Online Appendix

for

Jobs and Climate Policy: Evidence from British Columbia's *Revenue-Neutral* Carbon Tax

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1. Theory

This appendix provides a formal mathematical representation of the model presented in the main text.

I. Partial Equilibrium: One Industry Case

Firstly, the simplest case, a partial equilibrium analysis with only one industry, is analyzed. To simplify the analysis, a firm only uses labor and fossil fuels as inputs and takes the price of fossil fuels as given. Then a perfectly competitive firm would minimize its cost by solving:

$$\min_{e,l} \ c = w_1 l + w_2 e \quad \text{subject to} \quad q = f(l, e)$$

where l denotes labor, e denotes fossil fuels, and w_1 and w_2 are corresponding factor prices. By solving this, conditional input demand for l and e are derived as $l^* = l(w_1, w_2, q)$ and $e^* = e(w_1, w_2, q)$. Then using these equilibrium input demand, a cost function is defined as $c = c(w_1, w_2, q)$. By assuming a constant return to scale production function, the cost function can be shown as $c(w_1, w_2, q) = qc(w_1, w_2)$. With this cost function, a labor demand function can be derived by Shepard's lemma as follows:

$$l^d = qc_1 \tag{1.1}$$

where c_i indicates the partial derivative with respect to ith argument. c_1 is the amount of labor required to produce one unit of q, which is redefined as a_{LQ}. Then taking logs and totally differentiating (1.1) yield labor demand decomposition:

$$\widehat{l^d} = \underbrace{\widehat{q}}_{\text{Output effect}} + \underbrace{\widehat{a}_{\text{LQ}}}_{\text{Factor effect}} \tag{1.2}$$

where $\widehat{l^d} = dl^d/l^d$, and so on (i.e., " $\widehat{\ }$ " denotes a percentage change). This labor demand decomposition implies that a percentage change in labor demand is determined by two factors, the output and factor effect.

The demand function is given by $q = D(p)$, holding income fixed. Taking logs and totally differentiating yield:

$$\frac{dq}{q} = \frac{1}{D(p)}\frac{\partial D(p)}{\partial p}dp \tag{1.3}$$

By algebraic manipulation, (1.3) can be shown as follows:

$$\widehat{q} = \varepsilon_{\text{DP}}\widehat{p} \tag{1.4}$$

where $\varepsilon_{\text{DP}} \leq 0$ is price elasticity of demand. But conventionally, price elasticity of demand is perceived as a positive value in absolute term ($||\varepsilon_{\text{DP}}|| \geq 0$). To avoid the confusion, it is denoted as $-\varepsilon_{\text{DP}} \leq 0$.

Now to figure out an expression for $\widehat{p}$, a firm maximizes its profit by solving:

$$\max_{q}\ \pi = pq - qc(w_1, w_2)$$

The first order condition of firm's maximization problem yields $p = c(w_1, w_2)$. Now introducing a carbon tax on fossil fuels as follows:

$$w_2' = w_2 + \tau$$

Totally differentiating $p = c(w_1, w_2')$ and dividing it by p yield:

$$\frac{dp}{p} = \frac{c_1 dw_1}{p} + \frac{c_2 dw_2'}{p} \tag{1.5}$$

With simple manipulation, (1.5) can be shown as follows:

$$\widehat{p} = \theta_l \widehat{w}_1 + \theta_e \widehat{w}_2 + \phi\, \widehat{\tau} \tag{1.6}$$

where θ_i refers to the cost share of input i (i.e., $\theta_i = (c_i w_i)/c$) and ϕ refers to the cost share of a carbon tax (i.e., $\phi = (c_2\, \tau)/c$). However, in this paper we are only interested in an effect of a carbon tax on employment, which leads to an assumption that $\widehat{w}_1 = \widehat{w}_2 = 0$. Then (1.6) is reduced to:

$$\widehat{p} = \phi\, \widehat{\tau} \tag{1.7}$$

Finally, by plugging (1.7) back into (1.4), an expression for the output effect is derived.

$$\widehat{q} = -\varepsilon_{\text{DP}} \phi\, \widehat{\tau} \tag{1.8}$$

(1.8) shows that the change in output in response to a carbon tax is determined by two factors: price elasticity of demand and the cost share of a carbon tax.

Similarly, an expression for the factor effect can be derived. As $a_{\text{LQ}} = c_1(w_1, w_2)$, totally differentiating and dividing both side by a_{LQ} yield,

$$\frac{da_{\text{LQ}}}{a_{\text{LQ}}} = \frac{c_{11}}{a_{\text{LQ}}} dw_1 + \frac{c_{12}}{a_{\text{LQ}}} dw_2' \tag{1.9}$$

where c_{1i} is the partial derivative of c_1 with respect to ith argument (i.e., a second derivative of the cost function). By simple algebraic manipulation and $\widehat{w}_1 = \widehat{w}_2 = 0$, (1.9) can be shown as follows[1]:

$$\widehat{a}_{\text{LQ}} = \frac{c\, c_{12}}{c_1 c_2}\, \phi\, \widehat{\tau} \tag{1.10}$$

$$= \sigma \phi\, \widehat{\tau} \tag{1.11}$$

[1] The steps from (1.10) to (1.11) can be provided upon a request.

where $\sigma \geq 0$ is elasticity of substitution between labor and fossil fuels.[2] (1.11) shows that a percentage change in labor requirement in response to a carbon tax is determined by two factors: elasticity of factor substitution and the cost share of a carbon tax.

Finally, putting (1.8) and (1.11) back into (1.2) yields:

$$\widehat{l^d} = \underbrace{\sigma \phi \widehat{\tau}}_{\text{Factor effect}} - \underbrace{\varepsilon_{\text{DP}} \phi \widehat{\tau}}_{\text{Output effect}} \tag{1.12}$$

$$= (\sigma - \varepsilon_{\text{DP}}) \phi \widehat{\tau} \tag{1.13}$$

From (1.12), the sign of the employment effect of a carbon tax is determined by the degree of the negative output and positive factor effect. The size of the negative output effect depends on price elasticity of demand, whereas the size of the positive factor effect depends on elasticity of substitution between labor and fossil fuels. (1.13) makes it clear that the sign of the employment effect comes down to a comparison of price elasticity of demand and elasticity of substitution between factors.

Even in the one industry case, both positive and negative employment effects are possible. For example, for a tradable goods industry facing highly elastic demand and limited factor substitutability, the negative effect from price elasticity of demand outweighs the positive effect from elasticity of substitution. On the contrary, a non-tradable goods industry such as the service sector faces relatively inelastic demand and their factors are highly substitutable. Then the positive effect from elasticity of substitution outweighs the negative effect from demand elasticity. The example of the positive employment effect is illustrated in Figure 1. Although the output effect reduces the labor demand, the increase in labor demand by the factor effect outweighs the reduction, which results in the positive employment effect.

[2] When we allow for more than two inputs, σ can be negative if labor and fossil fuels are complement.

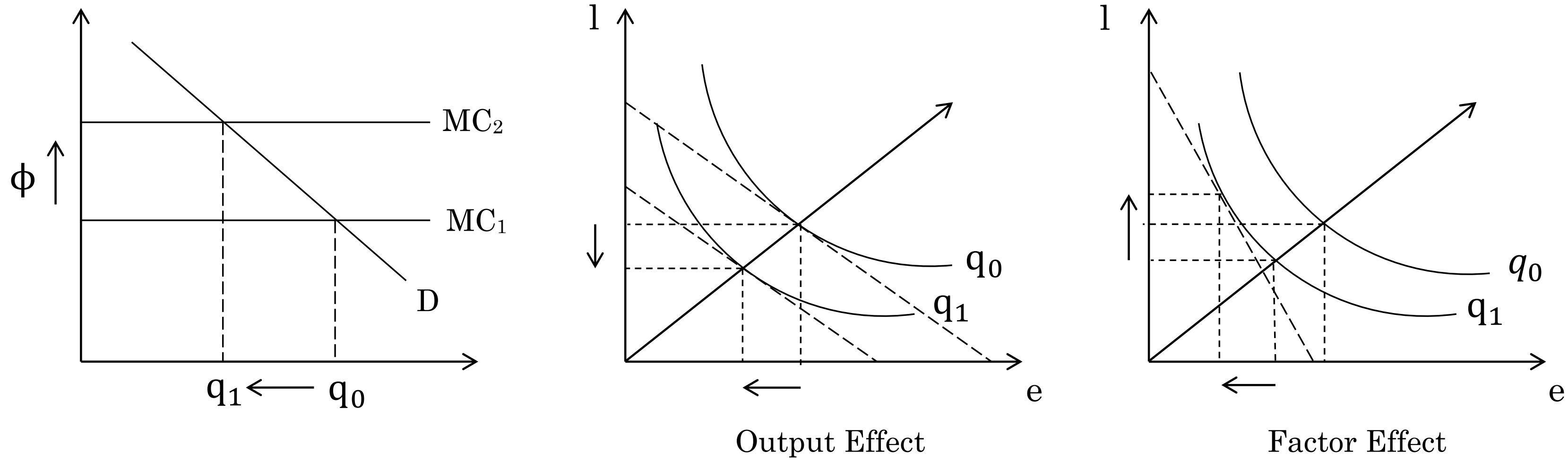

Figure 1: Output Effect vs. Factor Effect

Note: Figure 1 illustrates how a carbon tax could positively affect employment due to the larger positive factor effect than the negative output effect.

II. Partial Equilibrium: Many Industries Case

One caveat with equation (1.13) is that it does not allow for heterogeneity in employment effect across industries. To investigate heterogeneous industry-specific employment effects, multiple industries are needed to see how interactions between industries affect labor demand. To simplify the analysis, a case of two industries is discussed. Two industries are denoted as dirty (i) and clean (j).

With these two industries, a demand function is defined more generally as follows:

$$q_i = D_i(p_i, p_j) \tag{1.14}$$

where p_i denotes price for a dirty industry and p_j denotes price for a clean industry. This demand function assumes a quasi-linear preference as it is independent of income. By making the same algebraic manipulation that derived (1.4), (1.14) can be expressed as:

$$\widehat{q_i} = \varepsilon_{ij}\widehat{p}_j - \varepsilon_{ii}\widehat{p_i}$$

where $\varepsilon_{ii} \geq 0$ is own price elasticity of demand for the dirty industry and $\varepsilon_{ij} \in [-\infty, \infty]$ is cross price elasticity of demand. Then similar to (1.7), $\widehat{p_i} = \phi_i\,\widehat{\tau}$, which yields,

$$\widehat{q_i} = (\varepsilon_{ij}\phi_j - \varepsilon_{ii}\phi_i)\,\widehat{\tau} \tag{1.15}$$

where ϕ_i denotes the cost share of a carbon tax for the dirty industry.

As there is no interaction between two industries on the supply side, the factor effect would be the same as the case with one industry. σ_i denotes elasticity of factor substitution between labor and fossil fuels for the dirty industry. This gives an expression for the heterogeneous industry-specific employment effect of a carbon tax as follows:

$$\begin{aligned}\widehat{l_i^d} &= \underbrace{\sigma_i \phi_i \widehat{\tau}}_{\text{Factor effect}} + \underbrace{(\varepsilon_{ij}\phi_j - \varepsilon_{ii}\phi_i)\,\widehat{\tau}}_{\text{Output effect}} \\ &= \Big(\underbrace{(\sigma_i - \varepsilon_{ii})\phi_i}_{\text{Own industry effect}} + \underbrace{\varepsilon_{ij}\phi_j}_{\text{Cross industry effect}} \Big)\widehat{\tau} \end{aligned} \tag{1.16}$$

By the symmetry, the percentage change in labor demand for the clean industry can be shown as:

$$\widehat{l_j^d} = \Big((\sigma_j - \varepsilon_{jj})\phi_j + \varepsilon_{ji}\phi_i\Big)\,\widehat{\tau} \tag{1.17}$$

Based on (1.16) and (1.17), an industry-specific employment effect of a carbon tax with two industries depends on two factors, an own industry and cross industry effect. The labor demand decomposition under two industry case is almost the same as (1.13) except that now it has the output effect from the other industry. This means that cross price elasticity of demand and the cost share of a carbon tax from the other industry also affect own labor demand.

Now that the percentage change in labor demand depends on three factors, it is impossible to predict the sign of the changes in labor demand in response to a carbon tax. However, there are two cases where the sign can be determined analytically. The first case is when the own industry effect is negative and both industries produce complementary goods. In this case, the changes in labor demand would be negative because both own and cross industry effects are negative.

The second case is when the own industry effect is positive and goods are substitutes. In this case, the employment effect would be positive as both own and cross industry effects are positive. Other than these two cases, the sign of the employment effect is ambiguous.

Now to think of aggregate employment, simply adding (1.16) and (1.17) yields:

$$\widehat{L} = \widehat{l_i^d} + \widehat{l_j^d} = \Big((\sigma_i - \varepsilon_{ii} + \varepsilon_{ji})\phi_i + (\sigma_j - \varepsilon_{jj} + \varepsilon_{ij})\phi_j\Big)\,\widehat{\tau} \tag{1.18}$$

By using the Slutsky equation, it can be shown that $\varepsilon_{ij} = \varepsilon_{ji}$. Then (1.18) can be simplified and

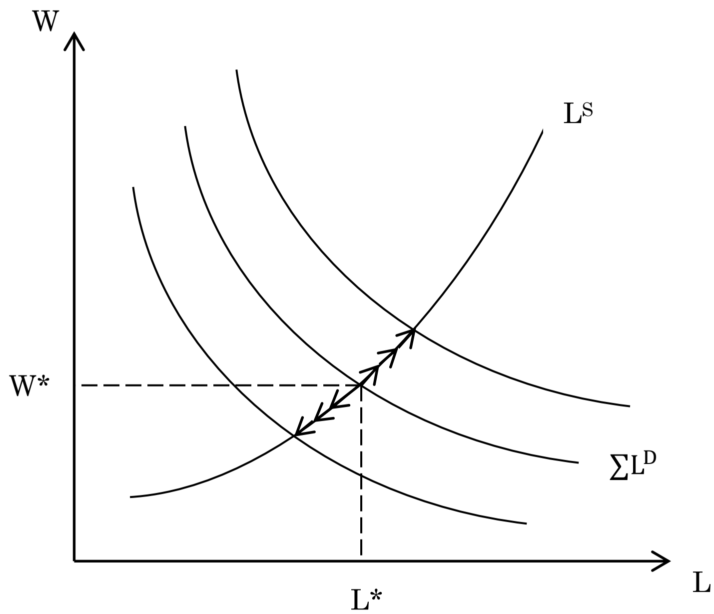

Figure 2: Shifts in Labor Demand

Note: Figure 2 illustrates the ambiguity of the aggregate employment effect of the carbon tax.

rearranged as follows:

$$\widehat{L} = \Big((\sigma_i - \varepsilon_{ii})\phi_i + (\sigma_j - \varepsilon_{jj})\phi_j + (\phi_i + \phi_j)\varepsilon_{ij}\Big)\,\widehat{\tau} \tag{1.19}$$

(1.19) makes it clear that the sign of the aggregate employment effect of the carbon tax is ambiguous, demonstrated in Figure 2.

III. Income Redistribution

As a part of British Columbia's (BC) carbon tax policy, tax revenues were redistributed back to BC residents via reductions in personal and corporate income taxes as well as lump-sum transfers. To investigate the effect of the redistributed tax revenues on labor demand, a partial equilibrium with one industry is re-analyzed to incorporate a lump-sum transfer.

To see how inclusion of the lump-sum transfer could change the employment effect, the assumption on the demand function is relaxed as follows:

$$q = D(p, I + T)$$

where I denotes income and T denotes the lump-sum transfer. Once again, taking the same algebraic manipulation that derived (1.4) yields,

$$\widehat{q} = (-\varepsilon_{\text{DP}}\phi)\,\widehat{\tau} + \varepsilon_{DT}\widehat{T} \tag{1.20}$$

where $\varepsilon_{DT} \geq 0$ is income elasticity of demand, particularly changes in demand in response to changes in the lump-sum transfer.

Then, putting this together with the factor effect yields:

$$\widehat{l^d} = \underbrace{\sigma\phi\,\widehat{\tau}}_{\text{Factor effect}} - \underbrace{\varepsilon_{\text{DP}}\phi\,\widehat{\tau}}_{\text{Output effect}} + \underbrace{\varepsilon_{DT}\widehat{T}}_{\text{Income effect}} \tag{1.21}$$

Now from this carbon tax, government receives tax revenues and gives them all back to residents of BC, which yields the following a government budget constraint:

$$T = \tau\ e(w_1, w_2')q$$

Taking logs, totally differentiating, and manipulating algebraically above yield:

$$\widehat{T} = \widehat{\tau} - \varepsilon_{e\tau}\,\widehat{\tau} + \widehat{q} \tag{1.22}$$

where $\varepsilon_{e\tau} > 0$ is price elasticity of input demand for fossil fuels, i.e., changes in demand for fossil fuels as inputs in response to a carbon tax. As $\widehat{q} = -\varepsilon_{\text{DP}}\phi\,\widehat{\tau}$ from (1.8), (1.22) can be rearranged as follows:

$$\widehat{T} = (1 - \varepsilon_{e\tau} - \varepsilon_{\text{DP}}\phi)\,\widehat{\tau} \tag{1.23}$$

(1.23) shows that changes in the size of the tax revenue, equivalently the lump-sum transfer, depends on three factors: price elasticity of factor demand, price elasticity of product demand, and the cost share of the carbon tax. The more inelastic factor demand for fossil fuels and product demand are, the larger the lump-sum transfer would be. One point to be careful about (1.23) is that it is always positive, i.e., $1 > (\varepsilon_{e\tau} + \varepsilon_{DP}\phi)$. Although these two elasticity in (1.23) could exceed 1 if demand is highly elastic, $\widehat{T}$ being negative means increasing the tax rate somehow decreases the size of the lump-sum transfer. In this simple theory, only one time implementation of a carbon tax is discussed, i.e., there are no dynamics in the tax rate. $\widehat{T}$ could be negative only if an additional change in tax rate from non-zero rate leads the tax rate to be high enough to erode a tax-base. Then, although the tax rate is higher, the tax revenue could be lowered. However, without the dynamics, it does not make sense for $\widehat{T}$ to be negative.

Finally, plugging (1.23) into (1.21) yields:

$$\begin{aligned} \widehat{l^d} &= \underbrace{\sigma\phi\,\widehat{\tau}}_{\text{Factor effect}} - \underbrace{(\varepsilon_{\text{DP}}\phi)\,\widehat{\tau}}_{\text{Output effect}} + \underbrace{\varepsilon_{\text{DT}}(1-\varepsilon_{e\tau}-\varepsilon_{\text{DP}}\phi)\,\widehat{\tau}}_{\text{Income effect}} \\ &= \Bigg(\Big(\sigma - (1-\varepsilon_{\text{DT}})\varepsilon_{\text{DP}}\Big)\phi + \varepsilon_{\text{DT}}(1-\varepsilon_{e\tau})\Bigg)\widehat{\tau} \end{aligned} \tag{1.24}$$

As income elasticity of demand is always positive and $\widehat{T} \geq 0$, the income effect would also be positive.[3] Then, the chances of the employment effect being positive are higher because now in addition to the positive factor effect, there is the positive redistribution effect that could outweigh the negative output effect. (1.24) suggests that revenue-neutrality of a carbon tax could increase the likelihood of positive employment effects as it pushes the labor demand curve further out to the right.

One possible criticism this subsection may receive is that the income redistribution from the BC carbon tax does not take a form of only lump-sum transfers. Even so the results from this subsection serve as a lower-bound for an employment effect of the revenue-neutral carbon tax policy because lump-sum transfers are roughly 20 percent of the total redistribution (Ministry of

[3]Here I assume goods are normal.

Finance, 2008).

IV. Employment Dividend

Up to now, my simple theory has focused on labor demand. The employment effect of a carbon tax could also arise from the changes in labor supply, especially when the tax revenues are refunded back to BC residents. The increase in labor supply from a revenue-neutral carbon tax is known as "employment dividend" in the double dividend literature (see Goulder (1995), Bovenberg (1999), and Bovenberg and Goulder (2002)). It basically means that by recycling the revenues from the carbon tax in a form of reductions of distortionary taxes, not only does the carbon tax bring environmental benefits, but also it lessens the sizes of distortion in the other tax system.

As there are many theoretical studies in the current double dividend literature, I do not provide theories here. Rather I briefly highlight that the employment effect of the carbon tax could also come from the supply side. Labor supply could increase if lowering the rate of personal income tax provides enough incentives to residents of BC to work more. Then the overall employment effect would likely to be positive unless the carbon tax negatively and largely affects aggregate labor demand.

After considering changes in both labor demand and supply in response to a revenue-neutral carbon tax, it is not clear which direction the equilibrium level of labor would go a priori. Both directions are possible, which is illustrated in Figure 3. Even with my simple theory, the sign of the aggregate employment effect is ambiguous.

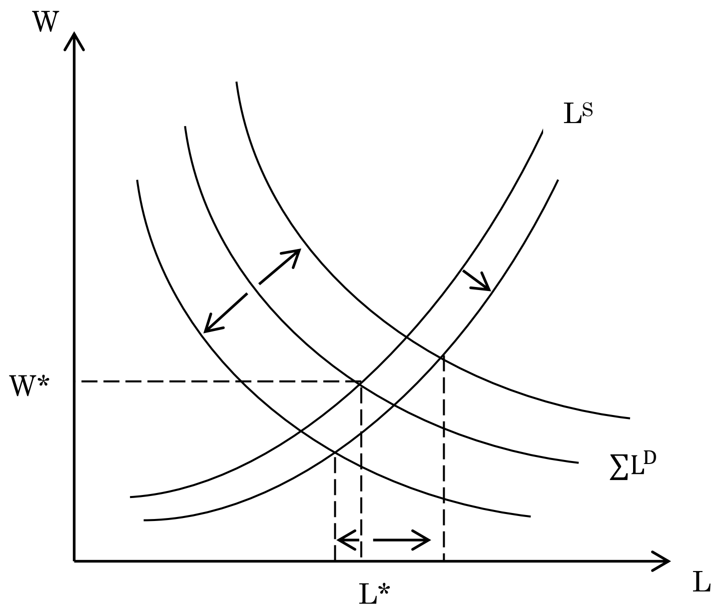

Figure 3: Shifts in Labor Demand and Supply

Note: Figure 3 illustrates the aggregate labor response to a carbon tax. Depending on the size of positive and negative labor demand responses across industries, aggregate labor demand could go either direction. Due to the reduction in personal income tax rates, labor supply is likely to be encouraged. Thus, aggregate employment effect in response to a carbon tax is ambiguous.

2. Additional Results

This appendix provides additional results referred in the main analysis.

I. Employment Effects Through Tax Rebates

In the main analysis, the term $GHG_p \times BC_p \times \tau_t$ is claimed to capture the redistribution effect of the employment effect from the revenue-neutrality of the carbon tax. To capture this effect more directly, the actual amount of tax revenue rebated to BC residents can be used to identify the effect. BC's Ministry of Finance annually reports the amount of tax credits in their budget reports (Ministry of Finance, 2010, 2011, 2012, 2013, 2014).

By using this data, the following equation is estimated:

$$\ln L_{ipt} = \beta_1(EI_i \times BC_p \times \tau_t) + \beta_2(Trade_{ip} \times BC_p \times \tau_t) + \beta_3(Rebate_{pt}) + \delta_{it} + \eta_{ip} + \epsilon_{ipt} \quad (2.1)$$

Table 1: Estimating the Employment Effect of Carbon Tax through the Rebate Effect

lnL	(1)	(2)	(3)	(4)	(5)
$EI_i \times BC_p \times \tau_t$	-0.0098**	-0.0097**	-0.0092**	-0.0097**	-0.0098**
	(0.0039)	(0.0039)	(0.0039)	(0.0039)	(0.0038)
$Trade_{ip} \times BC_p \times \tau_t$	-0.02**	-0.018*	-0.0071	-0.018*	-0.02**
	(0.010)	(0.009)	(0.006)	(0.009)	(0.010)
$GHG_p \times BC_p \times \tau_t$	0.263**				
	(0.102)				
Rebate$_{pt}$		0.349***			
		(0.132)			
Personal$_{pt}$			0.387***		0.207**
			(0.142)		(0.0926)
Corporate$_{pt}$				0.595***	0.508**
				(0.228)	(0.202)
N	4,181	4,181	4,181	4,181	4,181
R^2	0.803	0.803	0.803	0.803	0.803

Note: All specifications include industry × time FEs and 2-digit NAICS industry × province FEs. To account for serial correlations and within sub-industry correlations, standard errors are clustered by 3-digit NAICS industry × province, reported in parentheses. Rebate$_{pt}$ is the total amount of tax credits, measured in current billion dollars, to BC residents in year t; Personal$_{pt}$ is the sum of the rebate amount from the lump-sum transfer to the low-income households as well as the estimated tax credits by the tax cuts of personal income. Corporate$_{pt}$ is the estimated tax credits by the tax cuts of corporate income. *** Significant at the 1 percent level, ** Significant at the 5 percent level, * Significant at the 10 percent level.

where $Rebate_{pt}$ is the total amount of tax credits, measured in current billion dollars, to BC residents in year t, and all other variables are defined as in the main text. β_1, β_2, and β_3 are the parameters of interest. β_3 captures the redistribution effect of the BC revenue-neutral carbon tax on employment.

Estimates of (2.1) are reported in Table 1. These results suggest that, as expected, revenue-neutrality of the carbon tax gives a positive effect on employment. Every billion dollar returned to residents of BC increases provincial employment by 35 percent. To put it differently, as average annual returns over the post-carbon tax period is roughly $1 billion, a 10 percent increase in tax returns would lead to a 3.5 percent increase in employment. The results make it clear that any potential negative employment effects are lessened by the positive redistribution effect of the revenue-neutral carbon tax. Therefore, revenue-neutrality is an important feature of a well-designed carbon tax.

In column (3)-(5), Rebate_{pt} is separated into Personal_{pt} and Corporate_{pt}. Personal_{pt} denotes the sum of the rebate amount from the lump-sum transfer to the low-income households as well as the estimated tax credits by the tax cuts of personal income. Corporate_{pt} denotes the estimated tax credits by the tax cuts of corporate income. These results suggest that reduction of corporate income tax has a bigger effect than that of personal income tax and the lump-sum transfer combined.

II. Dynamics of Employment Effects

In the main analysis, the employment effect is assumed to be linear in tax rates.[4] This implies that the size of the employment effect would be the same between an increase from no tax to \$10/t CO_2e and another increase from \$10/t CO_2e to \$20/t CO_2e. It might be unlikely that all industries will adjust their labor by the same level every year when the rate is increased annually by \$5/t CO_2e, especially when the tax increases are known to everyone since the announcement. Some industries might adjust their labor only in the initial year, but do not adjust any more in the following years.

To analyze the time path of the employment effect, the following equation is estimated:

$$\ln L_{ipt} = \sum_{k=2008}^{2013} \beta_1^k \Big(EI_i \times BC_p \times \mathbb{1}(t=k)\Big) + \sum_{k=2008}^{2013} \beta_2^k \Big(Trade_{ip} \times BC_p \times \mathbb{1}(t=k)\Big) + \sum_{k=2008}^{2013} \beta_3^k \Big(GHG_p \times BC_p \times \mathbb{1}(t=k)\Big) + \delta_{it} + \eta_{ip} + \epsilon_{ipt} \qquad (2.2)$$

where all variables are defined the same as in the main text. Unlike the main analysis, there are eighteen parameters to be estimated as each post-carbon tax period is interacted to generate the employment effect for each year.

[4] As the estimation equation is in log-linear form, to be exact, the changes in log of L is linear in tax rates.

The results are reported in Table 2. The result from column (3) is based on the estimation equation (2.2). These results suggest that the employment effects are present every year since the implementation; however, the size of effects varies over time. As expected, the employment effects are slightly decreasing over time, i.e., adjustments are likely to occur in the earlier years.

III. Additional Robustness Check by Placebo Tests

In addition to a series of robustness checks in the main text, placebo tests are often performed to validate the identification in policy evaluations. A concern is a presence of contamination effects in control groups. As the employment effects are identified based on the assumption that the control group serves as a counterfactual for the treatment group, i.e., the control group mimics the treatment group in absence of the treatment. The contamination effects arise if the control group is also affected by the policy indirectly – general equilibrium effects.

To test the contamination effects, I have estimated the employment effect of a placebo carbon tax in other provinces. If there are no contamination effects, a placebo carbon tax in other provinces, structured in the same way as the BC carbon tax, should not have any employment effects.[5]

The results are reported in Table 3. Each column reports the results of estimation for each province. Aside from the results for Ontario, either all three coefficients are statistically insignificant or only one or two out of three coefficients is statistically significant. These results suggest that the identification in the main text is not biased by the contamination effects. Some might argue that the results for Ontario could indicate that the BC employment effects identified in the main text might be capturing non-carbon tax events. However, given that the signs of the coefficients are consistent with the model prediction only for New Brunswick and Ontario, the significant results for Ontario do not necessarily suggest the existence of the contamination effect.

[5]This version of a placebo test is conducted using multiple control groups (non-BC provinces), and treating one of them as a pseudo treatment group. See Imbens and Wooldridge (2009) for more details.

Table 2: Estimating the Dynamic Path of Employment Effects of Carbon Tax

lnL	(1)	(2)	(3)	(4)	(5)
$EI_i \times BC_p$					
$\times \mathbb{1}(t = 2008)$	-0.221***	-0.248***	-0.277***	-0.307***	-0.29***
	(0.0782)	(0.0856)	(0.0937)	(0.0991)	(0.101)
$\times \mathbb{1}(t = 2009)$	-0.231***	-0.228**	-0.248**	-0.296***	-0.285***
	(0.0846)	(0.0907)	(0.0966)	(0.104)	(0.107)
$\times \mathbb{1}(t = 2010)$	-0.233***	-0.225**	-0.248**	-0.313***	-0.312***
	(0.0838)	(0.0918)	(0.0961)	(0.109)	(0.111)
$\times \mathbb{1}(t = 2011)$	-0.225***	-0.214**	-0.234**	-0.315***	-0.327***
	(0.0787)	(0.0850)	(0.0916)	(0.112)	(0.116)
$\times \mathbb{1}(t = 2012)$	-0.231**	-0.225**	-0.246**	-0.312***	-0.341***
	(0.0903)	(0.0967)	(0.0961)	(0.111)	(0.114)
$\times \mathbb{1}(t = 2013)$	-0.206**	-0.202**	-0.226**	-0.302***	-0.351***
	(0.0841)	(0.0916)	(0.0917)	(0.108)	(0.114)
$Trade_{ip} \times BC_p$					
$\times \mathbb{1}(t = 2008)$	-1.166***	-1.303***	-0.51**	-1.072**	-0.947**
	(0.345)	(0.402)	(0.253)	(0.428)	(0.371)
$\times \mathbb{1}(t = 2009)$	-1.336***	-1.233***	-0.454*	-1.164**	-1.161**
	(0.315)	(0.366)	(0.254)	(0.499)	(0.510)
$\times \mathbb{1}(t = 2010)$	-1.477***	-1.321***	-0.549**	-1.42**	-1.588**
	(0.330)	(0.370)	(0.265)	(0.564)	(0.661)
$\times \mathbb{1}(t = 2011)$	-1.477***	-1.405***	-0.638**	-1.682***	-2.072**
	(0.333)	(0.369)	(0.273)	(0.637)	(0.858)
$\times \mathbb{1}(t = 2012)$	-1.443***	-1.323***	-0.557**	-1.821***	-2.486**
	(0.325)	(0.366)	(0.262)	(0.691)	(1.064)
$\times \mathbb{1}(t = 2013)$	-1.408***	-1.208***	-0.43*	-1.867**	-2.852**
	(0.315)	(0.366)	(0.256)	(0.766)	(1.325)
$GHG_p \times BC_p$					
$\times \mathbb{1}(t = 2008)$	12.36***	13.96***	7.03***	11.84***	9.68***
	(3.638)	(4.138)	(2.658)	(4.233)	(3.693)
$\times \mathbb{1}(t = 2009)$	13.74***	13.09***	6.278**	12.52**	10.9**
	(3.524)	(3.948)	(2.658)	(4.833)	(4.885)
$\times \mathbb{1}(t = 2010)$	15.02***	13.90***	6.957**	14.72***	13.90**
	(3.707)	(4.03)	(2.755)	(5.41)	(6.267)
$\times \mathbb{1}(t = 2011)$	14.80***	14.32***	7.655***	16.96***	17.28**
	(3.706)	(3.972)	(2.799)	(6.008)	(7.954)
$\times \mathbb{1}(t = 2012)$	14.72***	13.88***	7.044***	18.23***	20.02**
	(3.583)	(3.872)	(2.649)	(6.518)	(9.901)
$\times \mathbb{1}(t = 2013)$	14.25***	12.71***	5.939**	18.71***	22.29*
	(3.377)	(3.775)	(2.512)	(7.158)	(12.27)
N	4,181	4,181	4,181	4,181	4,181
R^2	0.736	0.739	0.803	0.806	0.807
Time FE	Y				
Industry FE	Y				
Province FE	Y	Y			
Industry × time FE		Y	Y	Y	Y
Industry × province			Y	Y	Y
Industry × province trends				Y	Y
Industry × province trends sq					Y

Note: Industry fixed effects are for 2-digit NAICSs. To account for serial correlations and within sub-industry correlations, standard errors are clustered by 3-digit NAICS industry × province, reported in parentheses. *** Significant at the 1 percent level, ** Significant at the 5 percent level, * Significant at the 10 percent level.

Table 3: Placebo Tests by Implementing Fake Carbon Tax in Other Provinces

lnL	(1) AB	(2) MB	(3) NB	(4) NS	(5) ON	(6) PE	(7) SK
$EI_i \times Province_p \times \tau_t$ (β_1)	0.00110	-0.00845**	-0.00873***	-0.00567	-0.00899***	-0.0145	-0.00226
	(0.00230)	(0.00417)	(0.00308)	(0.00430)	(0.00236)	(0.0172)	(0.00139)
$\text{Trade}_{ip} \times Province_p \times \tau_t$ (β_2)	-0.0342**	0.000811	-0.0129	0.0108	-0.0313***	-0.0138	0.00621
	(0.0136)	(0.00769)	(0.00948)	(0.00781)	(0.0110)	(0.0132)	(0.00847)
$Province_p \times \tau_t$ (β_3)	0.0220***	0.00467	0.00903*	-0.00451	0.0196***	0.0120	-0.000640
	(0.00782)	(0.00451)	(0.00490)	(0.00379)	(0.00640)	(0.00762)	(0.00417)
N	4181	4181	4181	4181	4181	4181	4181
R^2	0.803	0.802	0.803	0.802	0.805	0.802	0.802

Note: Provincial abbreviation is as follows: Alberta(AB), Manitoba(MB), New Brunswick(NB), Nova Scotia(NS), Ontario(ON), Prince Edward Island(PE), and Saskatchewan(SK). All specifications include industry × time FEs and 2-digit NAICS industry × province FEs. To account for serial correlations and within sub-industry correlations, standard errors are clustered by 3-digit NAICS industry × province, reported in parentheses. *** Significant at the 1 percent level, ** Significant at the 5 percent level, * Significant at the 10 percent level.

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