# Climate Policies and the Tax-Interaction Effect, in Context

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## Abstract

The tax-interaction effect is, arguably, a lynchpin in the modern apparatus substantiating a trade-off between economic efficiency and environmental quality. In recent years, it has come into particular focus in discussions of climate policy, meriting mention inside and outside of academia. Given relatively simple scenarios, the tax-interaction effect demonstrates that resultant distortions in the labor market explode the cost of most conventional environmental policy tools. It is the aim of this discourse to introduce concepts that will add realistic complexity to scenarios exhibiting the tax-interaction effect, allowing it to be placed better into the context of a real-world economy. This is done by synthesizing conclusions across widely differing bodies of literature to suggest perspectives which bring forward related, important and untapped concepts. Four findings are presented. First, recent developments in understanding of work effort open the possibility for previously modeled labor distortions to divert from real behavior. Second, pre-existing labor supply market failures possibly distort work incentives in tandem with labor taxes. Third, perspectives and results from environmental willingness to pay literature and median voter theory dictate that carbon policy distorts the labor market differently in the presence of a voting system. Each finding is conducive to reconsideration of climate policy costs as well as the tax-interaction effect in a real setting. Sections are written for a broad audience in academia and policymaking alike.

**Keywords:** tax-interaction effect; climate policy; environmental policy; economic policy; behavioral biases; median voter theory; labor economics; labor distortions; willingness-to-pay; work incentives

**JEL Classification:** J20, Q54

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# 1. Introduction

Historically, it is the benefits side of carbon policy cost-benefit analysis that has received a reputation for high levels of uncertainty and complexity. Indeed, the high level of sophistication needed to accurately estimate societal costs of externalities has been recognized since the inception of externalities themselves (Pigou, 1954). This is no less true for climate policy, as understanding the natural phenomena governing the climate is still a major challenge by itself. Once an attempt to estimate the future economic impacts of climate change is made, an entirely new layer of complexity is introduced. Meanwhile, examiners of the costs side of carbon policy, i.e. the policy efficiency side, have wrestled with the question of how to proceed to address the externality despite such uncertainties. This endeavor, however, has led economists down a path that is, itself, increasingly intricate.

It was at first thought that a deadweight loss roughly estimated the efficiency cost of carbon policy[3,4]; this consensus made an apparently correct carbon policy cost calculation relatively simple (Goulder & Williams III, 2003). As a deadweight loss is widely viewed as much smaller than, for instance, labor market distortions caused by an income tax, an idea was formed taking advantage of this cost comparison. By cleverly swapping a form of income tax for a carbon tax, the comparably large labor market distortions could be replaced in part by a much smaller deadweight loss[5]. Doing so would perceivably lead to a cost-negative policy outcome even before difficult-to-estimate environmental benefits were considered. The attractiveness of this structure was soon more than negated, however. The introduction of a concept called the tax-interaction (TI in diagrams) effect precipitated from a closer examination of the real economic context in which environmental policy exists[6]. With it came the implication that carbon taxes[7] interact with the greater fiscal system, causing this swap to exacerbate existing labor market distortions rather than allay them. Since then, tax-interaction effect literature has continued to carry out closer and closer examinations of how a carbon tax may interface with a realistic economy. It is from this junction that the current discourse submits its contribution. This paper argues that the pursuit of understanding the cost-side outcome of carbon policy is much closer to its infancy than commonly perceived. Tax-interaction effect literature has already produced significant departures from the original tax-interaction effect scenario, with several more caveats likely to exist. Even more fundamentally, however, this concept has opened carbon tax analysis to an implicitly broad consideration of labor market distortions. It is here that multiple perspectives are used to interpret the tax-interaction effect in a new light, and several insights are presented. The implications generated by this practice demonstrate a substantial scope for improvements to carbon tax cost-side estimates, as many concepts remain unincorporated or (likely) undiscovered. Likewise, obtaining estimates that will be confidently close to true and realistic costs is likely to be far more sophisticated, nuanced and uncertain than currently appreciated, meriting further research to recapture a decent sense of dependability.

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[3] And commodity taxes in general

[4] Carbon taxes and carbon policy are used interchangeably when speaking generally.

[5] This tax structure is referred to as a carbon replacement tax hereafter.

[6] Namely, "with other taxes"

[7] And, more generally, commodity taxes.

## 2. A Conceptual Approach

Newly introduced concepts relating to the tax-interaction effect are the main contribution of this paper. However, some features of the approach which differentiate it from the majority of relevant literature merit mention as well. This paper is conceptually focused, proposing economic mechanisms, expanding on implications of those mechanisms and revisiting established mechanisms in a new light. This will provide a more accurate notional economic context to policy makers and stimulate further research.

This article suggests perspectives and introduces concepts that are fundamentally different from those within literature thus far. For this reason, a distinction has been created between two different kinds of economic reactions to carbon taxation/carbon replacement tax (CRT): Level 1 Reactions (L1R) and Level 2 Reactions (L2R).

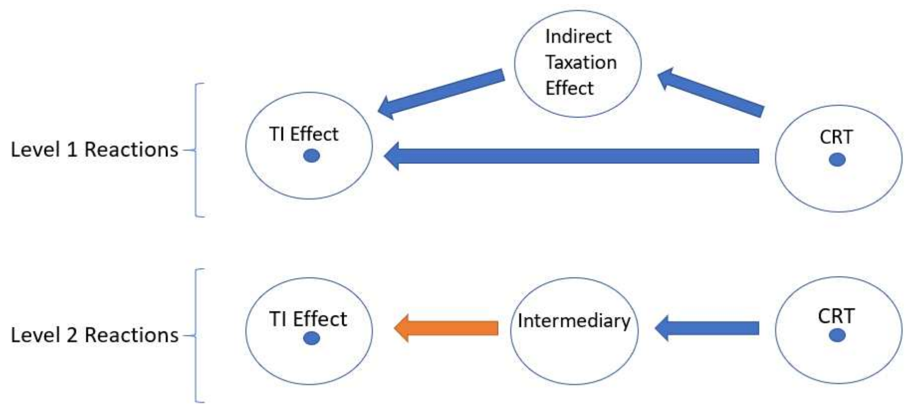


*Figure 1. A graphical representation of L1Rs and L2Rs.*

L1Rs refer to when the CRT incidentally taxes an activity or a good (e.g. a fixed factor) that is inefficiently lightly (harshly) taxed under an income tax alone (section 4). L1Rs lead to counteraction (exacerbation) of the tax-interaction effect, and tax-interaction effect literature so far has conventionally introduced L1Rs. L2Rs refer to when the fundamental economic reaction is filtered through an intermediary concept (e.g. near-zero labor market elasticity on the intensive labor margin) before interpretation of labor market reactions and the tax-interaction effect is complete (sections 5-7). L2Rs warp and change the nature and behavior of tax-interaction effect as well as its impact on cost-side estimates. This article introduces three broad L2Rs and reviews L2Rs.

Finally, most work so far has provided analyses from the same economic perspective. This paper follows along the mindset set out by (Chetty, 2015), which argues that considering behavioral economic perspectives alongside of neoclassical economic perspectives is effective in developing better answers to important policy questions. Likewise, to best reflect a real-world setting, this analysis is not bounded to the perspectives of any particular economic discipline. This paper presents the tax-interaction effect from an economically broad interdisciplinary standpoint, desegregating treatments and blurring the lines between academic disciplines, then presenting the insights which follow from that practice. Studies and perspectives from neoclassical economics, behavioral economics, environmental willingness to pay (WTP) literature, and political economy are used agnostically throughout this examination to progress towards a theoretical framework for the carbon policy costs that closer reflects the economic reality. This provides the current discourse with a special breadth that better allows a “meta-view” for the issue of climate policy.

## 3. The Basic Scenario

Here we begin our basic exposition of the tax-interaction effect by presenting a simple scenario that shows, when focusing on a narrow set of aspects in an ideal economy, income taxation is fundamentally more efficient than carbon taxation (or other forms of commodity taxation). The impact of that comparative lack of efficiency is then magnified when energy market distortions from carbon tax spill over into the already taxed labor market (hence, the tax-interaction effect).

Initially we have perfectly competitive markets with market clearance and no market failures[8]. Importantly, we assume that labor supply elasticity is such that economic agents will react to lowered returns on labor relative to returns on leisure by reducing their work effort, opting to spend an increased amount of time on leisure instead of (now relatively expensive) labor. At market equilibriums *e*, the diagrams below represent the initial scenario. Diagram 1 is the labor market and diagram 2 is the carbon-energy market. Both are in equilibrium. Now suppose that an income tax is implemented in order to collect revenue for the government represented by revenue area kjvt[9]. Assume this revenue is not returned to agents in exchange for work, but used for another purpose (e.g. income security). The equilibrium in the labor market diagram moves to LT because workers are opting to substitute some labor, which now provides less utility (in the form of income) per hour spent working, for leisure, whose utility remains comparably the same and has not been taxed. Agents collectively reduce their work effort from *e* to LT based on how much their income has been reduced, which is equal in aggregate to the amount of revenue collected. Net value lost from the economy so far is represented by the area B. Now suppose policy makers wanted to double their revenue, but do so with a carbon tax instead of another income tax in order not to distort the labor market any further.

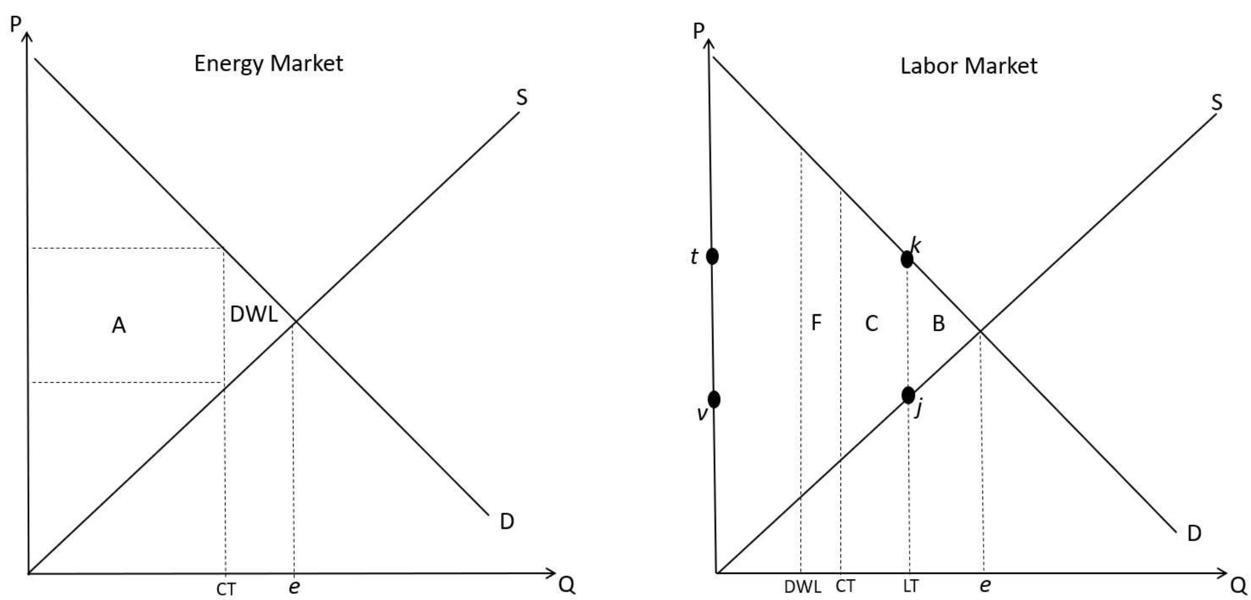


*Figure 2. A demonstration of the simple-scenario tax-interaction effect using the a carbon tax on the energy market, it its effects on the labor market.*

[8] Of course, policy makers would not be inclined to apply a carbon tax without market failures, but for the purposes of a clear demonstration of the tax-interaction effect in cost-side analysis, we do not consider them here.
[9] Lines for this area have been omitted for clarity purposes

In the energy market[10], equilibrium moves from *e* to CT, and revenue collected is represented by the area A, which is equal to initial labor tax revenue area kjvt. This is where the tax-interaction effect starts to take hold. If we turn back to the labor market, we note that things have not carried on as they were under the income tax alone. An "interaction" has taken place. The new market equilibrium is at DWL - a far more distorted state than before. It is realized that, by increasing the price of a fundamental intermediate good, prices have increased generally. This necessarily amounts to an overall fall in real income, or said another way, an income tax. If this were the end of the story, the carbon tax would result in an equilibrium in the labor market at CT. Since the revenue collected is the same, the difference between *e* and LT in the labor market should be the same as the difference between LT and CT, but we have forgotten one thing: the carbon tax deadweight loss. It is important to remember that the deadweight loss, represented by area DWL, signifies the extent to which consumers have changed their behavior to avoid the carbon tax. Provided that agents had maximized their utility before the carbon tax, avoidance behavior will result in a new, devalued optimal bundle of goods their income can purchase – a new income tax. In this income tax situation, however, it is different than before. First of all, there is no revenue to return, resulting in a net loss of value. The second part is that, since value lost out of the market as a return to labor due to income tax is A (=kjvt), but that for the carbon tax is A+DWL, the total reduction in real income, and in-kind reduction in work effort, is greater for the carbon tax. Because market value is a marginally decreasing function of Q, it is a marginally increasing function of -Q, and this greater inefficiency is drastically magnified if other taxes on labor exist before a carbon tax is applied. Even if revenue is recycled, as is the case with a CRT, and an income tax would have instead been replaced with a carbon tax, the distortion would be greater with a carbon tax because of areas DWL and F. It can therefore be seen from this demonstration, given the theoretical extent to which the tax-interaction effect increases the cost of climate policy, that understanding how this concept may play out in a non-ideal, more detailed and realistic environment can be a vital component of climate policy understanding and deliberations.

## 4. Prior work towards allowing a more holistic treatment

Tax-interaction effect literature has usually centered around L1Rs in the context of CRTs. Existence of under-taxed L1R-affected goods and activities turn out to change the costs-side situation considerably. These include but are not limited to fixed factors, leisure, tax evasion or avoidance and environmental health. Concepts below represent a few of the most central contributions to tax-interaction effect literature so far and give a sense for how complicated our understanding of economic reactions to carbon taxes is becoming. This paper first highlights those contributions here to provide context for its own insights.

An income tax, as it is implemented in many economies, constitutes several efficiency issues that are not communicated by the results of the simple scenario above. Income taxes tend to have a number of exemptions, such as charitable giving, health care, and the like. These open up the option for economic agents to consume "tax preferred" goods at an above optimal levels, resulting in an efficiency drop (Saez, Slemrod, & Giertz, 2012). By reducing the income tax rates, a CRT lowers the private returns on overconsuming these tax-preferred items and may tax some of them closer to the optimum. Another

[10] The energy market is used for simplicity, but in reality, a broad carbon tax would include other emitters like concrete processing and various agricultural activities.

uniquely inefficient aspect of an income tax is the ease with which it may be evaded or avoided. That evasion and avoidance activity not only takes a toll on authorities that try to put a stop to it, but also causes a waste of resources spent on hiring expertise in assistance of such activities. These wasted resources represent yet another inefficient aspect of an income tax. Carbon taxes compare well on this metric because they are much more difficult to avoid (Liu, 2013). Moreover, an income tax encourages economic agents to enter the informal employment market, which is clearly not taxed by an income tax by definition. Types of employment that are not taxed are then sought after at above optimum levels. In the context of a CRT, this can lead to an advantageous cost situation because the income tax is partially replaced by a carbon tax. A carbon tax falls on consumption instead of income, meaning that it incidentally taxes employment in the informal market as well, presumably shifting some agents back into the formal employment market. (Parry & Williams, 2010) (Parry & Bento, 2000) (Liu, 2013) all find these tax base-broadening aspects of an income tax to have a significant impact on the cost of a CRT in the context of the tax-interaction effect.

Another issue with an income tax is that it taxes labor but not leisure, incentivizing economic agents to allocate more of their time to leisure. It is well known in policy and economics circles, however, that one way to "get at" leisure is to tax items that are often consumed as complementary goods to leisure (Rosen & Gayer, 2014). While a carbon tax itself would have no intention of doing this, some studies have examined whether a form of carbon tax would incidentally tax leisure too. One good example study is (West & Williams III, 2004) in which a gasoline tax was found to be cost negative for its accidental taxation of leisure driving. In this specific instance of a CRT, leisure will be taxed at a relatively higher rate than with an income tax alone, incentivizing time spent on labor to move closer to the no-tax optimum. This is likely a value which will change over time, however, as consumption and technologies change. What is complementary to leisure and what is complementary to labor will change over time, and so will such a calculation. Thus, it is important not to assume without a time-tested theory that this fact is a natural outcome rather than a coincidental one. Moreover, it is also obvious that a gasoline tax only taxes a subset of what a carbon tax would tax, and therefore this result cannot be directly extrapolated for carbon tax situations. Regardless, it is a notable example.

Environmentally-influenced health issues are also affected by L1Rs. It is understood that a carbon tax would improve the environment, but more indirectly, much research has posited that health improvements could also flow from this policy as well (Cuevas & Haines, 2016) (Parry, Veung, & Heine, 2014) (Crawford-Brown, Barker, Anger, & Dessens, 2012). It is possible that labor productivity related to, for example, work absences, absenteeism or presenteeism would also be improved with such health quality increases. (Williams III, 2002) estimates that such improvements in work productivity could have significant positive effects on labor that would counteract an increased cost due to the tax-interaction effect. He also asserts, however, that if such health improvements result in lower health care bills, then labor could also be affected in the other direction, as health no longer comes as a return on labor hours.

The final L1R demonstrated here affects fixed factor markets. Valuable resources, such as fossil fuels, being found on one's land can result in the owner of these fixed factors coming into an increased income. As this "unearned" income is not a result of work, it constitutes a rent. Importantly, it is the optimal choice for that agent to sell all of her or his resources, as it is basically free capital. If a carbon replacement tax is implemented, that tax will fall partially on the fixed factor. The rate at which this fixed factor is taxed, though, will not change the owner's behavior because the optimal choice remains unchanged even if the tax rate is 99% (provided no chance at evasion). Thus, this extra, non-behavior-altering revenue can be used to go back and reduce other labor taxes as is the case with a CRT. (Bento & Jacobsen, 2007) find this to be the case such that the optimal carbon tax, taking into account some assumed environmental benefits, would result in an 11% reduction in carbon emissions. It is important to add the caveat, however, that the cost to the owner of the fixed factor is not always zero, as it is assumed in these calculations. Large trucks, construction, noise and even some local environmental effects may result. Thus, taxes that push the owner's profits below their value for land to be quiet and unpolluted may result in their decision not to sell their land in the first place. Clearly this would constitute a definite and large change in behavior.

These L1Rs represent the piecemeal work that has carried on after the introduction of the tax-interaction effect. They communicate a more complicated picture of the real economy than first put forth when the tax-interaction effect was introduced, but generally do not consider departures of perspective as is done in the following sections; these will also further imply a complex picture. It goes without saying that a rigorous analysis of policy costs will need to parse and simultaneously consider all of these complicating, and sometimes contradictory insights.

## 5. An expanded understanding of work effort

Since the tax-interaction effect was first theorized in the 1990s, academic understanding of how, the extent to which, and whose labor supply reacts to taxation has changed dramatically along with understandings of factors influencing this variable. By including these understandings, Tax-interaction effect literature, however, has been slow to react to these changes if at all. Most studies use a single labor supply elasticity value to calculate the results of the tax-interaction effect. This is a very important choice provided that this elasticity value essentially determines the degree of impact the tax-interaction effect renders on carbon tax costs. By considering some significant advances in the understanding of labor supply, this section demonstrates broad, diverse and sizable divergences from reality such a choice could induce. Work effort caveats are determined to be L2Rs, as they change the labor supply elasticity and cause possibly large divergences in the aggregate labor supply schedule.

The first issue begins with the method of obtaining a labor supply elasticity. To demonstrate a couple of the central critiques, basic theory is used as a starting point. It is a fundamental observation that, in order to know how taxation will change the work decision of a target population, the utilitarian social planner must first know the work, public good, and leisure preferences of that population. It is important to note, however, that economic theory does not offer an opinion on how labor supply *should* react to taxation. According to economic theory, individual preferences dictate that one could decide to work less, more or change nothing (Manski, 2012). The question of average labor supply reaction to tax therefore changes into a more happenstance empirical question rather than a theoretical one. This is where the need to calculate an elasticity comes in.

For the silence of theory, researchers have empirically estimated average labor supply elasticity values through revealed preference studies for decades. Since that time, it has become customary to use the most recent and apparently accurate labor supply elasticity estimates when parameterizing any model that incorporates the labor market. Tax-interaction effect literature to date has done just this, drawing upon empirical labor economics literature to obtain a labor supply elasticity and apply it to carbon tax cost estimates. Since that time, however, multiple examiners have agreed that obtaining acceptably accurate elasticity values using this method presents several problems. Economic theory dictates that the only assumption that can be made with confidence is that economic agents want both more income and more leisure. Having this as the only assumption, it has been shown that a revealed preference study cannot provide any information about the labor elasticity value (Manski, 2012). This fact is what pushes most studies looking to obtain labor elasticity values to make more assumptions, most of which lack the foundation required to produce trustworthy results (Manski, 2012). For instance, most of these studies do not actually allow for backward-bending behavior in the labor supply schedule that would be implied by working more when taxed at a higher rate. This cuts out one theoretically permitted option completely (Manski, 2012). Another criticized assumption, and one that is present in most studies, is that the entire society will react to taxation in the same way, i.e. each economic agent has the same work preferences. This is plainly incorrect. (Mankiw, 2013) critiques this assumption using economics professors as a counterexample. Many have forgone a higher income career in industry for a preference towards the lifestyle of a professor, which awards more creative and personal freedom. (Saez, Slemrod, & Giertz, 2012) echoed this sentiment in a review of labor elasticity studies, agreeing that the standard framework required unconvincing assumptions. Most, if not all, tax-interaction effect literature relies on labor elasticity values that were determined using these in-doubt methodologies.

Another realm which has yet to receive a discussion within tax-interaction effect literature is the impact of recent results within behavioral economics, which has also weighed-in on labor supply. Nonstandard preferences have been shown to encourage economic agents to depart from the standard model. One of those nonstandard preferences is concerned with relative income, as opposed to absolute income used in many models. Studies have shown that relative income is associated with happiness and life satisfaction (Clark, Frijter, & Shields, 2008) (Clark, Masclet, & Villeval, 2010). One study reveals, for instance, that Gini coefficients and relative income predicted the onset of depression as well as, but independent of, absolute income (Ladin, Daniels, & Kawachi, 2009). Suicide rate has also been demonstrated to increase when economic agents see their income decrease relative to the average (Daly, Wilson, & Johnson, 2013). Depression is well understood to have a significant negative impact on worker productivity (Evans-Lacko & Knapp, 2016). Even more directly related to work effort, (Neumark & Postlewaite, 1995) found that the work rate of women was very positively sensitive to whether her sister-in-law worked, or if her sister's husband earned more income than her own. A carbon tax is clearly susceptible to such preferences, as the incidence is very nonuniform and difficult to control. These types of preferences are not addressed in tax-interaction effect literature. Meanwhile, evidence that absolute income does not significantly influence work decision has been found in studies of taxi drivers. (Farber, 2005) found that taxi drivers, who uniquely decide their own working hours and whose wage rate changes over days and weeks, do not appear to work more (less) when the wage rate is high (low) (i.e. the returns on work effort is high (low)). While it is true that this type of study only considers a very narrow demographic, it merits consideration insofar as such counterintuitive preferences could be more widely applicable. Together these results work to diminish the dependability of the current model used in tax-interaction effect literature, which only uses absolute income.

Behavioral economics does not just add nuance by asserting the importance of relative income, but also has other important additions as well. Tax salience, complexity, fairness and other nonstandard preferences will also mix up an otherwise straightforward standard economic analysis. Evidence has consistently supported the conclusion that consumers have different demand schedules for the same item depending on whether complementary costs such as shipping, tolls, and importantly, taxes, are easily noticeable. To provide an example, (Chetty, Looney, & Kroft, 2009) find that changes in sales taxes, which are not included with item prices, have a smaller impact on alcohol sales than equivalent changes in excise taxes, which are included in item prices. The same study showed that when grocery store item prices were modified to include sales tax, this action suppressed demand. Not only this, but attentiveness to prices has been shown to differ up and down the spectrum of income (Mullainathan & Shafir, 2013). It follows from this result that the choice of how to reflect a carbon tax in the price could have decisive implications for the overall policy cost. Misperceptions of taxes are also a well-established concept. One study showed that consumers adjust labor decision differently to personal income taxes than to sales taxes. This result goes against standard assumptions present in tax-interaction effect literature, whose results rely on this equivalency (Blumpkin, Ruffle, & Ganun, 2012). Another study suggested that average tax rates are a stronger behavioral benchmark for consumers than marginal tax rates (de Bartolome, 1995). Several others of this type point in the same direction. Consumers have also been shown to be more likely to spend, rather than save, tax cuts presented as bonuses instead of rebates (Epley, Mak, & Idson, 2006). In a famous experimental study, (Fehr & Gachter, 2000) show that extra effort may be put forward if the economic agent believes she or he is being treated fairly and put forth less effort in the case of treated unfairly. Each of these concepts within behavioral economics, several well-established, are readily applicable to carbon taxes and add sensitivities that are not included in tax-interaction effect literature to date. Some attempts have been made to include some behavioral concepts into models of labor supply and taxation, but so far this has not been attempted within carbon taxation and tax-interaction effect literature.

The final issue in this subsection does not speak to critiques of the conventional approach, as do the preceding two, but instead acknowledges progress in understanding labor supply made using the conventional approach that is absent in tax-interaction effect literature. Some recent labor economics literature has converged on a new understanding about how different large groups within the population react in heterogenous ways. It turns out that labor supply reactions vary widely across the population. This poses a problem for tax-interaction effect literature because carbon taxes tend to have an incidence which is not set legally in terms of who pays, thus will fall on different parts of the population to varying degrees incidentally and over time. Notwithstanding, tax-interaction effect literature tends to use one labor supply elasticity for the entire population, as mentioned above. It has been concluded, for instance, that men have a labor supply elasticity of essentially zero; highly educated individuals in general have a very low labor supply elasticity. Labor participation elasticity (and therefore labor supply elasticity) of lower income men on the other hand is relatively larger, and elasticities in general are very low on the intensive margin but quite high on the extensive margin (McClelland & Mok, 2012) (Meghir & Phillips, 2008). This result has been reinforced the demonstration that US taxpayers bunch at the first kink point in the income tax schedule, which is where income taxation begins, but not others, as might be expected if middle or high-income individuals have a low labor supply elasticity. However, bunching [11]disproportionately occurred among the self-employed, raising suspicion that this result could actually reflect underreporting income, rather than distorted work incentives (Saez, 2010).

[11] It is important to note here that a parent who is responsible for taking care of a child before opting to use childcare services and formal employment is also working *before* using that childcare service. That work is simply in the informal market. There can be a fairly broad difference between moving from zero work effort to efficient work effort and going from inefficient work effort to efficient work effort. Thus, categorizing childcare policies and lowered income taxation as “increasing the work rate” may, in the first place, be a terminology error which would lead to not insignificant errors when examining the consequences of these policies on work rate.

The labor supply elasticity of women has been found to be much higher than that of men as well. And while it seems unlikely that women are responsible for considerably more carbon emissions than men, as to merit separate consideration in carbon tax cost estimates, concurrent childcare policy is still an important consideration. Many examiners have postulated that lower taxes grant women or households enough income to pay for childcare, allowing them to work at higher rates (Rosen & Gayer, 2014). As expected, many studies have shown that government-supplied, or subsidized childcare increases the work rate of women, particularly married and single mothers (Bettendorf, Jongen, & Muller, 2015) (Martinez A. & Perticara, 2017) (Lefebvre, Merrigan, & Verstraete, 2009). Provided that the intensive margin has a low elasticity and the extensive a high one, the high labor elasticity of women is likely due to decision to join the workforce, placing her into the intensive margin. The same would seem to be true for low income men as well, and if this is true, then elasticities should drastically decrease in magnitude after childcare is paid for externally. Indeed, (Akgunduz & Plantenga, 2015) finds that for places with high female participation rates, childcare policy is relatively ineffective in increasing female work rate. It remains to be directly seen, however, if regions that have salient, subsidized childcare exhibit lower magnitude labor supply elasticities for women compared to those without it. If the elasticity would in fact be lower in such a situation, then after government supplied childcare concurrently with a carbon tax could significantly dull the effects of labor distortions caused by the tax-interaction effect. If elasticities are higher on the extensive margin, however, then a carbon tax that disproportionately reduced returns to work effort in the first quantile, as is the case with a CRT, could have a larger than expected negative economic impact. This would constitute a divergence from conventional tax-interaction effect literature in the positive cost direction.

## 6. Labor markets with pre-existing, latent distortions

Acknowledgement that distortions can originate from causes other than taxation is a rather basic observation, as environmental externalities themselves fall into this category. To simplify the wording of this section, these will be termed latent distortions. Reverting back to the same standard assumptions made in tax-interaction effect literature, pre-existing, latent labor market distortions *should* have a fundamental effect on the outcome of the tax-interaction effect, as the carbon tax would also interact with these distortions as well. This section brings attention to two latent distortions existing in the labor market and explains the mechanisms through which they may change carbon tax cost estimates.

For decades, supply of college educated labor has not met demand in the US[12]. (Carnevale & Rose, 2013) writes that over the last 30 years, the shortfall in supply and demand growth has been an average of 0.5% per year. This does not amount to a small distortion – (Carnevale & Rose, 2013) shows that if supply met demand then it would add $500 billion to GDP. The causes of this shortfall are not proven as such, but a well-accepted theory is put forth by (Goldin & Katz, 2008) that technology has been and is simply outpacing investment in education. Incorporation of such a long-standing, apparently impactful and perhaps structural trend is important for the high probability that it will indeed significantly change the theoretical situation. At this juncture two observations are made. Observation 1 is that a CRT has been

[12] Analysis by (Tozer, 2018) reveals that countries in Northern Europe, like Denmark, Norway and Sweden find themselves in the opposite situation with respect to math skills, with low demand and high supply. One could reasonably expect this is also the case for other skills hallmark of higher education. With respect to these examples, the analysis here still applies, but in a different direction. The situation in the US is used as an explanatory example, but this analysis could be both qualitatively and quantitatively expanded upon.

concluded to be regressive, with the upper two quantiles actually better off as a result of the CRT and the lower two quantiles worse off (Parry & Williams, 2010). Observation 2 is that college degree attainment is highly correlated with the top two quantiles and much less correlated with the lower two (Carnevale, Jayasundera, & Gulish, 2016). Of course, there are some who are college-educated and remain in the lower two quantiles, but those are generally for jobs that do not have major shortfalls in supply and generally do not contribute much to this labor market distortion. Based on the same context conventionally assumed in tax-interaction effect literature, the simultaneous consideration of observation 1 and 2 will generate much more sensitive carbon tax cost estimates because of the top two quartiles. This concept is demonstrated in Figure 3 and Figure 4:

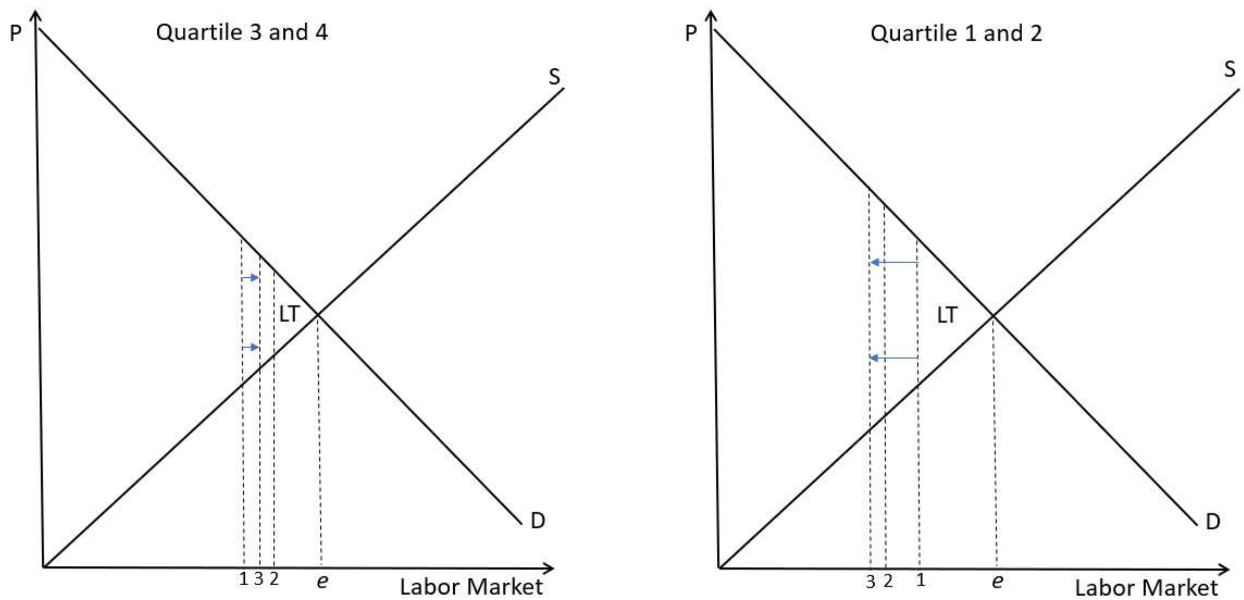


*Figure 3. The tax-interaction effect in the upper and lower quintiles in the absence of latent distortions.*

First, Figure 3 shows what happens in the upper and lower two quantiles when the only pre-existing distortion on labor is from an income tax, and part of that income tax is then reduced when a revenue-neutral carbon tax is introduced. For both graphs we have 1,2,3, labor tax distortion area LT and equilibrium point *e*. The point 1 represents the initial situation before the tax swap, 2 represents the revenue neutrality and 3 represents the extra labor distortions from the deadweight loss of the carbon tax. The lower quantiles, by virtue of CRT regressivity, are significantly worse off while the upper quantiles are better off. Partially because of the distance between 2 and 3, ie the deadweight loss, the exchange overall ends up having a positive cost value. But Figure 4 shows a different situation.

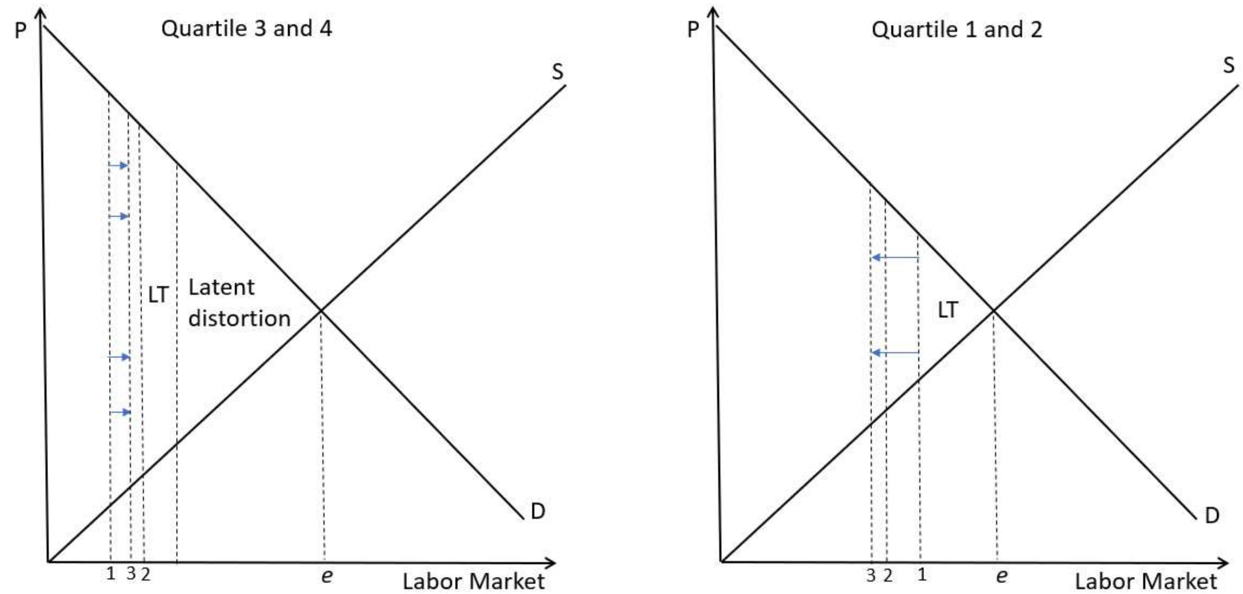


*Figure 4. The tax-interaction effect in the upper and lower quintiles in the presence of college educated labor-related latent distortions in the US labor market.*

Above it can be seen that applying pre-existing latent distortions, such as the education example above, may change the theoretical situation in a considerable way. The labels are the same as Figure 3, but now the initial situation in the upper quartiles, where the shortfall in demand for educated labor is assumed to exist, is greatly distorted by a labor tax *and* a latent distortion. In this case, since the regressivity of the carbon replacement tax makes the more greatly distorted upper quantiles better off and the comparatively less distorted lower quantiles worse off, the theoretical magnitude, and perhaps even the sign of the carbon tax cost estimates is more ambiguous.

A second theoretical distortion in the labor market introduced more briefly here originates from the energy efficiency gap. If one follows along the logic used when applying the tax-interaction effect, and apply it to the energy efficiency gap, a labor distortion does indeed follow. The energy efficiency gap refers to the phenomenon that economic agents evidently under consume energy efficient items that would make them better off in the long run. Whatever the reason for this, spending a more than an optimal amount on energy is the same as a reduction in real income as well, if that energy-related spending level is indeed more than optimal. Thus, fixing such a distortion *should* result in an effective increase in real income, and by that a higher return on labor, which will theoretically increase work effort. A carbon tax replacement would do this.

Two examples are given here to demonstrate that several other sources of labor distortion could exist, and once again have a significant impact on carbon tax cost estimates. Under the same general conditions assumed in tax-interaction effect literature, this becomes evident. However, once the complexities mentioned in section 5 and section 4 are incorporated, this analysis is likely to be greatly obfuscated. For example, if it is indeed true that labor elasticity along the intensive margin is virtually zero, then the demonstration above would certainly not hold. The second example is more ambiguous in that respect, however. For simplicity of demonstration the concepts above are not simultaneously considered, and a reversion to the conventional context is made.

## 7. Incorporating the voting system into the economy

Voting systems are often not included in economic analysis of tax systems and are seemingly vacant in tax-interaction effect literature. In these analyses, the government is viewed as a benevolent social planner trying to maximize the social welfare function. And while this could feasibly be true in economies that occur in the absence of a democratic governmental system, the accuracy of this analogy most likely decreases when applied to the democratic section of the world. Within the OECD, tax-to-GDP ratio can vary from 17% to 46%, and thus an economic model that ignores the influence of the voting system at minimum cuts out an important factor in what decides the fate of a considerable portion of economic value (OECD, 2017). As such, it has been commonly theorized, particularly in political economy circles, that voters do consider some kind of cost-benefits when voting or even holding political opinions[13]. There also does exist some direct evidence of this with regards to environmental issues (Shum, 2012). Indeed, opinion on climate change has been shown to make surprising downward swings when unemployment rate increases (Kahn & Kotchen, 2011). Moreover, many environmental willingness to pay studies are founded on the very assumption that this kind of calculation takes place among voters (Aldy, Kotchen, & Leiserowitz, 2012) (Kotchen, Boyle, & Leiserowitz, 2013). In such a context, politicians and social planners are not so much acting by their own will as they are following their mandate. This is a central idea of the median voter theorem (MVT). Furthermore, it remains a stable and unsurprising consensus that increased income is associated with higher WTP (Skuras & Tyllianakis, 2016) (Aldy, Kotchen, & Leiserowitz, 2012). If this basic result is assumed and the median voter theorem is applied then some interesting conceptual results follow for the tax-interaction effect. For a carbon tax, the tax-interaction in this context will be scaled by four concepts: tax salience, the relative position of the median voter in the income distribution, tax incidence, and the societal willingness to pay for carbon policy. The ability of a voting system[14] to fundamentally change the way in which the tax-interaction effect will be expressed leads to the determination that this is a L2R.

Willingness to pay for carbon policy, if voters do indeed make some kind of mental cost analysis when forming political opinions and voting, represents the foremost important factor in the voting system's effect on the tax-interaction effect. Carbon taxes are set on energy and this results in a direct increase in energy prices and an indirect increase the general price level. It is at this point that consumers will decide how to modify their work effort. The work effort decision will theoretically change depending on how much the consumer was willing to pay for carbon policy in the first place. Under standard assumptions in tax-interaction effect literature, a consumer with a very high WTP may actually *increase* his or her work effort. This would be a result of carbon policy that does not force this consumer to pay more than their WTP. This circumstance will create a new, higher value optimal bundle of goods for the same amount of work effort, increasing returns to labor. A consumer with a low but above zero WTP will decrease their labor hours *less* than what is currently predicted by the same principle, as willingness to pay is not considered in conventional cost estimates and effectively assumed to be zero. Conversely, a voter that would pay *not* to have carbon policy (even if it would cost them nothing) would reduce their work effort

[13] E.g. the Calculus of Voting equation

[14] The US is the focus example of discussions in this section due to its majoritarian election system; this the most straight forward system to which the MVT may be applied. Bearing this in mind, the same, albeit more complex analysis can be applied to other types of democratic government as well.

*more* than predicted. A consumer with a WTP of zero will follow model predictions. Note that, with regards to tax-interactions in the labor market, the *actual* direct returns of policy to the voter or economic agent do not have to be the same as cumulative WTP, as the consumer makes a prediction as to how much value she or he will receive from carbon policy and changes her or his behavior based on this prediction (as one might do in reaction to, for instance, visiting a dentist). Work effort, at least in the short-middle term, is based on an expected result rather than the actual result.

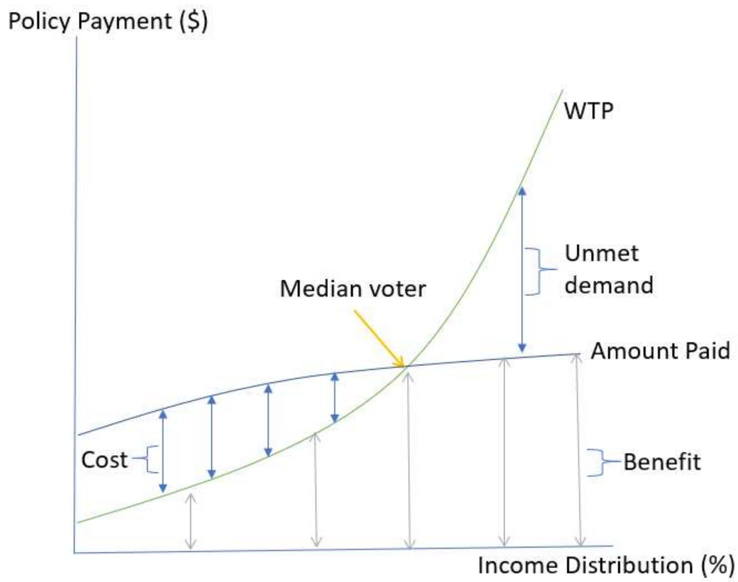


*Figure 5. An emphasis of the median voter's relative income in the context of costs and benefits of policy.*

With the WTP for policy framework in place, the MVT follows naturally. The relative income of the median voter and carbon tax distributional incidence go hand-in-hand in how they affect the tax-interaction effect. If the median voter votes based on her or his preferences (and perfect information), then the difference between how much the median voter is willing to pay and how much she or he will have to pay in aggregate price increases should be zero[15]. Since the WTP increases with income in aggregate, the portion of society with an income lower than hers or his will pay more in aggregate than their WTP, provided the policy is structured regressively. Equally, those with a higher income than the median voter will pay less than their willingness to pay. Thus, the relative income position of the median voter and the tax incidence will determine the extent of the cost and benefit situation because it determines who will pay above their WTP and who will pay below. Figure 5 demonstrates this[16].

On the horizontal axis is the income percentile, and the vertical axis is payment. It can be seen that the amount the median voter wants to pay for environmental quality will be the amount she or he does pay. Those who are above or below this price point are forced to pay below or above what they would prefer to pay, respectively. There is still some benefit for those who have a very low willingness to pay, but the benefit does not exceed the cost. Even below the median voter's WTP, the benefit can still exceed the cost, even if the price paid is above optimum. Think of this in terms of food. If someone is forced to eat more than they want, there might be a cost, but they would have to eat considerably more than they

[15] This interpretation is consistent with (Aldy, Kotchen, & Leiserowitz, 2012), which assumes WTP values reflect the level up to which the respondent would be indifferent to paying incrementally more or less for environmental quality.

[16] Curves are roughly approximated using results from (Parry & Williams, 2010) and (Aldy, Kotchen, & Leiserowitz, 2012) as well as World Bank data on income distribution. WTP values in the latter study are found to be within an approximate range of some policy costs, allowing the curves to intersect. The policies within these studies are not exactly the same, but do convey enough information ensure the above approximate framework for analysis is sound.

want to eat before the costs start to outweigh the benefits of food, period. The most striking feature of Figure 5 is that the amount paid and the WTP curves *must* intersect in order for policy to occur, baring the unlikely scenario of WTP being higher than amount paid at every income level. The condition of large costs being incurred implies a very well-off median voter and the a relatively low income median voter for small costs[17]. The position of the median voter will change as, for instance, inequality changes and the voting population changes.

The analysis in Figure 6 only considers a carbon tax without considering revenue recycling, though this is the case for a CRT. Once this is incorporated, the cost situation will change, possibly dramatically. When considering WTP for policy simultaneously with a CRT, the cost situation can start to look negative.

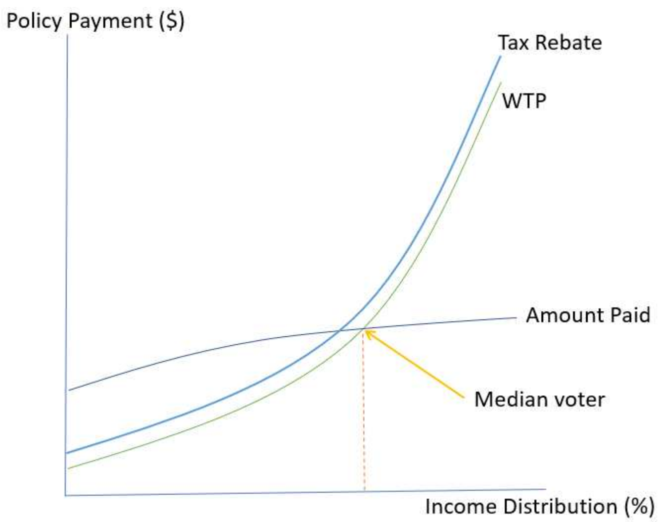


*Figure 6. An illustration of how the CRT policy structure may further change the carbon policy costs situation.*

While the analysis above is likely to have significant influence on some level, it overrepresents the possible benefits flowing from the CRT. The accuracy of the ideal situation will likely be scaled by how aware economic agents are of when they are paying for the carbon tax. One advantage of a carbon tax is that the cost of carbon emission is subsumed by the price of the good, meaning the consumer does not have to gather and process carbon emissions information her or himself for each economic decision made. This greatly lowers the cost in terms of time. The down side to this is that the consumer may not know that the price of one item is higher than the next specifically because of carbon footprint. Such a context allows for the tax-interaction effect to take place even for a voter with an arbitrarily high WTP for carbon policy, because they are completely unaware of when they are paying for policy. Instead, they may only notice that the prices of goods have increased in general, resulting in her or him reducing her or his work effort. On the other hand, the tax-induced price increase in directly purchased energy, like electricity, is much less likely to be lost on the consumer. As addressed above, a tax-interaction effect resulting from a salient price increase that is easily connected to voted-in policy will depend on willingness to pay for carbon policy, at least in theory. The low tax salience on non-energy products may be partially avoidable depending on how the carbon tax is reflected in the price, for instance in a very salient way, as mentioned in section 5. This is an example of how concepts presented here can complicate one another when considered simultaneously, and is addressed to a larger extent in the following and final section.

[17] It is important to note how "costs" have been defined here. The implication of our analysis is that costs are not introduced by, for example, an individual with high income that sees environmental quality supplied at a lower rate than preferred. Many would, however, say that this "shortfall in demand" does carry a cost. For conceptual clarity, however, this analysis has only applied costs to those who pay for environmental quality at above their preferred level.

## 8. Discussion and Conclusion

This paper argues that there are vast opportunities to improve carbon policy cost-side estimates. The current discourse rationalizes this conclusion by taking a "meta-view" across economic disciplines and literature discussions, a practice that has gained legitimacy in recent years, particularly in economics (Chetty, 2015). Such improvements will further allow policy makers to access information necessary for confident application of carbon policy intervention at the appropriate level. Conclusions across widely varying realms of literature have been synthesized here, and implications reported.

Advancements in understanding of labor market behavior significantly complicate interpretation of labor market reactions to carbon policy. Contemporary methodologies for obtaining labor elasticities are dubious by some academic accounts, leaving a lurking possibility that literature underpinning the tax-interaction effect has yet to reach a point where it can provide accurate information on this crucial parameter. Right or wrong, the conventional approach has carried forward, and come to new conclusions that are far more nuanced and themselves absent in tax-interaction effect literature. Thus, even if the conventional approach can provide accurate conclusions, excluded nuances will add uneasiness to results provided by current tax-interaction effect literature. Expanding the view to include conclusions from behavioral economics, tax-interaction effect literature could take even more sophisticated turns. Behavioral biases like relative income, tax misinterpretation, inattention and fairness have all been implied as or revealed to be important variables in work effort, and an accurate representation of these variables in tax-interaction effect literature will, at the least, put minds at ease that the current results are robust, if not result in new conclusions.

After it can be confidently accepted that this fundamental interpretation of how the labor market reacts to taxation in tax-interaction effect literature is indeed correct, other unrelated L2Rs pose significant challenges to the current treatment. Structural inefficiencies in the economy do not only react indirectly to the tax interactions, but are again tied in with the interpretation of them. One of these L2Rs is latent distortions in the labor market, which are distortions that occur in the labor market "naturally" and not as a result of taxation. These empirically exist in the form of supply and demand shortfall for skills within labor markets around the world and theoretically exist as a result of the energy efficiency gap. Latent labor market distortions essentially add more pre-existing distortions to the initial scenario than just taxes; the current interpretation is that recognized suppression of the labor market will only come from taxes. These latent distortions would not appear even in CGE models because the assumptions made for CGE models are such that these distortions would need to be deliberately included. These kinds of latent distortions could be greater in number than implied by the introduction here of just two, but the anatomy of how exactly latent labor market distortions could change the theoretical situation for one example has been laid out in this paper.

The voting system is the final L2R introduced in this discourse. Taking perspectives from median voter theory, it is hard to rationalize that all economic agents would view a voted-in policy such as a carbon tax as "sub-optimal" overall, resulting in reduced work effort. Likewise, a new framework for interpreting how economic agents may perceive carbon policy has been introduced here. When carbon policy is shown to be the result of a reciprocal process rather than a one-way burden, the two phenomena tend to better resemble the voluntary exchanges of the market. Said another way, if it is true that market agents are indeed rational and utility maximizing, it seems peculiar to think that they will react to price increases they are partially and unambiguously responsible for in a way that implies welfare reduction. This indubitably changes the carbon policy cost situation. How exactly this will change the cost situation will remain an important task for further research.

There is easily a possibility that some of the interpretations introduced here are imprecise in that some of the concepts used to create other concepts in this paper themselves can have their own flaws, and sometimes do not easily produce such sharp, dependable inferences. One example of this includes some criticisms of the median voter theory, or at least some apparent empirical departures from median voter theory. (Kim & Urpelainen, 2017), for instance, finds evidence that political polarization can lead to departures from what the median voter theorem would predict. Another is that the contingent valuation survey method used in some of the environmental willingness to pay research cited here has also been criticized as a method for uncovering true WTP. Finally, works cited here on relative income would seem to have contradictory conclusions where, on one hand, a someone may be more likely to choose to work if their sibling-in-law makes more than their spouse, but on the other hand, other studies have found that increased relative income of others suppresses work effort through depression. This could be down to a number of causes, such as differences in personality, but these results certainly imply a complex and nuanced situation. Existence of vexing or incomplete components of theories or results that are used here as premises, however, does not imply the need to throw the baby out with the bath water, as it were, just as this paper has not chosen to do so with the tax-interaction effect, which has been outlined here to also rely on possibly flawed concepts or results. At their foundation, each of these concept-premises have an associated ongoing debate within their own literature. However, it is only the essence of their concepts that are relevant here. A rigorous model including everything would need to cut one direction or the other on these very specific complexities in order to be of much use, but this discussion is not there yet. The point is that, if these concepts are included in any capacity, major, complex changes to the current treatment of a carbon tax in the literature are required. These possible imprecisions in concepts cited above only emphasize that point rather than diminish it.

It is also correct that some of the interpretations presented above cannot be true at the same time, and perhaps that is the final and main point of this paper. It is for this reason that insights presented here may give pause to many researchers investigating the carbon tax and its outcomes for the economy. This is because, bearing this in mind, it is very hard to escape the conclusion that even if each critique presented here will not individually change the costs-side carbon tax estimates, they will collectively. Interpretations exclusively contradict one another. For instance, if the work effort perspectives presented section 5 indeed have minimal impact on labor market distortions, this will essentially validate the arguments made in the following sections. If tax salience is not a significant variable after all, then cost is pushed significantly in the negative direction by a voting system. Conversely, if it is significant, then the effects of a voting system are considerably dulled, but a whole world of salience research becomes relevant. Another example lies in latent distortions, where the US labor market is greatly distorted by a shortfall in educated labor in the upper income quantiles. If it is true that the labor elasticity of the highly educated is very close to zero, then analysis above with respect to labor distortions of the college educated does not apply. Yet, this would also imply that labor supply elasticities used in existing tax-interaction effect literature do not apply either. This discourse is rife with these kinds of examples, partially thanks to the broad analysis undertaken and the great extent to which variables are entangled. That current tax-interaction effect literature results should change in consideration of these insights is an extremely difficult conclusion to escape. As such, this paper does not only constitute a contribution because it offers some new concepts that elicit small cost alterations individually, but because the potential for *substantial* change when these concepts are considered *simultaneously* is extremely high. This is due to the fact that insignificance of some concepts presented here imply the significance of others, and vice versa. Plucking these contradictions apart and rigorously examining which concepts hold and how to quantify them will be a task for research henceforth, even though considering the complexity involved, this could be a very heavy lift indeed.

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