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THE SCHOOL OF PUBLIC POLICY

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CAPSTONE PROJECT

The Impact of Output Based Allocations on the Carbon Tax and Policy: Measuring the Effective Tax Rates on Marginal Costs

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Introduction

As the global climate challenge intensifies, countries are working to reduce the adverse effects caused by an increasing amount of Greenhouse gas (GHG) emissions. In 1997, the Kyoto Protocol was signed in an agreement that global warming is happening due to GHG emissions and industrialized countries commit to reducing GHG emissions according to their individual targets (United Nations 2021).

Canada has been progressive in climate accountability plans. Under the Paris Agreement, Canada is committed to carbon net-zero by 2050 (Environmental and Natural Resources Canada 2021). As one of the largest energy producers in North America, Alberta introduced its first carbon tax regulation in 2007, the Specified Gas Emitters Regulation (SGER). The SGER introduced the concept of output based allocations in Canada and has been a model for the concept in other provinces and the federal government.

As policies to reduce emissions are imposed, such as carbon taxes, concerns over the competitiveness of energy intensive production in industrialized countries rise. Carbon emissions can relocate in response to country specific policies, a phenomenon known as carbon leakage. Evidence suggests that overall global emissions have not declined with GHG emission policies introduced in industrialized countries as carbon leakage occurs to undermine the efficacy of the Kyoto Protocol's anticipation (Babiker 2005).

Output based allocations (OBAs) have been introduced as a solution to prevent carbon leakage and preserve firm competitiveness. OBAs are intended to reduce the side-effects of strengthening the environmental regulations while at the same time preserving the incentives to reduce emissions. Carbon border adjustment is another method intended to relieve the issues of carbon leakage. It adds import tariffs to specific products based on the carbon footprint and provides an export subsidy for domestic exporters. It effectively inhibits domestic producers' offshoring due to the increasing stringency of the carbon regulatory environment.

In this study, we will review background information around the emission regulations impacting Canada and Alberta. We will provide simulation analysis on output based allocations (OBAs) regarding effective tax rates on marginal costs (McKenzie, Mintz, and Scharf 1997). The results indicate that OBAs disrupt the correlation between energy input and effective tax rates on marginal costs (ETRMC), and therefore, promote energy production under a carbon tax.

Background Review

This section reviews the background information and public opinion for Canada's climate plans and carbon regulations. Furthermore, we explain the output based allocations (OBAs) and carbon border adjustments (CBA) as powerful tools to ease the impacts of carbon leakage.

Climate Change and Canada

Climate change has become the most serious concern for all global citizens living on this planet. Canada is no exception to experiencing climate change and its associated environmental challenges. According to Environment and Climate Change Canada (2019), there is an increase of 1.7ºC for Canada as a whole and 2.3ºC for northern Canada between 1948 and 2016. Canada is experiencing extreme heat in summer, and the annual extreme heat days have witnessed an increase in the same time duration. In different locations of Canada, the influence of climate change is being identified. Wildfire, flooding, and rapid decreases of the glacier are showing the effect and calling for proper responses (Environment and Climate Change Canada 2018). Climate change adaptation - a suite of policies aiming to improve the resilience of communities against climate challenges is needed for Canada.

Canada's stand to confront climate change with progressive climate policies became apparent after the Paris Agreement in 2015. The Pan-Canadian Climate Framework provides a plan and emission trajectory to reduce emissions before 2030 and achieve net-zero before 2050 (Environment and Climate Change 2016). It proposes sectoral transformation and inter-governmental actions; among all the suggestions, carbon pricing is the priority of this framework to drive low-carbon innovation and transition into the decarbonized economy.

Climate Policy and Public Opinion

Carbon pricing is an efficient tool to reduce carbon emissions and encourage low-carbon technology development. It imposes a tax on the production, distribution and consumption of carbon emission associated products (Hájek et al. 2019). Many studies support the environmental benefits of carbon pricing. The detrimental economic effects of carbon pricing can also be solved by effective policy design. Some concerns of the carbon tax may be around the tax burden on low-income families; Murray and Rivers (2015) argue that proper tax rebates eliminate tax incidence on low-income families while the unproportionable increase of tax rates to tax rebates might exacerbate the situation if the carbon tax rate climbs significantly.

Public opinion on climate change in Canada has witnessed a positive trend where more people acknowledge global warming and recognize human activities as reasons for climate change. According to Mildenberger et al. (2016), most Canadians believe in climate change, which is a belief that exceeds 60% in over 97% of electoral districts. Nevertheless, the support for climate policy is less robust. The respondents who support a carbon tax and believe in the human cause of global warming are less than half of the surveyed population.

Alberta is a little different compared to overall Canadian attitudes towards climate change. Only 28% of Albertans agree that Earth is getting warmer due to human activities in the surveyed population. In the bottom ten districts where the belief in global warming is lowest, seven out of ten districts come from Alberta. In addition, the political complexions of climate policy in Alberta are noteworthy. In 2019, Alberta repealed the obligations of the federal carbon tax against its constitutionality, aiming to remove financial pressure on industries and families (Alberta 2019). In 2021, the Supreme Court ruled in favour of federal legislation, upholding the federal carbon tax's constitutionality (King et al. 2021).

The political framing of climate policy results in segregated and conflicted opinions. Some climate policies have been introduced as harming the working class and devastating economic development (Copland 2020). The cultural antipathy toward a carbon tax is rooted in the population due to years of political opposition and manipulation; policy labelling has been implemented inexplicitly into the carbon tax (Rabe and Borick 2012). To apply carbon tax is also to overcome the political differentiation and to seek common interests. The benefits of output based allocations (OBAs) should be provided transparently and evidently to the public.

Table 1 – Percentage of population who believe that Earth is getting warmer

Top 10 Districts	Bottom 10 Districts
Brampton East (ON)	Battle River–Crowfoot (AB)
Dartmouth–Cole Harbour (NS)	Bow River (AB)
Halifax (NS)	Foothills (AB)
Laurier–Sainte-Marie (QC)	Fort McMurray–Cold Lake (AB)
Outremont (QC)	Lakeland (AB)
Papineau (QC)	Peace River–Westlock (AB)
Rosemont–La Petite-Patrie (QC)	Portage–Lisgar (MB)
Surrey–Newton (BC)	Red Deer–Lacombe (AB)
Terrebonne (QC)	Souris–Moose Mountain (SK)
Vancouver East (BC)	Yorkton–Melville (SK)

Chart 1 – Public Opinion on Climate Policy in Canada

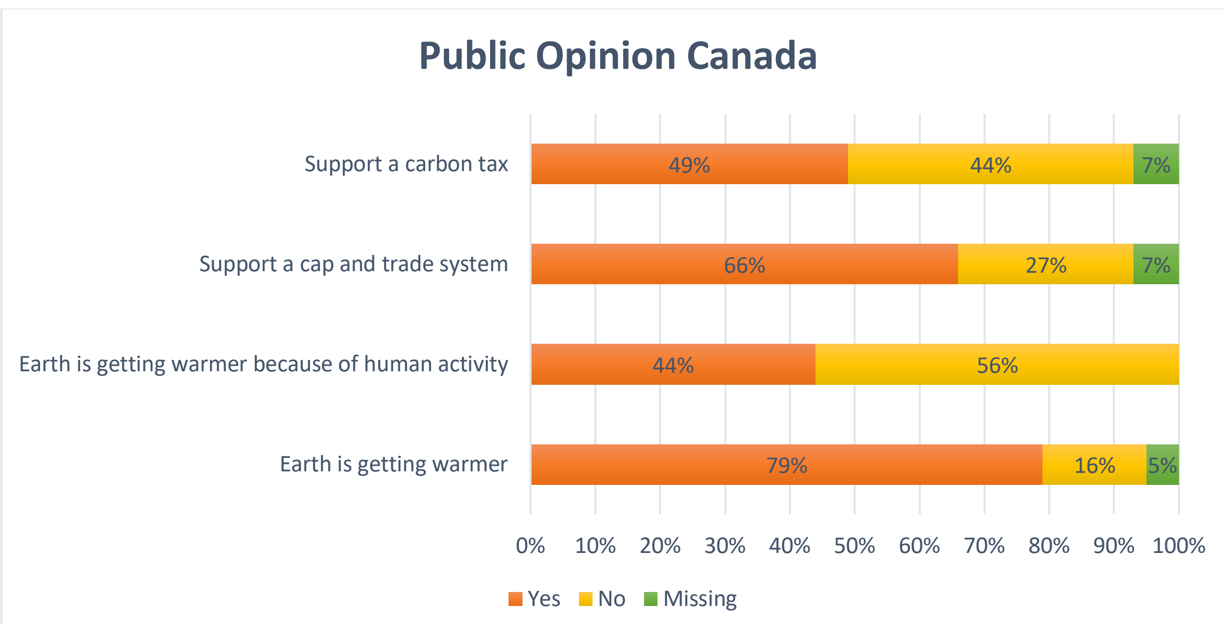
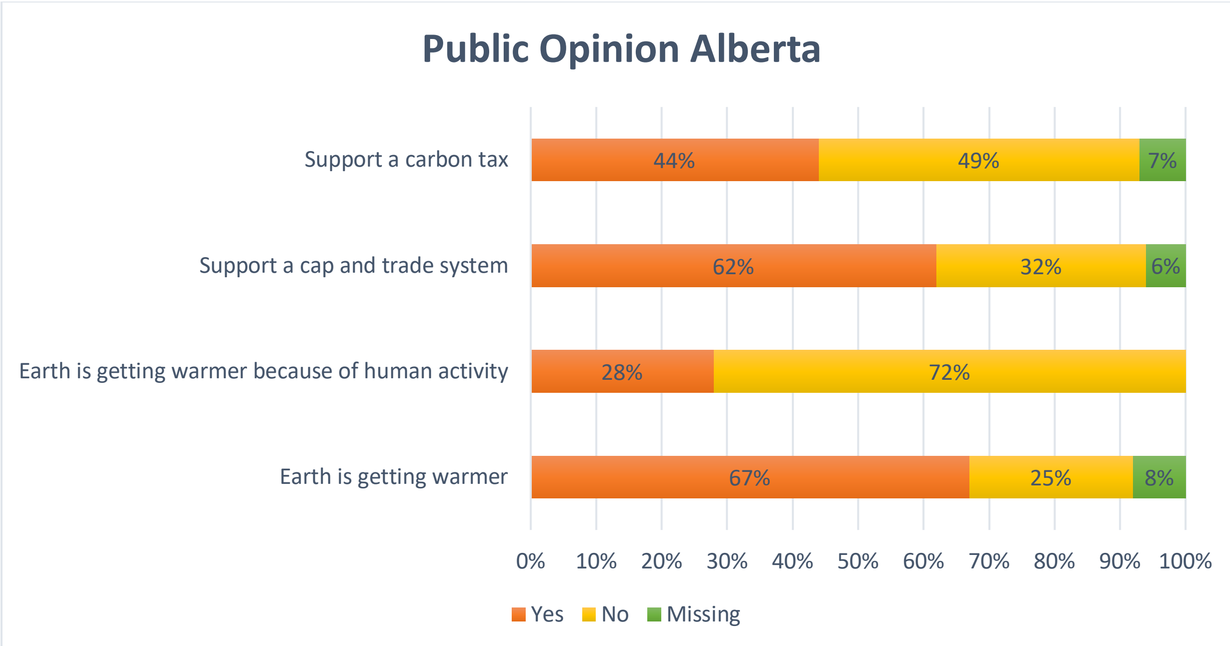


Chart 2 – Public Opinion on Climate Policy in Alberta



Emissions and Regulations in Alberta

Alberta is Canada's largest producer of oil and natural gas. According to Canada Energy Regulator (2021), 82% of total Canadian oil production and 65% of total Canadian natural gas production comes from Alberta. Most of the carbon emissions in Alberta are generated from the oil and gas sectors.

Alberta's carbon tax regime began with Specified Gas Emitters Regulation (SGER), the first policy in North America to charge carbon emissions (Alberta 2007). The SGER applied to facilities with CO_{2e} emissions of more than 100,000 tonnes after 2003. The SGER was a facility specific regulation; only individual facilities whose CO_{2e} emissions were beyond the threshold were held accountable under this policy. In detail, all eligible facilities were required to reduce their emission intensity by 12% regarding the government baseline. Otherwise, the company would either pay for its facilities' extra emissions or purchase emissions-performance credits from the Alberta Emission Performance Credit Registry. Following SGER, Alberta introduced Carbon Competitiveness Incentive Regulation (CCIR) and Technology Innovation and Emission Reduction Regulation (TIER) under different political leadership (Alberta 2017; 2019). Minor changes and edits have been applied to SGER, but the essence of this carbon regime stays the same. Alberta's carbon tax policies are emissions-intensity regulations, meaning that merely the proportion of emissions exceeding beyond the stated threshold will be punished with a price. The emissions-intensity regulations serve as an implicit subsidy to output, mitigating negative impacts on the competitiveness of energy production companies (Dobson and Winter 2015).

Carbon Leakage

Unilateral efforts to handle global climate challenges are faced with carbon leakage. Countries are moving forward with climate policies individually. The discrepancy of various emission policies reflects different outcomes. Non-acting countries might have a comparative advantage in production competitiveness. The acting countries could then suffer from production offshoring from their regulated sectors, giving rise to carbon leakage.

Carbon leakage occurs when there is an asymmetric regulatory environment on emission control (Huang, Tan, and Toktay 2021). In a globalized society, when a country publishes emission regulations, the other can potentially take advantage of international trade to weaken the competitiveness of production in those emission regulated countries. The carbon emissions meanwhile transfer from acting countries to non-acting countries. The production capacity might also be shifted from regulated regions to unregulated one. Thus, carbon leakage precipitate reverse outcomes of carbon regulations. The incentives to charge carbon emissions in industrialized countries can be exchanged with the relocation of energy intensive production, leading to an increase in global emissions (Babiker 2005).

Output Based Allocations (OBAs)[1]

One of the defects of the carbon tax is the declined competitiveness of local industries and companies. For regions with carbon regulations, the added cost of production may impinge upon the competitiveness of production. If the other countries trade without equivalent carbon

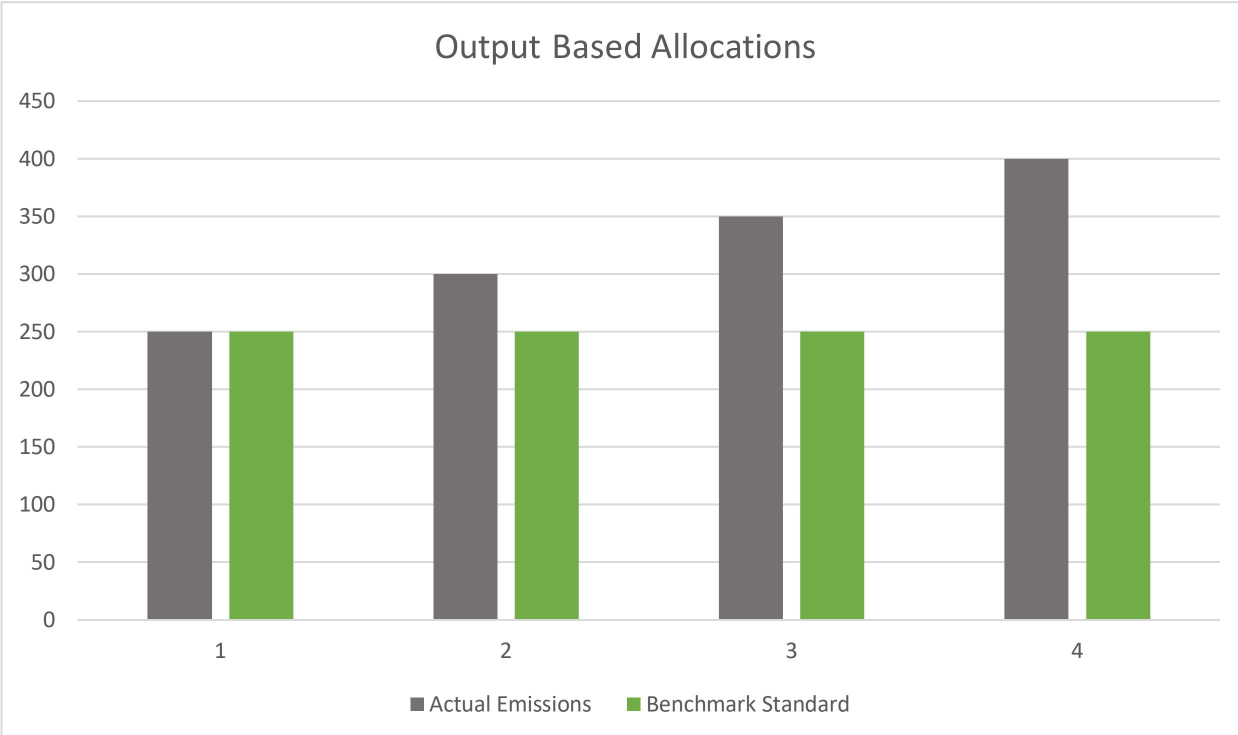
[1] The following is based largely on lecture notes provided by Dr. Kenneth McKenzie and are used with his permission.

regulations, it is unfair for them to undermine local businesses where carbon regulations are employed.

Output based allocations stand out as an innovative policy design to treat the competitiveness issues due to the administration of a carbon tax. “Cap and trade” emission trading programs are an original form of output-based allocation in diverse countries. Traditional “cap and trade” emission trading system grants participating companies a fixed allowance regardless of the market environment. An increase in the marginal costs of production for these firms will directly move to the burden of consumers, and firms entering the market in different sequences receive discriminatory treatments (Fischer and Fox 2007).

Output based allocations impose an intensity “cap” in the specific sector proportional to the respective outputs. The allocation will change according to the shares of emissions to the corresponding outputs (Fischer and Fox 2007). It is designed to relieve the undesirable influence of emission regulation on producers by imposing an intensity performance standard. The intensity performance standard works as a benchmark for tonnes of emissions per unit of output. For firms whose emission intensity is over the benchmark, they are obligated to pay the price for the extra emissions. Otherwise, firms are rewarded credits for future use, or they sell the credits to others.

Chart 3 – Illustration of OBAs



Referring to Chart 3, for example, if firm 1 sets the emission intensity standard. Every firm in this market would receive carbon credits equivalent to firm 1's amount if they were as efficient as firm 1. However, if they perform worse than firm 1, they pay the carbon price for emissions beyond the benchmark. The less efficient they were compared to firm 1, the more notable emissions they need to pay.

However, output based allocations might lead to inefficiency in emission reduction. Companies can be more inclined to lower energy intensity, and consumers can remain resilient to emission related products with more minor price changes due to production subsidy (Fischer and Fox 2007). Moreover, implementing output based allocations add the costs of a country's environmental commitment. In contrast, the effectiveness of output based allocations remain uncertain without an accurate measure of outputs in different sectors (Haites 2003). Haites (2003) argues for comparing alternative options regarding costs and benefits to decide on policy implementations.

Carbon Border Adjustment (CBA)

Carbon border adjustment is another policy system targeting carbon leakage. Condon and Ignaciuk (2013) argue three main themes on carbon border adjustment – competitiveness, leakage, and leverage. Carbon border adjustment will impose a levy on imports of certain products; it functions as putting a carbon price on imports to prevent production from shifting to jurisdictions with less stringent emission policies. European Union is a leader in carbon border adjustment mechanism, and it intends to complement the emission trading system in Europe to ensure a global carbon reduction (Delbeke and Vis 2020).

In a unilateral policy environment against climate change, carbon border adjustment stands as an efficient method to mitigate the results of carbon leakage. Carbon border adjustment imposes tariffs on products with carbon footprints from unregulated regions. It delivers rebates for domestic producers on exports, alleviating the competitiveness loss for domestic firms and integrating climate change into domestic prices (Böhringer, Balistreri, and Rutherford 2012).

Carbon border adjustment also serves as a stimulus to change policies in other countries without emission regulations. By modifying domestic climate policies, carbon border adjustment can be circumvented for these countries and therefore, carbon border adjustment results in a reduction of total carbon emissions globally (Condon and Ignaciuk 2013).

Both output based allocations and carbon border adjustment are innovative carbon regulations. Output-based allocation suggests a direct incentive to encourage technology improvement in the emission regulated regions. Carbon border adjustment is more effective in decreasing global emissions and blocking carbon leakage than output based allocations (Huang, Tan, and Toktay 2021). Regarding the effectiveness of combating asymmetric carbon regulations, carbon border adjustment presents a stronger anti-leakage outcome (Huang, Tan, and Toktay 2021).

Methodology[2]

To understand the effect of a carbon tax on firms' production costs with and without output based allocations (OBAs), we use the concept of the effective tax rates on marginal costs (ETRMC). The ETRMC was developed and introduced by McKenzie, Mintz and Scharf (1991). The ETRMC measures the impact of various taxes levied on the factors of production and the marginal cost of production. The approach taken here is to extend the concept of the ETRMC to include the carbon tax with OBAs.

Generally, we consider a firm with production function q = F (E, K), where q is output, E is energy, and K is capital. In the absence of taxation, the firm's cost minimization problem is:

$$Min\ eE + rK$$
$$s.t. q = F(E, K)$$

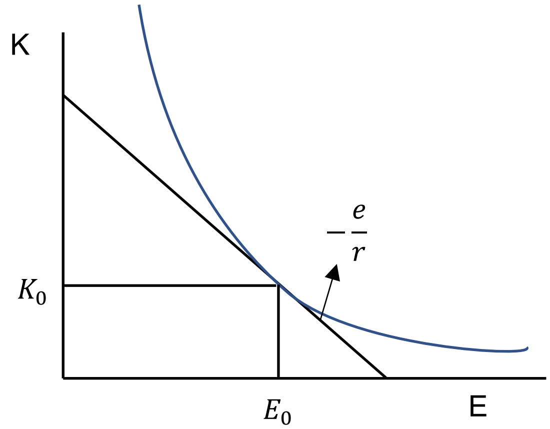
This gives rise to conditional input demand functions E(q,e,r) and K(q,e,r) and a minimized cost function:

$$C(q, e, r) = eE(q, e, r) + rK(q, e, r)$$

The marginal cost function will be:

$$MC(q, e, r) = \frac{dC(q, e, r)}{dq}$$

[2] This section is based largely on notes provided by Dr. Kenneth McKenzie and are used with his permission.

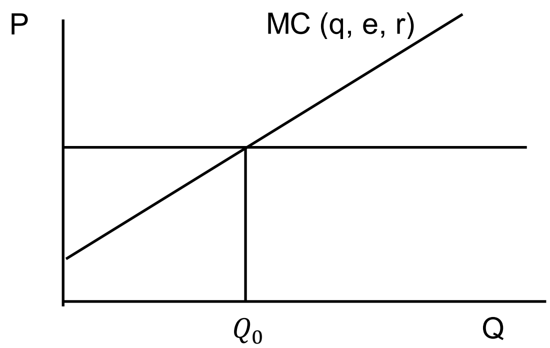


The profit maximization problem is:

$$Max\ Pq - C(q, e, r)$$

Which gives rise to the standard result:

$$P = MC(q, e, r)$$



We now introduce taxes on both capital and energy. We first consider a simple carbon tax without OBAs. Following McKenzie, Mintz and Scharf (1997), the cost minimization problem is now:

$$Min\ (e + t_e)E + r(1 + t_k)K$$
$$s.t.\ q = F(E, K)$$

Here t_e is the per unit tax levied on energy, which in our context is the carbon tax converted to a tax on the energy input, and t_k is the marginal effective tax rate (METR) on capital, which reflects the imposition of a corporate income tax on capital (Bazel and Mintz 2020).

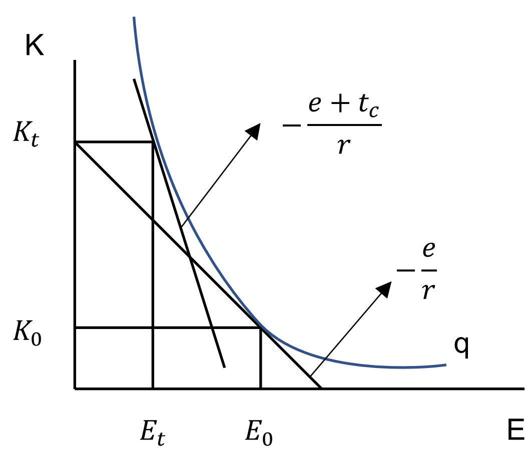
The imposition of these taxes generates a marginal cost function MC (q, e+t_e, r(1+t_k)), which reflects the increase in input prices due to the imposition of the taxes. Following McKenzie, Mintz and Scharf (1997), the ETRMC is then defined as:

$$T_{No\ OBA} = \left[MC\left(q, e + \ t_c, r(1 + t_k)\right) - MC(q, e, r)\right] / MC(q, e, r)$$

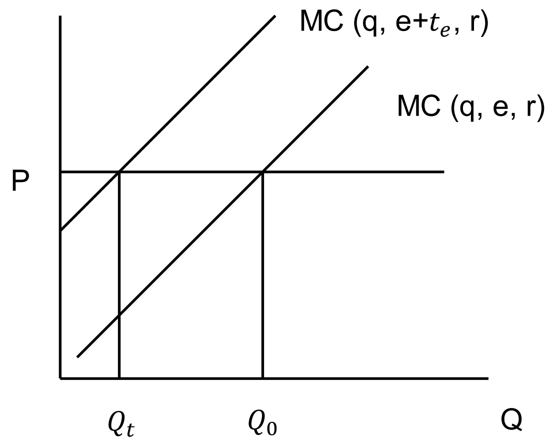
It measures the increase in the marginal cost of production due to the carbon tax and the CIT.

Ignoring for the moment the tax on capital, the essential mechanism of the carbon tax's impact on the firm's cost is the rise of the relative price of energy. Due to the rise of the relative price of energy, emissions decrease through two channels: the factor substitution effect (FSE) and the output effect (OE).

In a factor substitution effect, the carbon tax increases the relative cost of energy, hence moving the firm to substitute towards low emission intensive factors.



The output effect lowers emissions because the carbon tax increases the cost of energy and, therefore, the marginal cost of production. Thus, firms reduce their production to lower emissions.



As discussed above, if production moves to other jurisdictions because of the increase in the marginal cost of production, then the economic activity is stifled, and carbon leakage occurs. Output based allocations are a way of combating this.

If we impose a carbon tax at rate t_e with OBAs, the firm's cost minimization condition remains unchanged, and the marginal cost function remains MC (q, e+t_e, r(1+t_k)).

Thus, the factor substitution effect remains in play by increasing the relative price of energy and incentivizing firms to substitute away from the emission intensive input. However, firms now can obtain emission credits of qs, where q is the output and s is the emission intensity standard (tonnes per unit of output). Those credits can lower the carbon tax obligations for these firms as the credits reduce the carbon tax payable, or the credits can be sold on the market for t_c, which is the carbon tax rate.

The profit maximization problem now becomes:

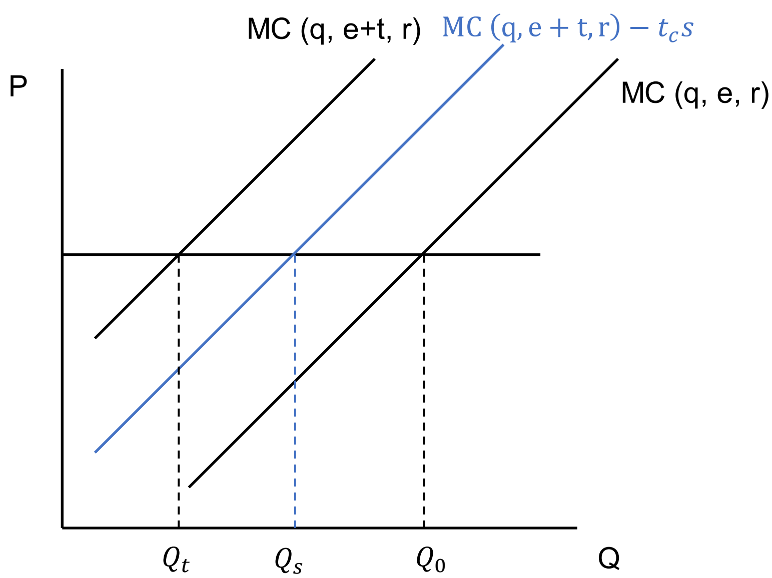
$$Max\ Pq - C(q, e + t_e, r(1 + t_k)) + t_c qs$$

And the profit maximization condition is now,

$$P = MC(q, e + t_e, r(1 + t_k)) - t_c s$$

Here we see that the OBAs act as an output subsidy at the rate $t_c s$ per unit of output, which lowers the marginal cost of production relative to the situation without OBAs.

The result is shown in the following diagram:



The OBAs based on an intensity standard act like a production subsidy. It maintains the factor substitution effect by increasing the relative cost of energy, incentivizing firms to use fewer emissions intensive factors of production and encourage investment in low-emission technology. However, significantly, it alleviates the output effect by lowering the related marginal cost of production as it works as an implicit output subsidy.

The ETRMC in the presence of the OBAs is now:

$$T_{OBA} = \left[MC\left(q, e + \ t_c, r(1 + t_k)\right) - t_c s - MC(q, e, r)\right] / MC(q, e, r)$$

or

$$T_{OBA} = T_{No\ OBA} - t_c s / MC(q,e,r)$$

Simulations

In this section, we provide some illustrative simulations to show how carbon taxes with and without the output based allocations (OBAs) and corporate income taxes affect firm competitiveness through effective tax rates on marginal costs (ETRMC). To do so, we must parameterize the production function. We assume a Cobb-Douglas function where L is labour, K is capital, and E is the energy input:

$$f(L,K,E) = AL^{\alpha}K^{\beta}E^{\gamma}$$

We assume constant returns to scale so that $\alpha + \beta + \gamma = 1$.

The cost function (if we set w=1 by choice of units) is:

$$C_{OBA}^{T} = q(r(1+t_k))^{\beta}(e\left(1+\frac{t_e}{e}\right))^{\gamma}\phi - qt_c s$$

q is the quantity of output; t_e is the carbon tax, which is level per tonne of carbon emissions; t_k is the corporate income tax; s is the intensity standard, which is measured in tonnes of carbon emissions per output; t_c is a converted carbon tax to represent energy output.

The marginal cost function is:

$$MC_{OBA}^{T} = (r(1+t_k))^{\beta}(e\left(1+\frac{t_E}{e}\right))^{\gamma}\phi - t_c s$$

With this parameterization, the ETRMC without and with the OBAs are:

$$T_{No\ OBA} = (1+t_k)^{\beta}\left(1+\frac{t_e}{e}\right)^{\gamma} - 1$$

$$T_{OBA} = T_{No\ OBA} - \frac{t_c s}{r^{\beta} e^{\gamma} \phi}, where\ \phi = \frac{1}{\alpha^{\alpha} \beta^{\beta} \gamma^{\gamma}}$$

Moreover, we see that the output based allocations reduce the effective tax rates on marginal costs (ETRMC), alleviating concerns of firm competitiveness and carbon leakage.

We now provide some illustrative calculations of the ETRMC using reasonable values for the parameters and undertake some sensitivity analysis:

$$t_k = 0.3$$
$$t_c = 170$$
$$t_e = 9.3$$
$$e = 2.5$$
$$r = 0.05$$
$$s = 0.001$$

As illustrated in the above section, output based allocations (OBAs) can decrease the marginal cost of production for energy intensive firms under a carbon tax. With these parameters, OBAs are shown to reduce the ETRMC under the same rate of the carbon tax for these firms. If we choose $\alpha = 0.4, \beta = 0.3, \gamma = 0.3$ and parametrize the ETRMC without and with OBAs, the outcome is displayed in Table 2 below.

Table 2 – Output Based Allocations (OBAs) Lower Effective Tax Rates on Marginal Costs (ETRMC)

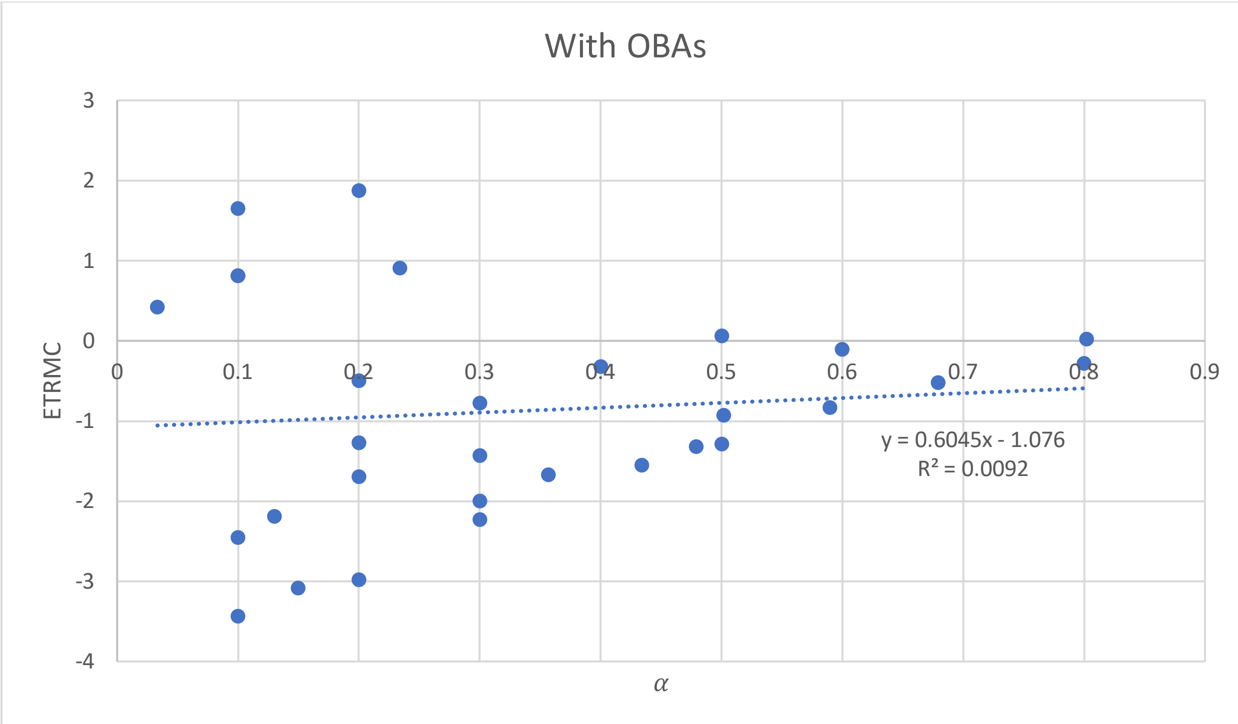
	Effective Tax Rates on Marginal Costs (ETRMC) $t_c = 170, t_e = 9.3$	Effective Tax Rates on Marginal Costs (ETRMC) $t_c = 50, t_e = 2.7$
Without Output Based	0.72331871	0.34772724

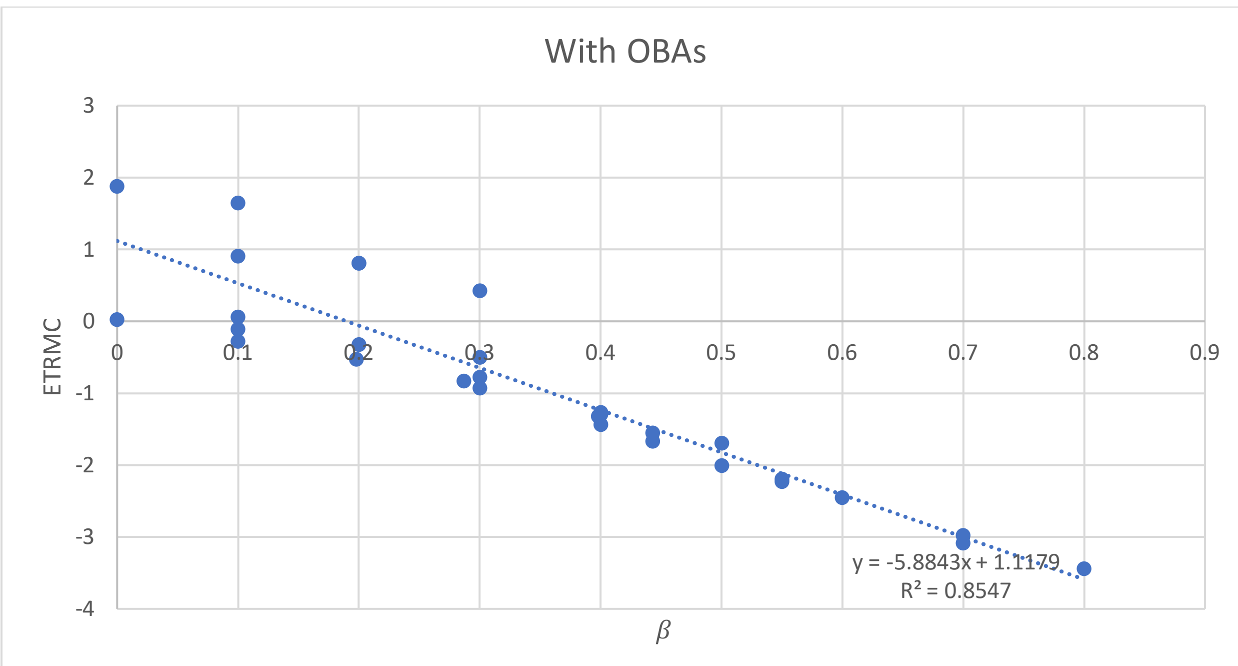
Allocations (OBAs)		
With Output Based Allocations (OBAs)	-0.909895588	-0.132629907

From Table 2, we can find that the OBAs significantly reduce the ETRMC as an implicit output subsidy. In our assumed parameterization, ETRMC is negative with OBAs, suggesting an overly effective reduction of the carbon tax's impact on production cost.

We now examine the change of effective tax rates on marginal costs (ETRMC) with and without output based allocations (OBAs) in accordance with different parameterizations of α, β, and γ. Hence, we can see the impact of the share of labour, capital, and energy input on the effective tax rates on marginal costs (ETRMC).

Chart 4 – Effective Tax Rates on Marginal Costs (ETRMC) with Output Based Allocations (OBAs)


With OBAs
ETRMC
α
y = 0.6045x - 1.076
R² = 0.0092


With OBAs
ETRMC
β
y = -5.8843x + 1.1179
R² = 0.8547

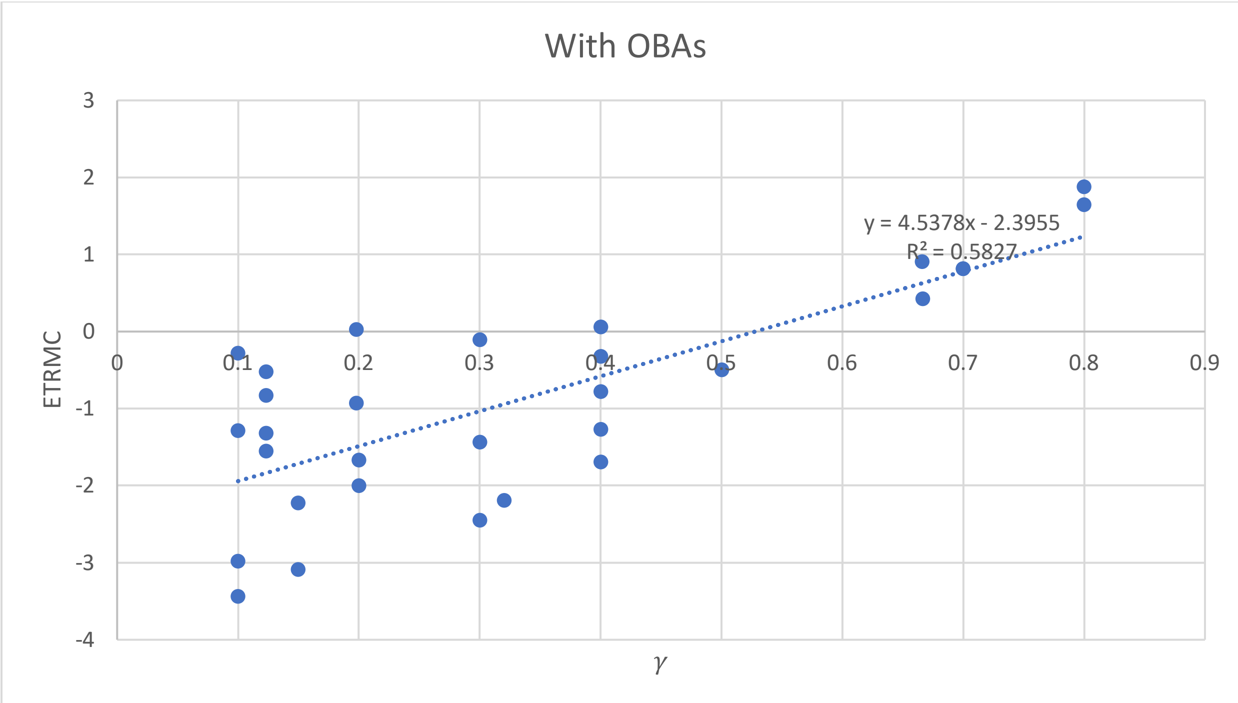
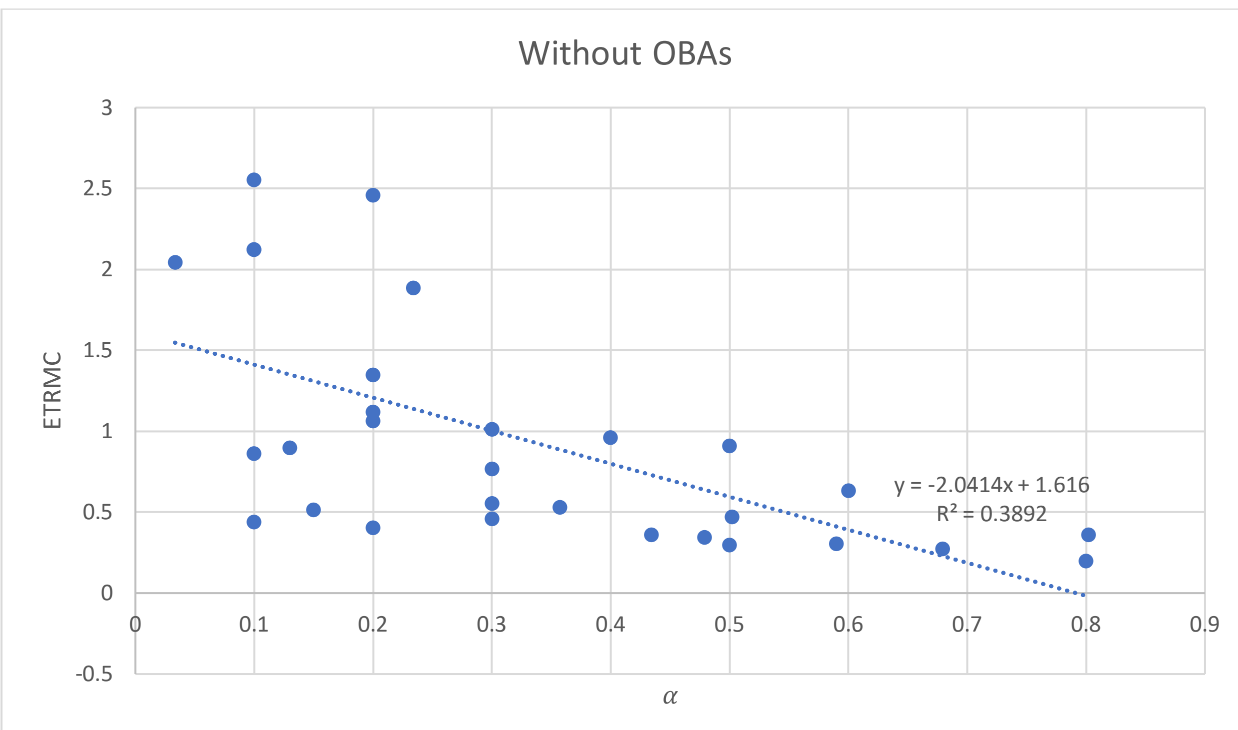
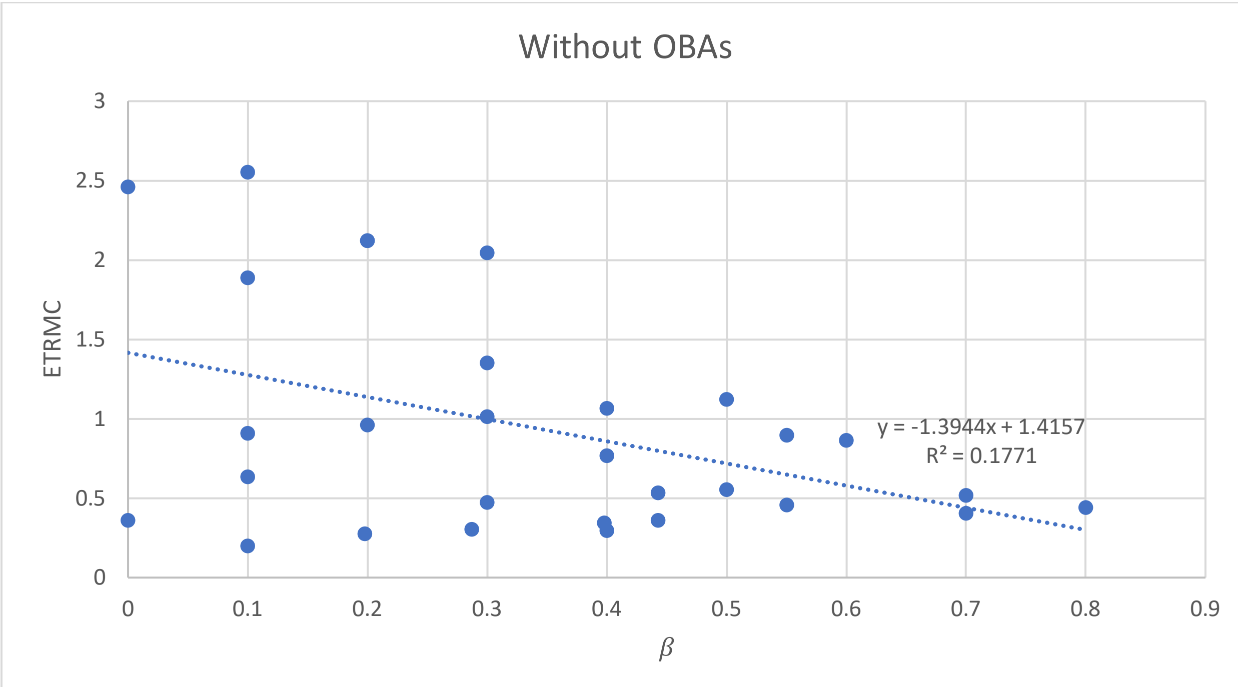
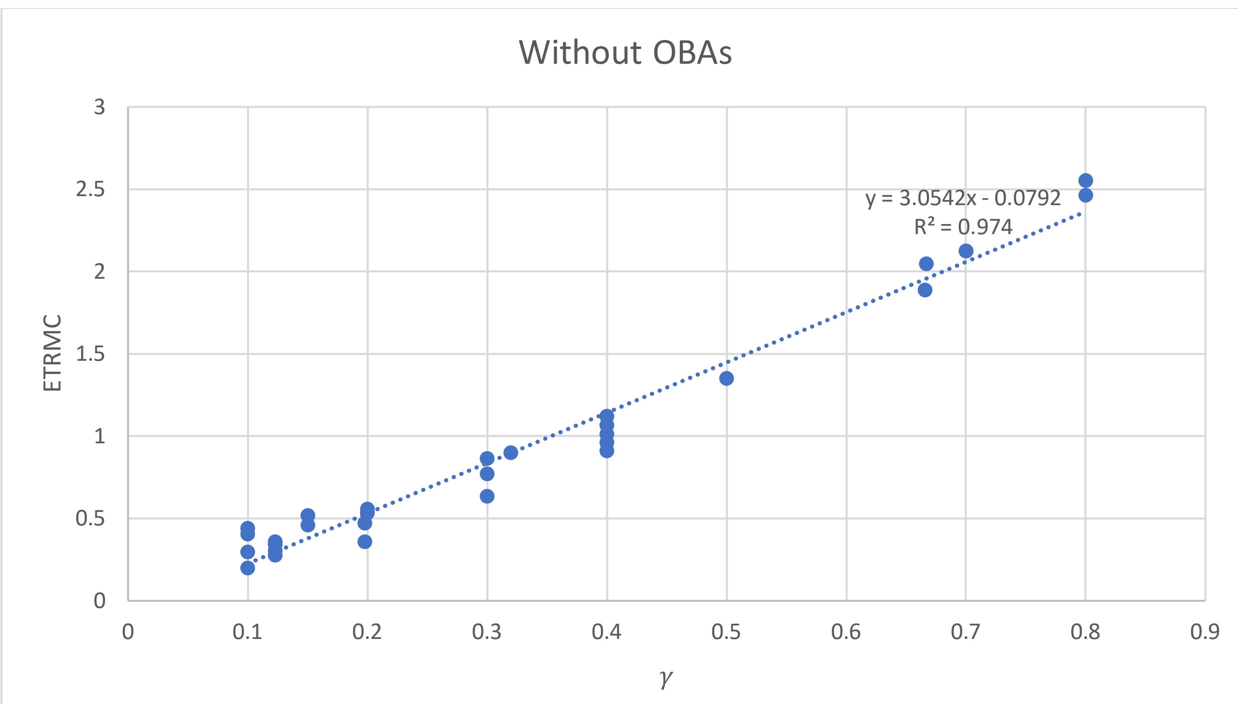


Chart 5 – Effective Tax Rates on Marginal Costs (ETRMC) without Output Based Allocations (OBAs)







We first consider the relationship with OBAs. With OBAs, regarding labour's share of costs, α, the relationship between α and ETRMC is minimal. For β, capital's share of costs, there is a marked negative correlation between β and ETRMC. This is sensible. As the share of capital in the production processes increases, there is less impact of the high tax levied on energy, which is higher than the tax rate on capital. Similarly, as energy's share of costs γ increases, there is a marked positive relationship between the ETRMC, as the high tax rate levied on emissions becomes more important.

Without OBAs, there is a marked negative relationship between the ETRMC and the share of labour (α) and capital (β), as would be expected. For γ, the correlation is the clearest among the parametrizations that a positive correlation exists between γ and ETRMC. Higher energy input results in larger ETRMC, hence significant impacts on energy production costs from a carbon tax. With OBAs, the impacts of higher energy input on ETRMC shrink as the correlation is weakened. Without OBAs, companies will bear larger burdens on production costs from a carbon tax than the cases with OBAs. OBAs clearly disrupts the impacts of the carbon tax on energy production cost by lowering ETRMC.

The simulation supports the notion that OBAs mitigates the production costs for firms in the implementation of the carbon tax. Specifically, γ as the parameter of energy inputs displays dispersed correlation to ETRMC with OBAs and a linear positive correlation to ETRMC without OBAs. OBAs obliterate the channel where the increase of energy inputs leads to greater ETRMC in certain.

Conclusion

Carbon pricing is the most effective method to deal with increasing challenges in climate change. It is suggested as the priority of Canada's climate response framework, and it has presented its efficacy across Canada. Output based allocations (OBAs) are an innovative design to protect the competitiveness of domestic firms and prevent carbon leakage, which is developed in Alberta's carbon tax regime and introduced into the federal carbon tax system. OBAs reduce the production cost of energy production by serving as an output subsidy. This paper explores the energy production affected by the carbon tax through analyzing the effective tax rates on the marginal costs (ETRMC). The results from a simulation show that the share of the energy input is the most crucial factor leading to the increase of ETRMC; however, OBAs effectively interrupt the strong correlation between energy inputs and ETRMC. Therefore, the impacts of a carbon tax on energy production cost could be alleviated due to the implementation of OBAs. More rigorous studies of this simulation are needed to confirm this conclusion.

Through the method of ETRMC, OBAs are proven to be efficient in complementing the carbon tax's drawbacks in firm competitiveness. The benefits of OBAs need to be presented transparently and evidently to Canadians to inform the public opinion and construct evidence based policy recommendations.

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Appendix – Datapoints for Simulation

α	With OBAs	α	Without OBAs
0.3	-2.0018573	0.3	0.55510628
0.5	0.05972632	0.5	0.90972632
0.5	-1.2890618	0.5	0.29709427
0.3	-1.4345373	0.3	0.76913079
0.1	-2.4500879	0.1	0.86444086
0.1	0.81232419	0.1	2.12282803
0.1	-3.4372669	0.1	0.44061815
0.8	-0.2773773	0.8	0.19891539
0.1	1.64806461	0.1	2.55261327
0.6	-0.1059284	0.6	0.6352228
0.2	-1.2683278	0.2	1.06611333
0.3	-0.7773238	0.3	1.01261083
0.2	-1.6962478	0.2	1.12103813
0.4	-0.3217687	0.4	0.96049379
0.1	0.81232419	0.1	2.12282803
0.2	-0.498379	0.2	1.35046617
0.2	-2.9788092	0.2	0.40331299
0.15	-3.0848143	0.15	0.51653224
0.3	-2.227069	0.3	0.45800879
0.13	-2.1899849	0.13	0.89814893
0.234	0.90669832	0.234	1.88562377
0.357	-1.6685095	0.357	0.53202307
0.434	-1.5533081	0.434	0.35947671
0.679	-0.52382	0.679	0.27483991
0.59	-0.8314073	0.59	0.30495822
0.479	-1.321858	0.479	0.34352057
0.19995	1.87669387	0.19995	2.46066289
0.80195	0.0242422	0.80195	0.35970975
0.502	-0.928295	0.502	0.47103675
0.0333334	0.42411374	0.0333334	2.04423116

β	With OBAs	β	Without OBAs
0.5	-2.0018573	0.5	0.55510628
0.1	0.05972632	0.1	0.90972632

0.4	-1.2890618	0.4	0.29709427
0.4	-1.4345373	0.4	0.76913079
0.6	-2.4500879	0.6	0.86444086
0.2	0.81232419	0.2	2.12282803
0.8	-3.4372669	0.8	0.44061815
0.1	-0.2773773	0.1	0.19891539
0.1	1.64806461	0.1	2.55261327
0.1	-0.1059284	0.1	0.6352228
0.4	-1.2683278	0.4	1.06611333
0.3	-0.7773238	0.3	1.01261083
0.5	-1.6962478	0.5	1.12103813
0.2	-0.3217687	0.2	0.96049379
0.2	0.81232419	0.2	2.12282803
0.3	-0.498379	0.3	1.35046617
0.7	-2.9788092	0.7	0.40331299
0.7	-3.0848143	0.7	0.51653224
0.55	-2.227069	0.55	0.45800879
0.55	-2.1899849	0.55	0.89814893
0.1	0.90669832	0.1	1.88562377
0.443	-1.6685095	0.443	0.53202307
0.443	-1.5533081	0.443	0.35947671
0.198	-0.52382	0.198	0.27483991
0.287	-0.8314073	0.287	0.30495822
0.398	-1.321858	0.398	0.34352057
0.00005	1.87669387	0.00005	2.46066289
0.00005	0.0242422	0.00005	0.35970975
0.3	-0.928295	0.3	0.47103675
0.3	0.42411374	0.3	2.04423116

γ	With OBAs	γ	Without OBAs
0.2	-2.0018573	0.2	0.55510628
0.4	0.05972632	0.4	0.90972632
0.1	-1.2890618	0.1	0.29709427
0.3	-1.4345373	0.3	0.76913079
0.3	-2.4500879	0.3	0.86444086
0.7	0.81232419	0.7	2.12282803
0.1	-3.4372669	0.1	0.44061815
0.1	-0.2773773	0.1	0.19891539

0.8	1.64806461	0.8	2.55261327
0.3	-0.1059284	0.3	0.6352228
0.4	-1.2683278	0.4	1.06611333
0.4	-0.7773238	0.4	1.01261083
0.4	-1.6962478	0.4	1.12103813
0.4	-0.3217687	0.4	0.96049379
0.7	0.81232419	0.7	2.12282803
0.5	-0.498379	0.5	1.35046617
0.1	-2.9788092	0.1	0.40331299
0.15	-3.0848143	0.15	0.51653224
0.15	-2.227069	0.15	0.45800879
0.32	-2.1899849	0.32	0.89814893
0.666	0.90669832	0.666	1.88562377
0.2	-1.6685095	0.2	0.53202307
0.123	-1.5533081	0.123	0.35947671
0.123	-0.52382	0.123	0.27483991
0.123	-0.8314073	0.123	0.30495822
0.123	-1.321858	0.123	0.34352057
0.8	1.87669387	0.8	2.46066289
0.198	0.0242422	0.198	0.35970975
0.198	-0.928295	0.198	0.47103675
0.6666666	0.42411374	0.6666666	2.04423116