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Abstract

This article examines the effect of a revenue-neutral carbon tax, as implemented in Washington State Initiative 732, on the agricultural and forestry sectors in Washington State using a computable general equilibrium model. In particular, we examine the effect of the policy during the two-year initial phase-in period, when the carbon tax reaches a level of $25/ton of emitted carbon and the agricultural sector is still partially exempt from paying the majority of the carbon tax. We find that the value of output in the agricultural and forestry sectors increases by 1.76% and 0.11%, respectively. 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 1.44% but exports in the forest sector see a negligible drop of 0.05%.

Key words: Computable General Equilibrium Model; Revenue Neutral Carbon Tax; WA I-732; Agriculture; Forest

JEL Codes: C68, H23, Q10

Introduction

Carbon Washington (CarbonWA), a lobby group in Washington State, is currently proposing a revenue-neutral carbon tax called Washington State Initiative 732 (WA I-732).[1] The objective of such an instrument is to incentivize adoption of cleaner fuel sources and reduce market inefficiencies that arise through the use of distortionary taxes (CarbonWA, 2015). In general, a revenue-neutral tax instrument has the potential to simultaneously increase aggregate social welfare and boost growth in a renewable fuel industry (Skolrud and Galinato, 2015). The specific revenue-neutral tax policy proposed by CarbonWA is phased into the economy at different rates depending on the sector, leading to differential impacts across sectors, especially in those that can be used as feedstocks in the renewable fuel industry.

The focus of this research is analyzing the impact of the revenue-neutral tax on two sectors with strong significance to the Washington State economy, the agricultural sector and forestry sectors. The agricultural and forestry sectors are important contributors to Washington State's economy. Combined, they account for over $10 billion in output annually (NASS, 2013; Smith, 2012). They are also important contributors to two related sectors: the manufacturing and food processing sectors, which have an annual output of $1.5 billion dollars and account for 100,000 jobs (Brady and Taylor 2010). These two sectors in Washington State have been identified as significant sources of cellulosic feedstocks, which can be refined to produce a second-generation biofuel with a much lower carbon footprint than fuel refined from crude oil (Yoder et al. 2010). As the carbon tax increases and the demand for low-carbon fuel increases, we eventually expect an increase in demand for agricultural and forestry output.

[1] For more information, visit www.carbonwa.org.

This study determines the effect of the proposed revenue-neutral-carbon tax, as outlined in WA I-732, on output, prices, input use, employment and carbon dioxide emissions in the agricultural and forestry sectors in Washington State during the first two years of policy implementation. We utilize a computable general equilibrium model that has 11 primary industrial sectors and allows for endogenous changes in prices and output production. The results of the study not only forecast sector-specific policy effects but may also point to policy prescriptions that may help ameliorate negative effects and enhance positive effects. This study also speaks to the potential effectiveness of such a policy in boosting or shrinking a renewable fuels sector currently in its infancy.

WA I-732 has four direct policy effects. The first is a tax of $25 per metric ton of carbon dioxide emitted from the use of fossil fuels in the state of Washington. Farm diesel and public transportation are exempt from the full amount in the first 40 years of the policy, facing instead a gradually increasing carbon tax schedule. The second policy effect is a 1% reduction in sales tax, from 6.5% to 5.5%. The third effect is a reduction in business and occupation tax in the manufacturing sector from 0.484% to 0.001%, effectively removing the tax in that sector. Finally, the revenues from the carbon tax funds the state's Working Families rebate policy which allows for a tax rebate of up to $1,500 per year for low income families (CarbonWA, 2015).

The proposed tax policy is considered revenue-neutral because the revenues raised by the carbon tax are used to offset losses from sales and business tax reductions and to fund the tax rebate for low income families. In requiring less revenue from distortionary taxes such as sales, income and/or business taxes, and gaining more tax revenue from taxes that correct market failure such as carbon taxes, a "double-dividend" may be achieved in the economy (Pearce, 1991; Parry, 1995). The first dividend occurs through the reduction of pollution to an efficient level, and the second dividend results from a reduction in deadweight loss or market inefficiency in a market where an existing distortionary tax is reduced.

We examine the effect of the policy on the agricultural and forestry sectors directly after the two-year initial phase-in period, when the carbon tax reaches a level of $25/ton of emitted carbon and the agricultural sector is still exempt from paying the majority of the carbon tax. Based on the specific targets of WA I-732, we hypothesize three direct effects in the agricultural and forest sectors from each policy change. In the second year of the policy, the partial exemption results in the agricultural sector paying just 5% of the tax borne by other sectors. We anticipate a negative impact on the value of output due to the increase in the price of fossil fuel from the carbon tax alone. The sales tax reduction may lead to a marginal change in the consumption mix of consumers away from products that rely heavily on fossil fuel towards other goods. Because the agricultural sector faces a comparatively lower tax rate, we expect a smaller change in the output price of agricultural goods compared to goods from other sectors, which may precipitate a shift towards agricultural good consumption. From the farmer's perspective, there may also be an increase in capital investment given this reduction in sales tax. A business tax reduction in the manufacturing sector does not directly affect the agricultural sector but there might be an indirect impact if food manufacturing processors pass on their reduced cost of production to the agricultural sector. Finally, transfers to low income families may increase welfare for eligible employees in the agricultural sector. We turn to a computable general equilibrium model for Washington State to measure all the welfare effects and test the hypotheses of the impacts of the carbon revenue-neutral tax.

Timeline and Policy Specifics of WA I-732

The impact of the policies outlined in WA I-732 are not immediate but come in various phases as outlined in Table 1. We focus our analysis during the first two years of the proposal. The carbon tax will be $15 per ton in the first year before rising to $25 per ton in the second year. After the second year, the carbon tax rate rises by 3.5% plus the rate of inflation. This is to account for the predicted carbon tax revenue drop as fossil fuel related emissions decline. The carbon tax will be capped at $100/ton which is expected to occur after more than 40 years (CarbonWA, 2015). Farm diesel and public transportation are partially exempt during the first 40 years of the policy which means they do not face the full carbon tax value. Instead, they face a rising carbon tax rate that will converge toward the level imposed on the rest of the economy by year 40 (OFM, 2016). Table 2 summarizes the rates of exemption for agriculture (i.e. farm diesel) and public transportation.

The full implementation of the sales tax reduction occurs in the second year of the policy. The sales tax will reduce by 0.5% in the first year leading to a 6% sales tax rate. During the second year of the proposal, the sales tax rate will be reduced again by 0.5% leading to a 5.5% sales tax rate which will be implemented in the succeeding years. On the other hand, the business tax reduction from 0.484% to 0.001% in the manufacturing sector occurs immediately in the first year (CarbonWA 2015).

Funding the Working Families Rebate is based on a proposed schedule by the lobby group CarbonWA. In the first year of the policy, when the carbon tax rate is only $15/ton, the total funds from the carbon revenues allotted to the Working Families Rebate is $157.74 million. Once the carbon tax rate is $25/ton, total funds allotted to the Working Families Rebate is

$262.90 million. During the subsequent years, annually funding will be in the range of $279 million to $296 million (OFM, 2016).

Model

We modify the Washington-Idaho CGE model originally developed by Holland et al. (2007). The general equilibrium model allows us to examine the behavior of producers and consumers given a variety of shocks related to the revenue-neutral carbon tax policy to determine output and price changes in various sectors of the economy.[2]

We use data from IMPLAN. It contains approximately 530 industry clusters. These clusters are then aggregated into 11 distinct industries: Agriculture, Forestry, Mining, Utilities, Fossil fuel, Construction, Processed food, Wholesale and retail trade, Services, Manufacturing, and Miscellaneous. We primarily focus on agriculture and forestry but to allow for a general equilibrium relationship, we include all other sectors in the state economy. 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. We allow for international trade in all sectors. Fossil fuel is identified as an input in several important sectors such as agriculture, transportation, and energy. All markets are perfectly competitive and prices and quantities are allowed to adjust. The model also contains sales tax rates and business tax rates.

In addition to the 11 commodity inputs each sector employs labor and capital, which are substitutable across sectors. Labor and capital are substitutable but all other inputs are assumed

[2] Nadreau (2016) summarizes a detailed technical discussion of the data, functional forms and various assumptions used in the model.

to be perfect complements in fixed proportions. The assumption of fixed proportions is a limitation of our 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. Unfortunately, this assumption is required for our computations to be tractable.

We incorporate four significant changes to the original Holland et al. (2007) model to assess the effect of the revenue-neutral carbon tax policy during the first two years of the policy. First, we impose a $0.24/gal tax on fossil fuels, which is equivalent to the $25/ton of carbon from fossil fuels, in all sectors that use the input except agriculture.[3] In the first year of the policy when the carbon tax is $15/ton, we impose a $0.14/gal tax on fossil fuels. In the agricultural sector, we instead impose a $0.01/gal tax which is equivalent to the $1.25/ton of carbon in the second year. Second, we reduce the sales tax by half a percent in the first year and 1% in the second year. Third, we reduce the business tax for the manufacturing sector from 0.484% to 0.001% in both years. Finally, we treat the expenditures that fund the Working Family Rebate program as a lump sum payment to the poorest household.

Calibrated parameters remain fixed throughout the simulations, meaning that technology change is limited. While this may be an issue over a longer simulated horizon, we suspect that this limitation has only a minor impact over our simulation period of two years. 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 as:

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[3] 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,

(1) $$q_i = \min_{z_{i1}, z_{i2}, \ldots, z_{i11}} \left\{ \frac{z_{i1}}{a_{i1}}, \frac{z_{i2}}{a_{i2}}, \ldots, \frac{z_{i11}}{a_{i11}} \right\} \times \left(\alpha_K K_i^{\rho} + (1-\alpha_K) L_i^{\rho} \right)^{1/\rho},$$

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 parameterizes 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:

(2) $$U = \prod_i (q_i - \lambda_i)^{\beta_i}$$

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.

There are three main assumptions in the model. First, given the open economy nature of the model, 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. Note that we also allow international trade in the model to examine how the policy affects agricultural exports and assume a flexible exchange rate.

Results

To test the validity of the model, we introduce each shock separately and examine if the direction of changes to the agricultural and forest sectors are as predicted. Then, we introduce all shocks simultaneously to analyze the net effect.

Table 3 shows the effect of each individual shock (sales tax reduction, business tax reduction, and carbon tax imposition) along with the simultaneous effect of all shocks in the agricultural sector during the first two years of the policy. We find that the value of agricultural output increases by 0.93% after the first year and 1.76% in the second year. The impact of the carbon tax only in the agricultural sector leads to a reduction in value by 0.08% and 0.24% in the first two years of the policy respectively. This is due to a decrease in fossil fuel expenditures by almost 30%. However, this negative impact is offset by the reduction in sales tax which increases the value of agricultural output by almost 2% in the second year. This may be due to an influx in both labor and capital into the agricultural sector since the cost of these inputs decline from a reduction in sales tax.

During the second year of the policy, the increase in the value of output is due to an increase in domestic output by 1.43% and an increase in price by 0.30%. Not all output is consumed in-state, approximately 61% is exported. The net effect of the policy is a minimal increase in exports by 1.44%. Since world prices are not affected by the policy and domestic production increases by only 1.71%, we would expect that there is a small positive impact on exports.

The direction of change in the agricultural sector is similar to the forestry sector but the net effects are not as large as shown in Table 4. The aggregate value of output increases by 0.17% in the first year and 0.11% in the second year due to the price rising in the sector. The increase is primarily driven by the inflow of labor and capital into the sector due to the reduction in sales tax. The overall growth in the sector after the policy is smaller compared to the agricultural sector because the forest sector is not exempt from the fossil fuel tax. The fossil fuel tax alone reduces the value of output in the forest sector by 0.26% in the first year which is three times larger in reduction compared to the agricultural sector during the same year. In the second year, the fossil fuel tax alone reduces the value of output by 0.55% which is more than double the case of agriculture during the second year.

Approximately 42% of products from the forest sector are exported. During the first year of the policy, there is a 0.58% in the rise of exports. However, by the second year of the policy, exports decline by 0.24% which is primarily due to a 2.33% decline in domestic output. The decline in output during the second year is because the forest sector faces the full $25/ton of carbon unlike the agricultural sector. Therefore, we find that some sectors in the economy can still thrive and grow after the full policy is implemented even if they do not have the luxury of being exempt from the carbon tax. These sectors that benefit from the revenue-neutral tax policy are likely labor and capital intensive and have relatively little fossil fuel expenditures compared to other inputs in production.

Even with the carbon tax exemption, the agricultural sector does see a reduction in fuel use after the implementation of the policy as shown in Table 5. This corresponds to a 9% drop in carbon dioxide emissions from that sector. Since the forest sector faces the full carbon tax rate, the percentage drop in fuel and reduction in carbon dioxide emission level is higher at 11%.

We also find differential effects of agricultural product consumption across household income brackets. The biggest gains in consumption are from the higher income brackets. As we go to the lower income brackets, the consumption gains become smaller but as we reach the lowest income bracket, the consumption in agricultural production consumption actually rises. We attribute this increase in consumption by the lowest income households to the state subsidies received by these households from the Working Families Rebate program.

Discussion and Summary

This study analyzed the effect of the revenue-neutral carbon tax suggested by WA I – 732 on the agricultural and forestry sectors. We find that the value of output in the agricultural and forestry sectors rise by 1.76% and 0.11%, respectively, during the second year of the implementation of the policy. Our simulations are constructed to evaluate the effects of WA I – 732 during the first two years of the policy, when the carbon tax reaches $25/ton, the sales and business taxes are reduced, and the agricultural sector is subjected to a partial exemption from the carbon tax. Exports rise by 1.44% in the agricultural sector while the forestry sector show a decrease by 0.24%. Average household consumption of agricultural products increases, with the high income and lowest income households seeing the largest increases in consumption. We find that as long as a sector does not have a large expenditure share of fossil fuel in their production of a good, they may see an increase in growth after the implementation of the policy even without any exemptions as shown in the case of the forestry sector.

Overall, the agricultural sector will see a modest gain in year 2. As the fossil fuel tax rises over time, the increase in value of output will be lower, holding all other factors such as technological development constant. When the carbon tax is fully implemented in the agricultural sector, its impact will vary greatly depending on the extent to which the sector substitutes to technologies that requires less carbon. In this regard, the agricultural sector has a significant advantage compared to the remainder of the economy, which will have to substitute to less carbon-intensive technologies while continuing to pay the full-amount of the carbon tax.

The effect of the carbon tax on the value of output in the forestry sector is slightly more significant than the agricultural sector, mainly due to the sector's lack of a partial carbon tax exemption. This has interesting repercussions to the cellulosic biofuel sector currently in its infancy. As carbon-intensive inputs become more expensive across the state, the demand for low-carbon energy alternatives, such as second-generation biofuels sourced from agricultural and forestry sectors, will likely increase. Our analysis indicates that the initial impact from the revenue-neutral carbon tax will be minimal on these sectors, and may eventually lead to expansions as cellulosic feedstock refining technology improves.

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Table 1. Stages During the Implementation of WA I-732.

Timeline	**Phase – in and adjustments**	**Exemption**
Year 1	Carbon Tax: $15/ton, Sales Tax: 0.5% reduction to 6% Business tax in the manufacturing sector: 0.439% reduction to 0.001%	Farm Diesel and Public transportation
Year 2	Carbon Tax: $25/ton year Sales Tax: 1% reduction to 5.5% Business tax in the manufacturing sector: 0.439% reduction to 0.001%	Farm Diesel and Public transportation
Year 3 - 40	Increase in carbon tax by 3.5% annually plus inflation rate	Farm Diesel and Public transportation
After year 40	Increase in carbon tax by 3.5% annually plus inflation rate until $100/ton is reached	None

Table 2. Carbon Tax Rates in the Agricultural Sector During the Exemption Period.

Year	General Carbon Tax Constant 2016 Dollars	Agricultural, and Public Transit Carbon Tax % of General	Agricultural, and Public Transit Carbon Tax Constant 2016 Dollars
1	$ -		$ -
2	$ 15	5%	$ 0.75
3	$ 25	5%	$ 1.25
4	$ 26	10%	$ 3
5	$ 27	10%	$ 3
6	$ 28	15%	$ 4
7	$ 29	15%	$ 4
8	$ 30	20%	$ 6
9	$ 31	20%	$ 6
10	$ 32	25%	$ 8
11	$ 33	25%	$ 8
12	$ 34	30%	$ 10
13	$ 35	30%	$ 11
14	$ 36	35%	$ 13
15	$ 38	35%	$ 13
16	$ 39	40%	$ 16
17	$ 40	40%	$ 16
18	$ 42	45%	$ 19
19	$ 43	45%	$ 20
20	$ 45	50%	$ 22
21	$ 46	50%	$ 23
22	$ 48	55%	$ 26
23	$ 50	55%	$ 27
24	$ 51	60%	$ 31
25	$ 53	60%	$ 32
26	$ 55	65%	$ 36
27	$ 57	65%	$ 37
28	$ 59	70%	$ 41
29	$ 61	70%	$ 43
30	$ 63	75%	$ 47
31	$ 66	75%	$ 49
32	$ 68	80%	$ 54
33	$ 70	80%	$ 56
34	$ 73	85%	$ 62

35	$	75	85%	$	64
36	$	78	90%	$	70
37	$	81	90%	$	72
38	$	83	95%	$	79
39	$	86	95%	$	82
40	$	89	100%	$	89

Source: OFM (2016)

Table 3. Effect of WA I-732 on the Agricultural Sector

	Base (Year 0)	Sales Tax Reduction	B&O Tax Reduction	Carbon Tax	Total	Total Difference from base
Year 1						
Value of output	12,505.43	12629.00	12510.71	12495.07	12621.83	116.40
		0.99	0.04	-0.08	0.93	
Quantity of Domestic output	12,505.43	12588.72	12510.77	12519.06	12605.75	100.32
(% change relative to base)		0.67	0.04	0.11	0.80	
Quantity of exports	7,625.47	7668.25	5273.13	7643.28	7689.58	64.10
(% change relative to base)		0.56	-30.85	0.23	0.84	
Output price	1.00	1.00	1.00	1.00	1.00	0.00
(% change relative to base)		0.00	0.00	0.00	0.11	
Fossil Fuel Expenditures	0.03	0.03	0.03	0.03	0.03	-0.01
(% change relative to base)		0.00	0.00	0.00	0.00	
Year 2						
Value of output	12,505.43	12752.98	12511.36	12474.95	12725.89	220.46
(% change relative to base)		1.98	0.05	-0.24	1.76	
Quantity of Domestic output	12,505.43	12671.57	12511.41	12514.51	12684.68	179.25
(% change relative to base)		1.33	0.05	0.07	1.43	
Quantity of exports	7,625.47	7710.62	5274.05	7646.03	7735.58	110.11
(% change relative to base)		1.12	-30.84	0.27	1.44	
Output price	1.00	1.01	1.00	1.00	1.00	0.00
(% change relative to base)		1.00	0.00	0.00	0.30	
Fossil Fuel Expenditures	0.03	0.03	0.03	0.02	0.02	-0.01
(% change relative to base)		0.00	0.00	-33.33	-33.33	

Table 4. Effect of WA I-732 on the Forestry Sector

	Base (Year 0)	Sales Tax Reduction	B&O Tax Reduction	Carbon Tax	Total	Total Difference from base
Year 1						
Value of output	1,114.65	1116.62	1116.15	1111.80	1116.56	1.91
(% change relative to base)		0.18	0.13	-0.26	0.17	
Quantity of Domestic output	1,114.65	1113.59	1116.16	1113.29	1115.03	0.38
(% change relative to base)		-0.10	0.14	-0.12	0.03	
Quantity of exports	471.96	471.89	151.32	471.34	472.54	0.58
(% change relative to base)		-0.01	-67.94	-0.13	0.12	
Output price	1.00	1.00	1.00	1.00	1.00	0.00
(% change relative to base)		0.00	0.00	0.00	0.10	
Fossil Fuel Expenditures	0.04	0.04	0.04	0.03	0.03	-0.01
(% change relative to base)		0.00	0.00	-25.00	-25.00	
Year 2						
Value of output	1,114.65	1118.99	1115.73	1108.47	1115.93	1.27
(% change relative to base)		0.39	0.10	-0.55	0.11	
Quantity of Domestic output	1,114.65	1112.91	1115.74	1110.92	1112.32	-2.33
(% change relative to base)		-0.16	0.10	-0.33	-0.21	
Quantity of exports	471.96	471.98	472.44	470.26	471.71	-0.24
(% change relative to base)		0.00	0.10	-0.36	-0.05	
Output price	1.00	1.00	1.00	1.00	1.00	0.00
(% change relative to base)		0.00	0.00	0.00	0.26	
Fossil Fuel Expenditures	0.04	0.04	0.04	0.03	0.03	-0.01
(% change relative to base)		0.00	0.00	-25.00	-25.00	

Table 5. Change in Fossil Fuel Use and Carbon Dioxide Emissions

	Fossil Fuels (gallons)		Emissions (MT)	
	Before	**After**	**Before**	**After**
Agriculture	60,454,193	54,714,772	538,042	486,961
Forestry	5,373,854	4,784,936	47,827	42,586