). Unlike the sales tax, the business tax reduction in the manufacturing sector from as much as 0.484% to 0.001% occurs immediately in the first year (CarbonWA, 2015).

In addition to financing decreases in existing taxes, low-income families will also receive a rebate. Revenues from the carbon tax rate will be used to fund the Working Families Tax Rebate, created by state legislators in 2008 but not funded. I-732 will use some of the money earned from carbon taxes to match a portion of the Federal Earned Income Tax Credit. In particular, the policy stipulates a 15% match in the first year and a 25% match in the subsequent years. This is equivalent to about $157 million in the first year and $263 million in the second year (OFM, 2016). The individual household returns will vary depending the number of children and household income, but the maximum level is about $1500.

Model Description

We modify the Washington-Idaho computable general equilibrium (CGE) model originally developed by Holland et al. (2007). The model contains 530 industries combined into 11 sectors: agriculture, forestry, mining, utilities, fossil fuel, construction, food manufacturing, wholesale and retail trade, services, general manufacturing, and miscellaneous. To show consistency in how we aggregated the sectors, we compared the share of the sectors in the Washington State economy using the IMPLAN data versus data from the Bureau of Economic Analysis in Table 1. The sectoral compositions are very close between the two datasets indicating a reasonable baseline starting point. Some sectors produce output that are used as inputs in other sectors of the economy. For example, agricultural output is an input in the food processing and manufacturing sectors, and the forestry sector output is used as an input in the construction sector. Fossil fuel is a separate sector and is identified as an input in several important sectors such as agriculture, transportation, and utilities.

Table 1. Comparing the Percentage Share of Each Sector Relative in the Washington State Economy using Data from IMPLAN versus the Bureau of Economic Analysis.

Industrial Sectors	Percentage Share of each sector using IMPLAN Data	Percentage Share of each sector using BEA DATA
Agriculture	2.03	1.78
Forestry	0.16	0.00
Construction	3.99	3.82
Utility	1.32	0.86
Fossil Fuel	0.72	NA
Wholesale and Retail Trade	11.86	12.47
Mining	0.14	0.27
Food Manufacturing	1.01	2.79
General Manufacturing	11.50	10.70
Services	52.16	50.45
Miscellaneous	15.11	16.85

NA – not available because no explicit subcategory in BEA

In addition to a subset of the 11 commodity inputs, each sector employs labor and capital, which are substitutable across sectors. All other inputs are assumed to be perfect complements utilized in fixed proportions. The assumption of fixed proportions is a limitation of the model, as sectors are unable to change the ratio of their input uses when responding to policy changes, with the exception of labor and capital inputs. However, such a function is reasonable in the short run when adjustments are not easily made especially if transactions costs are significant when adopting new technology in the long run after the policy is implemented.

Domestic and international trade occurs in all sectors. All markets are perfectly competitive and prices and quantities adjust. This general equilibrium model allows us to examine the behavior of supply, demand, and prices in the state economy after allowing for a variety of shocks from the revenue-neutral carbon tax policy. Data from 2014 is used to initialize the model.

We modify the Holland et al. (2007) model by incorporating four significant changes which allow us to assess the effect of the revenue-neutral carbon tax policy. We impose a \$0.14/gal tax and \$0.24/gal tax on fossil fuels, in the first two years of the policy, respectively, which are equivalent to the \$15/ton of carbon dioxide and \$25/ton of carbon dioxide from fossil fuels in all sectors except agriculture.[4] In the agricultural sector, we impose \$0.007/gal tax in the first year and a \$0.01/gal tax in the second year, which are equivalent to \$0.75/ton and \$1.25/ton of carbon dioxide, respectively (OFM, 2016). To calculate the total carbon tax revenues generated by each sector, we multiply these tax rates by the amount of fossil fuel used in each sector after all the shocks have occurred.

Second, we reduce the sales tax collected from the consumer by 0.5% in the first year and then 1% in the second year.[5] From this change we are able to determine the aggregate loss in sales tax revenues but we are not able to see how each sector is directly affected by the sales tax rate reduction. To tease out the effect, we calculate the share of output of each sector to the total economy and multiply that share with the total decrease in sales tax revenue collected.

Third, we reduce the business and occupation tax for the manufacturing sector to 0.001%. We are able to determine the output levels before and after all shocks to the economy are implemented and we have approximate measures of the business tax rates in each sector. We calculate the change in business tax revenue collected in each sector given the change in output after the policy is implemented while assuming that the business tax rates stay the same in all sectors except the manufacturing sector.

Finally, we rebate households in the lowest income bracket an amount equal to \$157.74 million in the first year and \$262.90 million during the second year (OFM, 2016). This serves as an income effect for those specific households.

Calibrated parameters remain fixed throughout the simulations, meaning that there is no technology change. While this may be an issue over a longer simulated horizon, we do not expect immediate technological changes over the first two years of the policy. Production functions are Leontief with respect to commodity inputs to production and CES with respect to labor and capital. The composite Leontief-CES functional form can be written a $q_i = \min_{z_{i1}, z_{i2}, \ldots, z_{i11}} \left\{ \frac{z_{i1}}{a_{i1}}, \frac{z_{i2}}{a_{i2}}, \ldots, \frac{z_{i11}}{a_{i11}} \right\} \times \left(\alpha_K K_i^{\rho} + (1-\alpha_K) L_i^{\rho} \right)^{1/\rho}$, where q_i is the quantity produced by sector *i*, $\{z_{i1}, z_{i2}, \ldots, z_{i11}\}$ represents the input quantities from the eleven sectors employed by sector *i*, K_i and L_i are the respective quantities of capital and labor used in sector *i*, $\{a_{i1}, a_{i2}, \ldots, a_{i11}\}$ are technical coefficients parameterizing the Leontief component, α_K is the share parameter for capital in the CES component, and ρ is a parameter in the elasticity of substitution between capital and labor, defined as $\sigma = 1/(1-\rho)$.

The utility function is Stone-Geary, which assumes a minimum level of expenditure on each good consumed, and results in a linear expenditure system. The functional form is given by $U = \prod_i (q_i - \lambda_i)^{\beta_i}$, where utility *U* is expressed as a function of the consumption of each good *i*, the subsistence level of each good λ_i, and share parameter β_i.

[4] To derive this value, we multiply \$25/ton by the conversion rate from ton to kilogram (907.185 kg per ton) and multiply it by the amount of carbon emitted per gallon (8.9 kg/gal), i.e. \$25/ton x 1 ton/907.185 kg x 8.9 kg/gal = \$0.24/gal.

[5] Expenditures exempt from the sales tax reduction are net out proportionally from the service sector.

There are three main assumptions in the model. First, capital is mobile across sectors and aggregate supply of capital is variable. This allows for capital inflow from outside the state when tax rates change and it does not restrict aggregate capital within the state. Second, labor is mobile across sectors and there is no requirement for full employment. Finally, savings is based on the marginal propensity to save and not the autonomous level of consumption. We also allow international trade with a flexible exchange rate.

Simulation Results

To determine if the model is correctly integrating the effects of the policy, we first examine each policy in isolation and then we examine the simultaneous implementation of all policies. Baseline quantities and prices for the sectors of interest are reported in the second column of Table 2. Columns three through five examine the sales tax reduction, business and occupation tax reduction, and carbon tax imposition in isolation, respectively, and column six examines the joint implementation of all policies. If only a 1% sales tax reduction is implemented, we find that the output in most sectors increase as expected. Three sectors, the forestry, general manufacturing and miscellaneous sectors, realized a slight decline in output. This could happen as the result of a strong substitution effect, wherein an increase in quantity demanded in one sector decreases the demand in either of the three other sectors. The isolated reduction in the business and occupation tax in the food and general manufacturing sectors led to an increase in output in both sectors, as expected. It also increased output in other sectors such as the service sector, and the retail and wholesale trade sector. This illustrates how the tax savings could be passed on to other sectors in the form of lower prices leading to more output. Finally, output generally declines in all sectors when a carbon tax is imposed, with the exemption of agriculture which does not face the full carbon tax rate. In general, sectors that are not dependent on fossil fuel see a rise in output while the more fossil fuel dependent sectors see a decrease in output. The overall price of all sectors rise mainly due to the increase in the price of fossil fuel. Figures 1 and 2 show the percentage changes in quantities and prices resulting from each component of the policy shock.

We summarized the effect of the policy on inflation in Table 3.[6] In year one, the increase in the price level caused just over a quarter of a point increase in the CPI, raising it from 100 to 100.26. In year two the CPI increased to 100.51. Looking at components of the CPI, fossil fuel prices rose the most, from 1 to 1.07 in year 1 and to 1.19 in year two. Utilities, mining, and construction saw the second, third, and forth largest increases in price respectively. In terms of percentage increases in the price level, the policy would likely generate a 0.3% increase in years one and two. Percent increases in the CPI nationally were 1.6% and .1% from 2013 to 2014 and from 2014 to 2015, respectively.[7] Relative to the national inflation, these price increases are minor.

Tables 4, 5, and 6 present sector-level decompositions of changes in tax revenue generation as a result of the simultaneous implementation of all policies pertaining to I-732. In Table 4, we present estimates of carbon tax generation for the first two years of the tax policy, decomposed by sector. Aggregate tax revenues rise from almost $1.2 billion in the first year to almost $2 billion in the second year. The rise is due to the increase in the carbon tax rate from $15/ton of

[6] Our baseline scenario represents our base year of 100. Weights for each commodity consumed by households were calculated as a percentage of total household commodity expenditures.

[7] This data was gathered from the Bureau of Labor Statistics March 2016 “CPI Detailed Report” and can be found in Table 24. http://www.bls.gov/cpi/cpid1603.pdf.

carbon dioxide to $25/ton of carbon dioxide. The fossil fuel sector provides the largest share of carbon revenues with 46% and 43% during the first two years, respectively. The household sector is the second largest contributor at about 20% followed by the service sector at about 15%. Since the household sector is dependent on transportation and the service sector includes transportation services, it is reasonable to find that they are the second and third leading provider of carbon revenues to the State. These three sectors account for almost 80% of carbon revenues. Even though the agricultural sector is a significant consumer of fossil fuel, its contribution to all carbon tax revenues is the smallest among the sectors because of its partial exemption in the beginning stages of the policy.

Table 2. Output and Price Changes with the Introduction of the WA I-732 During the Second Year of the Policy.

Quantity (millions)	Base	Sales Tax Reduction	B&O Tax Reduction	Carbon Tax	Total
Agriculture	12,505	12,672	12,512	12,515	12,686
Forestry	1,115	1,113	1,116	1,111	1,113
Construction	37,787	39,248	37,765	36,741	38,308
Utility	16,896	17,174	16,910	16,221	16,489
Fossil fuel	18,126	18,351	18,120	12,379	12,573
Wholesale and retail Trade	74,244	75,842	74,286	73,417	75,032
Mining	1,201	1,213	1,201	1,159	1,174
Food manufacturing	23,236	23,777	23,242	23,088	23,618
General manufacturing	140,029	139,674	140,173	139,316	139,333
Services	385,061	391,098	385,171	381,904	387,794
Miscellaneous	70,891	70,735	70,495	71,409	70,851
Price					
Agriculture	1	1.006	1	0.997	1.003
Forestry	1	1.005	1	0.998	1.003
Construction	1	1.005	1	1.001	1.006
Utility	1	1.007	1	1.009	1.016
Fossil fuel	1	1.005	1	1.114	1.12
Wholesale and retail Trade	1	1.004	1	0.997	1.002
Mining	1	1.007	1	1.006	1.013
Food manufacturing	1	1.006	1	0.998	1.004
General manufacturing	1	1.006	1	0.997	1.004
Services	1	1.005	1	0.997	1.003
Miscellaneous	1	1.002	1	0.999	1.001

Table 5 summarizes the reduction in aggregate sales tax revenues. In the first year with a half-percent reduction in sales tax, total sales tax is reduced by about $700 million. With a full one-percent reduction, the total reduction in sales tax revenue doubles to $1.4 billion. The elasticity of sales tax revenue from a reduction in the sales tax rate is equal to 0.91, which is close to the long-run elasticity of 0.93 for Washington State and well within the short-run elasticity range between 0.15 to 1.41 (Brown, 2002). The service sector is the largest beneficiary at about 18% of total sales tax savings followed by the manufacturing sector at 7% sales tax savings. Given the sizes of the other sectors in the economy, their sales tax savings are relatively small. Thus, we find that unlike the sectors contributing to the carbon tax revenues, the benefits from the sales tax reduction is relatively more evenly distributed across the sectors.

Figure 1: Percent Change in Output with the Introduction of WA I-732 During the Second Year of the Policy.

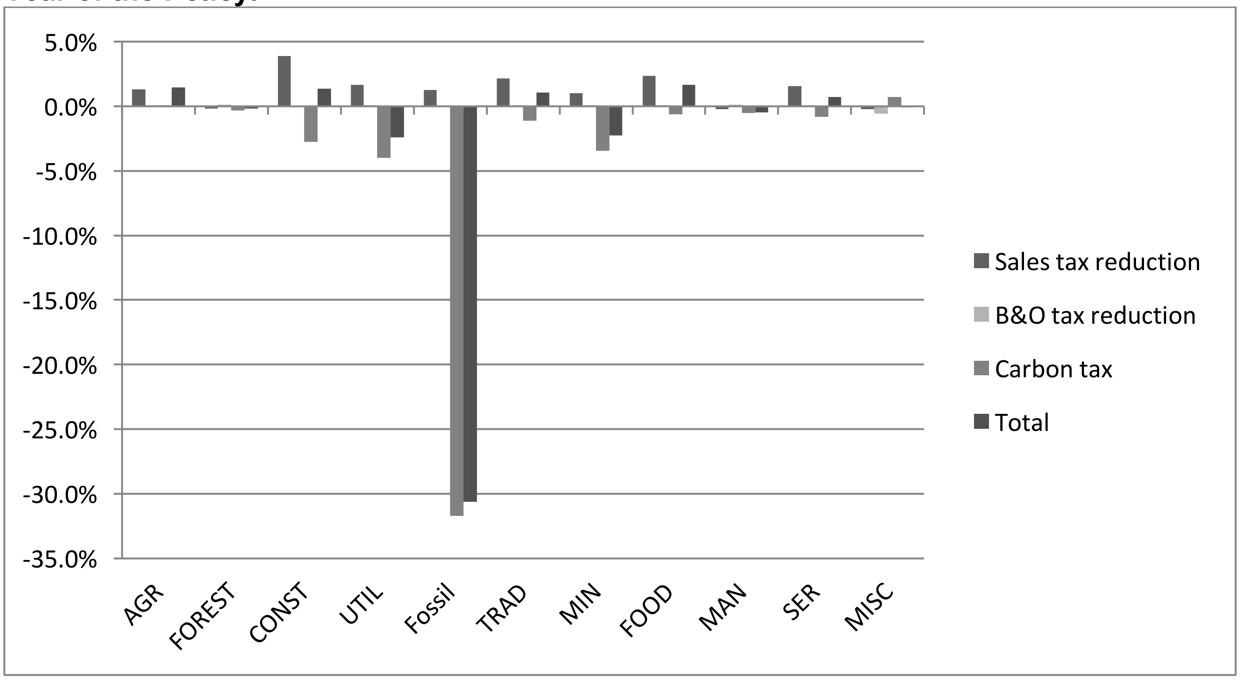

Figure 2: Percent Change in Prices with the Introduction of WA I-732 During the Second Year of the Policy.

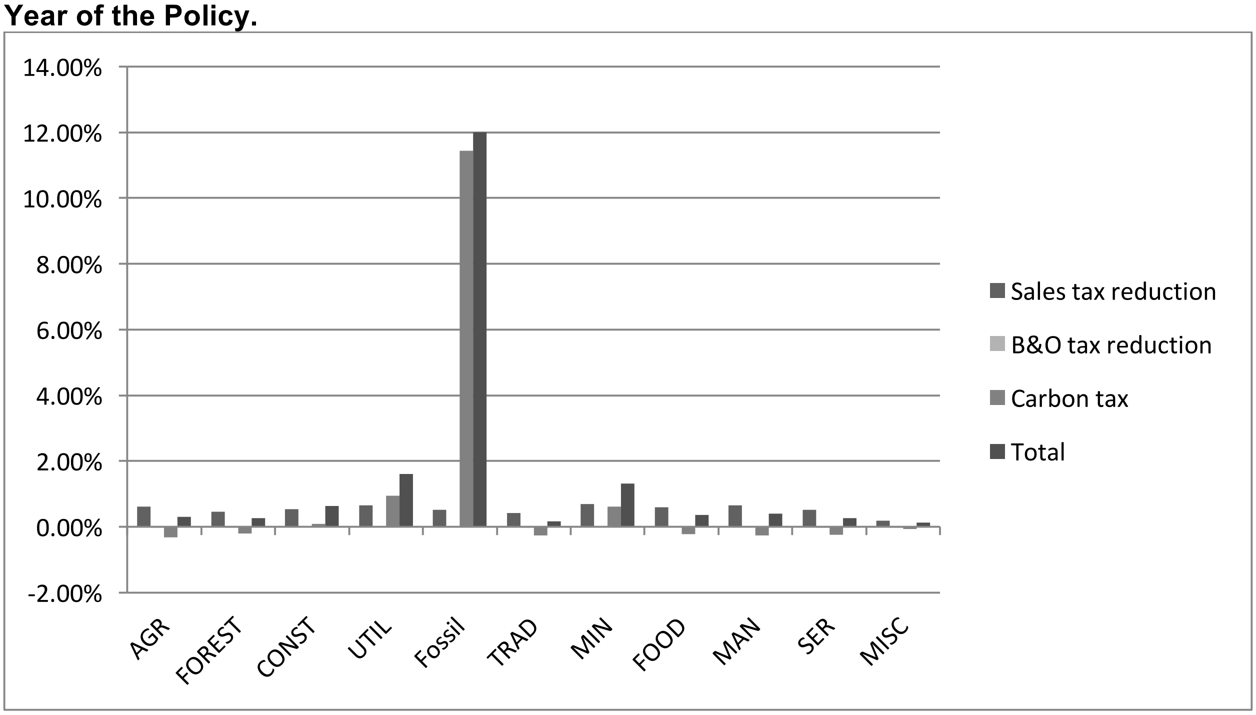

Table 3. Price Changes, Commodity Weights, and Inflation Due to Policy Change.

Sector	Commodity weight	Year 1	Year 2
Agriculture	0.01	1.0011	1.0030
Forestry	0.00	1.0010	1.0026
Construction	0.00	1.0033	1.0063
Utility	0.02	1.0090	1.0161
Fossil fuel	0.02	1.0719	1.1200
Wholesale and retail trade	0.12	1.0005	1.0017
Mining	0.00	1.0073	1.0132
Food manufacturing	0.05	1.0016	1.0036
General manufacturing	0.10	1.0018	1.0041
Services	0.62	1.0011	1.0027
Miscellaneous	0.06	1.0005	1.0012
Consumer Price Index		**100.26**	**100.52**

Table 4. Distribution of Carbon Tax Revenues by Sector in Millions of US$ (Base year 2014).

Sector	Year 1	Year 2
Agriculture	$0.40	$0.84
Forestry	$0.85	$1.47
Construction	$69.05	$121.29
Utility	$40.94	$70.47
Fossil fuel	$546.16	$835.20
Wholesale and retail trade	$11.91	$20.87
Mining	$5.19	$8.96
Food manufacturing	$4.71	$8.27
General manufacturing	$52.45	$91.10
Services	$170.98	$299.08
Miscellaneous	$54.88	$95.72
Household sector	$241.72	$405.93
Aggregate carbon tax revenue	**$1,199.25**	**$1,959.19**

Note: During the same year (2014), aggregate tax revenue was approximately $17.75 billion. Therefore, during the first two years of the policy, the additional tax revenue translates to a 6.75% and 11.04% increase in tax revenues, respectively.

Table 6 summarizes the effect of the reduction in business and occupation tax in the manufacturing sector across all sectors. The direct effect of the policy is a reduction in the business and occupation tax in the manufacturing sector of approximately $682 million.[8] The amount of business and occupation tax paid by each sector is proportional to the value of its output, so changes in production and/or prices will influence business and occupation tax generation in a proportional manner. Taxes collected in the retail trade and services sectors increase by about $15 million each in the first year and about $35 million each in the second year. Other sectors see a decline in output and a resulting decline in the business and

[8] From our data, the initial B&O tax for the general manufacturing sector is approximately 0.44% while for food manufacturing it is relatively lower at 0.39%. We reduced both general and food manufacturing rates to 0.001%. This would mean that if the data starting points are larger than the amounts in reality, our numbers would be high especially if specific subsectors have B&O rates lower than 0.44%.

occupation tax such as the case of the utility and fossil fuel sectors. The change in business and occupation tax in the non-manufacturing sectors can be attributed to two effects. First, sectors purchasing from the manufacturing sector may see a decrease in cost if the business tax reduction in the manufacturing sector leads to a reduction in price in that sector. Second, the other shocks from the policy such as the sales tax reduction and Working Families Tax Rebate may drive overall demand for goods higher leading to more output and higher business tax revenues. We see a net reduction in tax collections stemming from the business tax reduction in the manufacturing sector of $671 million after accounting for changes in all other sectors.

Table 5. Distribution of Sales Tax Revenue Savings by Sector in Millions of US$ (Base year 2014).

Sector	Year 1	Year 2
Agriculture	-$4.33	-$8.77
Forestry	-$0.38	-$0.77
Construction	-$13.05	-$26.48
Utility	-$5.71	-$11.40
Fossil fuel	-$4.92	-$8.69
Wholesale and retail trade	-$25.63	-$51.87
Mining	-$0.41	-$0.81
Food manufacturing	-$8.05	-$16.33
General manufacturing	-$48.04	-$96.32
Services	-$132.71	-$268.07
Miscellaneous	-$24.31	-$48.98
Reduction in sales tax revenue	**-$719.61**	**-$1,448.36**

Note: During the same year (2014), total sales tax revenue was approximately $7.8 billion. Therefore, during the first two year of the policy, the reduction in sales tax revenue translates to a 10.84% and 18.57% drop, respectively.

The overall net effect of the policy is a reduction in revenues of about $349 million in the first year and $380 million in the second year. Note that in our model, a balanced budget constraint is imposed such that aggregate revenues equal aggregate spending. To meet the constraint, consumption spending and investment by the government is immediately reduced so that a deficit does not transpire.

Thus, our results suggest that the policy is not revenue neutral. In the first year of the policy, total carbon tax revenues are equal to $1.2 billion. The tax increase is used to cover a total sales tax reduction of $720 million and $671 million from the reduction in business and occupation tax as well as an allocation of $158 million to fund the Working Families Tax Rebate program. In the second year of the program, the net revenue reduction is similar because even though total carbon taxes reach almost $2 billion, the amount is not enough to cover the loss in sales tax revenue of $1.4 billion, the loss in business and occupation tax of $627 million and funding the Working Families Tax Rebate at $263 million. These shortfalls are covered by reductions in government investment spending.

Table 6. Effect of Reduction in Business and Occupation Tax in the Manufacturing Sector in Millions of US$ (Base year 2014).

Sector	Year 1	Year 2
Agriculture	$0.27	$0.51
Forestry	$0.01	$0.00
Construction	$1.03	$2.49
Utility	-$2.80	-$3.27
Fossil Fuel	-$3.25	-$4.72
Wholesale and Retail Trade	$14.57	$35.24
Mining	-$0.03	-$0.04
Food Manufacturing	-$68.80	-$68.56
General Manufacturing	-$614.38	-$614.38
Services	$15.69	$38.71
Miscellaneous	$9.76	$9.82
Reduction in B&O Revenue	**-$671.15**	**-$627.66**

The original estimates from Carbon WA, based on historic data, show a total tax swap of $1.7 billion (CarbonWA, 2015). By their estimates, in the second year of the policy carbon taxes are estimated to be $1.7 billion which are used to cover a $200 million loss in business and occupation tax revenues, a $1.3 billion in sales tax reduction and $263 million to fund the Working Families Tax Rebate program. Given their calculations, it is close to revenue neutral with only a $63 million deficit.

Our estimates are larger for all tax changes. Here, we derive about $300 million dollars more in carbon tax revenues but also about $100 million and $427 million more in sales tax reductions and business and occupation tax reductions, respectively. The main difference between our model and the CTAM used by CarbonWA is that in our analysis, we use a general equilibrium model that allows changes in prices and quantities in one sector to affect those in another sector of the economy. In our case we capture direct effects of the policy within a sector as well as spillover effects across sectors. If these spillover effects are significant, they can increase or negate in some instances the direct effects of a policy.

Given the average annual reduction of revenues of about $360 million, we calculated the potential changes in the carbon tax rate, sales tax rate or business and occupation tax rates needed to achieve revenue neutrality for the first two years of the policy and summarized the results in Table 7. In the first year, revenue neutrality can be achieved if a small change in the business and occupation tax is made by cutting it by half of the proposed level at a rate of 0.22% instead of effectively eliminating it altogether. By the second year, it will need to be raised slightly to 0.24% to achieve revenue neutrality. If sales tax is to be adjusted instead of the other policies, it would have to be lowered by 0.22% to only 6.28% instead of 6% in the first year, and in the second year lowered to 5.78% instead of 5.5% to achieve revenue neutrality. Another alternative would be to keep the scheduled changes in the sales and business tax rates but increase the carbon tax. In the first year it would need to be $20/ton instead of $15/ton while in the second year it would need to be $30/ton instead of $25/ton to achieve revenue-neutrality. Finally, one could also adjust the money given to the Working Families Tax Rebate where it would be smaller in lean years and larger in boom years. However, given our simulations, eliminating the Working Families Tax Rebate entirely would not fully achieve revenue neutrality.

Table 7. Changes in Rates Needed to Achieve Revenue Neutrality.

	Carbon Tax	Sales Tax	B&O Tax	Family Tax Rebate
Year 1	$15/ton	6.000%	0.220%	$157.74M
	$15/ton	6.280%	0.001%	$157.74M
	$20/ton	6.000%	0.001%	$157.74M
Year 2	$25/ton	5.500%	0.242%	$262.899M
	$25/ton	5.780%	0.001%	$262.899M
	$30/ton	5.500%	0.001%	$262.899M

Our analysis shows a reduction in government revenues. This is purely an accounting measure that does not give any indication if a policy is welfare improving or not. We calculate Washington State's Gross Domestic Product (GDP) and Green GDP before and after the policy to determine if it is welfare improving as shown in Table 8. Green GDP refers to GDP net of pollution damages from carbon dioxide emissions. Unsurprisingly, Green GDP is higher with the policy than without it. Pollution damages were reduced from $1.38 billion to $955 million. Interestingly, simple GDP also increases with the policy from $443 billion to $447 billion mainly due to growth of various sectors in the economy such as the service sector. Thus, based on these welfare metrics, such a policy is welfare improving as long as a balanced budget is achieved.

Table 8. GDP and Green GDP Before and After Policy Implementation.

	GDP (mill)	Pollution Damages (mill)	Green GDP (mill)
Without policy	$443,391	$1,376	$442,015
With policy	$447,268	$955	$446,313

Note: Calculations for GDP using the income approach.

Lastly we check the effect of the policy on welfare across different household income brackets, with the results shown in Table 9. Based on equivalent variation and utility measures, most income brackets see a rise in welfare. The majority of gains were seen by the lowest and highest income categories. The general rise in welfare can be attributed to the decline in sales tax and increase in purchasing power. Since the high income group consumes the most, this income group receives a relatively high increase in income. The gain by the lowest income bracket can be attributed to the reallocation of some funding from carbon taxes towards the Working Families Tax Rebate. Given their relatively low starting consumption point, the redistribution to the lowest income bracket yields the largest marginal gain. This also illustrates the importance of the Working Families Tax Rebate program in offsetting any negative impacts from the carbon tax. Without such a policy, the lowest income brackets sees a reduction in equivalent variation during the first year.

Conclusion

This publication examines the effect of a revenue-neutral carbon tax, or Washington State Initiative 732, on different sectors in Washington State using a computable general equilibrium model. The fossil fuel sector, household sector and service sector are the largest contributors to the carbon tax revenues since they contribute, in aggregate, about 80% of total carbon taxes. The benefits from the sales tax reduction are relatively more spread across our sectors with the service sector benefiting the most at 18%. The business and occupation tax reduction in the manufacturing sector also benefits other sectors that use their output in their production process. Finally, we do find a revenue reduction of about $349 million and $380 million in the first two years of the policy respectively.

Table 9. Household Surplus and Percentage Change in Utility by Year and Income Level.

Income Category	Equivalent Variation Year 1	Equivalent Variation Year 2	% Change In Utility Year 1	% Change In Utility Year 2
<$10k	161.46	271.18	29.6%	49.3%
$10-$15k	(0.03)	1.75	0.0%	0.6%
$15-$25k	2.25	14.93	0.2%	1.3%
$25-$35k	3.24	25.33	0.3%	1.8%
$35-$50k	3.65	49.76	0.2%	2.2%
$50-$75k	13.15	119.59	0.4%	2.7%
$75-$100k	15.66	119.84	0.5%	3.1%
$100-$150k	35.11	201.32	0.7%	3.5%
>$150k	46.90	228.60	0.8%	3.8%

Even with a reduction in revenues, we find that GDP net of pollution damages and GDP itself increases with the policy which indicates that the policy is welfare improving based on this metric as long as a balanced budget is achieved. Welfare across most household income brackets increases after the policy but the lowest income brackets are most vulnerable which implies that the Working Families Tax Rebate is critical.

Even though we benefit by using a computable general equilibrium to capture the spillover effects across sectors, our model also has three important limitations. The first limitation is the assumption of perfect complements between non-labor and non-capital inputs. This implies that when we raise the tax on fossil fuel, fossil fuel use, along with all other inputs aside from labor and capital will also decrease proportionally. There is no possibility for substitution towards other fossil fuel substitutes. The Leontief production function could lead to larger decreases in output compared to the case where some substitutability between inputs could occur. This, in turn, could lead to an overestimate of our loss in sales tax revenue and business tax revenue since they are both based on equilibrium output adjustment. Also, we may underestimate the reduction in fossil fuel use if there are alternative substitutes for fossil fuel which implies that our carbon tax revenue estimates may be overestimated.

The second limitation is that we cannot disaggregate the individual business and operating tax for all subsectors of the manufacturing sector. We use the average business and operating tax rate of the sector from our available data. There are some subsectors within manufacturing that face a lower tax rate than our baseline estimate. We may overestimate the lost business tax revenues when reducing the business and operating tax rate for the manufacturing sector.

The third limitation is that all parameters in the model remain fixed which hinders us from conducting any long run analysis. If firms adjust behavior by investing in technology that is less fossil fuel intensive we would expect fossil fuel use to decline in the long run leading to lower carbon tax revenues. If the adoption of less fossil fuel intensive technology is slow, it is likely to lead to revenue-neutrality and even a slight surplus in the medium to long run. However, if there is rapid adoption of less fossil fuel intensive technology, carbon tax revenues may severely drop and lead to a larger reduction in revenues. Without any information regarding future technological progress regarding the substitutes for fossil fuel and the willingness of various sectors to adopt such technology, it is difficult to forecast the long run policy effects. Therefore, there should also be some flexibility in the other aspects of the policy (i.e. re-raising the sales tax or business tax) if shortfalls ever occur.

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