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Carbon Tax Incidence: Empirical Evidence from Canada's Gasoline and Diesel Markets

par

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Résumé

Cette étude utilise le niveau de taxe carbone, le prix de vente des permis d'émission de GES ainsi que les autres taxes d'accises appliquées sur le carburant pour démontrer que le poids de ces taxes se répartit de manière presque égale entre les firmes pétrolières et les consommateurs au Canada. Les résultats suggèrent que le transfert de ces taxes vers le prix final se comporte de manière hautement non-linéaire avec le niveau de contrainte appliqué à l'étape du raffinage ; le transfert s'accentue lorsque les raffineries augmentent leur production, mais diminue significativement lorsque celles-ci produisent près de leur capacité maximale. Les résultats démontrent également que le niveau de transfert des taxes varie selon le degré de compétition présent dans le marché du commerce de détail de carburants ; les détaillants situés dans une ville marquée par une compétition accrue ont une capacité plus restreinte à transférer un changement de taxe vers le consommateur final.

Mots-clés

Incidence fiscale, Transfert des taxes sur le carburant, Tarification du carbone, Industrie pétrolière, Concurrence imparfaite, Recherche longitudinale, Économétrie, Analyse multivariée

Méthodes de recherche

Recherche longitudinale, Économétrie, Analyse multivariée

Abstract

This study uses carbon tax levels, CO_2 emission allowance prices and excise taxes applied at the city-level and at the province-level to demonstrate that the burden of fuel taxes is shared almost equally between refining firms and final consumers across Canada. The results indicate that the extent of tax shifting behaves nonlinearly with refinery constraints, in fact increasing when refineries ramp up production but falling when they operate near full capacity. The estimates also suggest that fuel tax pass-through is greatly influenced by a city's retail competition level, with outlets located in cities facing more competition having less ability to pass forward excise taxes.

Keywords

Tax incidence, Fuel tax pass-through, Carbon pricing, Petroleum industry, Imperfect competition, Longitudinal research, Econometrics, Multivariate analysis

Research methods

Longitudinal research, Econometrics, Multivariate analysis

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Liste des abréviations

AIC Akaike information criterion

BIC Bayesian information criterion

CER Canada Energy Regulator

CO_2 Carbon dioxide

CPI Consumer Price Index

EIA Energy Information Regulator

FD First-difference estimator

FE Fixed effects estimator

GES Gaz à effet de serre

GHG Greenhouse gas

GHGPPA Greenhouse Gas Pollution Pricing Act

HDD Heating degree day

MECP Ministry of Environment, Conservation and Parks

MELCC Ministère de l'Environnement et de la Lutte contre les changements climatiques

SBC Sales-below-cost

WCI Western Climate Initiative

WTI West Texas Intermediate

Avant-propos

L'intelligence collective est la résultante d'une coopération entre plusieurs individus ayant pour but d'atteindre un objectif commun. Elle se caractérise par une réponse plus efficace que si ces individus avaient travaillé de manière isolée. Dans un contexte où les changements climatiques toucheront l'ensemble des personnes qui vivent ou vivront sur cette planète, il est impératif d'agir dès maintenant en se dotant d'outils communs qui permettront d'affronter cette problématique de manière sérieuse. Le monde d'aujourd'hui attribue la valeur de toute chose en valeur monétaire ; il apparait donc évident d'y parler le même language en attribuant un prix aux dommages environnementaux que nous engendrons. Bien que des changements plus profonds devront s'effectuer dans nos modes de vie et d'échange, la tarification du carbone enclenche un pas dans la bonne direction. Aux lecteurs des pages suivantes, décideurs ou simplement intéressés, je vous invite à réfléchir à des pistes de solution qui permettront d'avancer - tous ensemble - vers notre objectif commun.

Remerciements

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Introduction générale

Traduction littérale de l'introduction en version anglaise, afin de satisfaire aux exigences de la M.Sc. Pour la correction du mémoire, se référer à 1.1 Introduction.

Les taxes sur l'énergie se répercutent ultimement sur le prix de l'ensemble des biens et services ; il s'avère donc important de bien saisir ce qu'elles impliquent pour les consommateurs et producteurs qui y sont touchés les premiers. La question posée ici vise à comprendre quelle est leur incidence au Canada. Une meilleure compréhension sur ce sujet est particulièrement pertinente pour ce pays, où une taxe carbone y a été introduite il y a quelques temps et où le débat quant à sa légitimité y est toujours vif. Certaines provinces sont particulièrement dépendantes de l'industrie pétrolière, et l'économie canadienne est fortement liée à celle de ses voisins du Sud. Le fait de connaître dans quelles proportions le poids des taxes sur les carburants sont réparties entre les producteurs pétroliers et les consommateurs finaux permettra de compenser de manière équitable pour les coûts qu'elles engendrent et favorisera la mise en place de politiques publiques plus éclairées.

Il n'existe toujours pas de consensus à savoir quel est le pourcentage d'une taxe qui est transféré au consommateur final, et ce, malgré l'abondante littérature traitant de l'incidence fiscale des taxes sur les carburants. Plusieurs études supportent l'idée d'un transfert complet au consommateur (idée qui sert d'ailleurs comme intrant dans certains champs d'application connexes). Plusieurs de ces mêmes études soulignent toutefois certaines situations où l'hypothèse de transfert complet ne s'applique pas. Par exemple, pour les États-Unis, Chouinard et Perloff (2004) trouvent un transfert complet pour les taxes sur l'essence appliquées par les États, mais trouvent une répartition du poids de 50-50 pour les taxes appliquées au niveau fédéral. Doyle Jr et Samphantharak (2008) étudient l'effet d'un moratoire sur les taxes sur l'essence et dénotent un certain degré d'asymétrie : 80-100% de la réintroduction de la taxe est transmise vers le prix final, mais seulement 70% de la réduction est reflétée sous la forme de plus faibles prix. Même si Alm et collab. (2009) ne trouvent pas de telle relation d'asymétrie, leurs résultats suggèrent néanmoins un transfert complet dans les États très urbanisés et un transfert incomplet dans ceux plus ruraux. Au Canada, les seules études qui s'attardent à la question d'incidence fiscale pour les taxes sur les carburants trouvent des taux de transfert différents selon la province étudiée (Erutku, 2019).

L'objectif de cette étude est de mesurer le degré de transfert des taxes sur l'essence et sur le diesel vers le prix de vente au consommateur final pour 18 villes canadiennes. Une attention particulière est mise sur les taxes carbone, mais les taxes appliquées aux paliers gouvernementaux municipaux et provinciaux sont également considérées. Le but de ce travail est également de fournir certaines explications sur le rôle de deux facteurs sous-jacents au transfert des taxes. Les facteurs étudiés ici sont les contraintes au niveau de l'offre - plus précisément les contraintes au niveau du raffinage et du stockage - ainsi que le degré de compétition dans le marché du commerce de détail sur les carburants. Ces deux facteurs sont explorés étant donné qu'ils sont des déterminants principaux dans le niveau de transfert, affectant à la fois sa variation géographique et temporelle.

La contribution de cette étude à la littérature existante se décline de trois façons. D'abord, elle est la seule étude à fournir des résultats à l'échelle nationale, couvrant les 10 provinces, plus deux territoires. Cette étendue permet de saisir des composantes locales importantes, étant donné que les villes échantillonnées possèdent des caractéristiques inhérentes très différentes. Deuxièmement, cette étude est la première qui consolide les prix des permis d'émission pour les provinces qui participent à un marché du carbone avec le niveau de taxe carbone appliqué dans les autres provinces. Cette consolidation permet d'avoir un aperçu global de la tarification du carbone au pays. Étant donné qu'à priori l'effet d'une taxe carbone sur le prix de détail du carburant n'est pas différent de celui des autres taxes d'accises, celles-ci sont également utilisées pour mesurer l'incidence. Finalement, un modèle en première différence est ici employé, ce qui fournit une approche complémentaire aux études existantes pour le Canada, qui, elles, utilisent plutôt un modèle en niveau.

Les résultats suggèrent une répartition du poids des taxes presque égale entre les producteurs et les consommateurs, avec un transfert légèrement supérieur à 50% pour la taxe carbone et légèrement inférieur pour les taxes d'accise municipales et provinciales. Les résultats écartent l'hypothèse du transfert complet, indiquant donc que les consommateurs ne sont pas les seuls à supporter le fardeau. Les résultats sont cependant moins clairs concernant le délai de transmission ; ils suggèrent un transfert immédiat pour l'essence, mais un transfert prenant place sur une période de deux mois pour le diesel. Les résultats d'incidence sont robustes aux différentes spécifications du modèle ; ils sont pratiquement les mêmes lorsque les prix du West Texas Intermediate (WTI) sont remplacés par celui du Brent, lorsque le prix de gros est utilisé plutôt que celui du brut ainsi que lorsque le prix de l'essence super est utilisé plutôt que celui de l'essence ordinaire. En ce qui a trait aux facteurs sous-jacents affectant le degré de transfert, les contraintes appliquées au niveau des raffineries démontrent une relation hautement non-linéaire avec le degré de transfert. En effet, le transfert s'accentue au fur et à mesure que les raffineries augmentent la production, sauf dans le cas extrême où celles-ci produisent à capacité maximale. Finalement, le niveau de compétition dans le marché du commerce de détail, mesuré par les marges d'opérations marketing, n'a pas de relation linéaire avec le degré de transfert à la fois pour l'essence que pour le diesel. Toutefois, de manière générale, les stations-essence localisées dans les villes avec les marges d'opération les plus faibles ont une moins grande possibilité de transférer une taxe au consommateur. Cela signifie que les ménages demeurant dans les endroits plus éloignés supportent un plus gros fardeau d'une telle taxe.

L'étude se divise de la manière suivante : la section 2 résume la littérature existante sur l'incidence fiscale et souligne son importance pour ses champs d'application. La section 3 définit le cadre théorique appliqué en analyse d'incidence fiscale. Étant donné que le cadre varie selon la structure de marché, je décris à la fois lorsqu'en compétition pure et parfaite ainsi que lorsqu'en compétition imparfaite. La section 4 spécifie les données utilisées, présente les statistiques descriptives et explique quelle stratégie empirique est retenue et pour quelle raison. La section 5 présente les résultats. La section 6 discute de leurs implications sur la réglementation actuelle et comment ils pourraient être utilisés pour ajuster les politiques publiques en place. L'étude conclut également avec des voies possibles de futures recherches.

Chapitre 1

Carbon Tax Incidence : Empirical Evidence from Canada's Gasoline and Diesel Markets

1.1 Introduction

Energy taxes ultimately affect the price of all goods and services, so it is important to understand what they involve for upstream producers and consumers. The question asked herein is : what is the incidence of such taxes in Canada ? Better comprehension of this matter is crucial for this country, where the not-so-recent implementation of a nation-wide carbon tax is still a highly debated subject. Some provinces rely heavily on the petroleum industry, and the country is deeply tied to the one of its southern neighbors. Knowing in what proportions the burden of fuel taxes is shared between refining firms and final consumers will allow to compensate accordingly for its associated costs and will help to design sound economic policy.

Yet despite the abundant literature on gas tax incidence, there is no consensus on how much of a fuel excise tax in passed forward to final consumers. Several studies find evidence supporting the idea of full-pass-through to consumers (which is often assumed in related application fields). On the other hand, many of these same studies also expose situations in which the full pass-through hypothesis does not hold. For example, Chouinard et Perloff (2004) estimate a complete burden transfer for fuel state taxes in the U.S. but measure a 50-50 repartition for federal taxes. Doyle Jr et Samphantharak (2008) use the effect of a gas tax moratorium and discover some degree of asymmetry with 80-100% of the tax reinstatement transmitted to final prices, while only 70% of the tax break passed on to consumers in the form of lower prices. Although Alm et collab. (2009) do not observe such asymmetric response, their results suggest a full pass-through in urban states but not in rural states. In Canada, the few works on that question point to different pass-through rates depending on the provinces examined (Erutku, 2019).

The purpose of this paper is to measure the transfer of gasoline and diesel excise taxes to final consumers for 18 selected cities in Canada. A special focus is placed on the carbon tax, but taxes applied at the city-level and at the province-level are included as well. The aim is also to explain the role some underlying factors play on the extent of tax shifting. The factors studied here are supply constraints - more precisely refining and storage constraints -

and retail competitiveness, since these seem to be the main determinants affecting both the level of tax forwarding and its variation across time and geography.

The contribution of this work to the existing literature is threefold. First, it is the sole attempt at providing nation-wide results, covering all 10 provinces plus two territories. This scope allows to catch valuable local market determinants as the cities in the sample possess very different inherent characteristics. Second, it is the first study that merges emission allowance prices settled in provinces who participated in a cap-and-trade program with carbon excise taxes applied in other provincial jurisdictions. Such consolidation provides a comprehensive outlook on carbon taxation across the country. Since the a priori effect of carbon taxation on retail prices does not differ from other energy taxes', the latter are also used to predict carbon tax incidence. Finally, a first-difference model is used to estimate gas and diesel pass-through. This brings an alternative approach to estimating in levels, which is the empirical strategy undertaken in the existing studies focusing on gas tax incidence in Canada.

Results point towards nearly equal burden sharing between producers and consumers, with a pass-through slightly above 50% for the carbon tax and slightly below 50% for city-level and province-level excise taxes. These rule out the hypothesis of full burden transfer to final consumers. Results are less clear regarding the transmission time needed to reach final prices ; they suggest an immediate forward shifting for gasoline but a two-month transition period for diesel. Incidence is quite robust to model specification ; results are virtually the same when changing West Texas Intermediate (WTI) prices for Brent's, when using wholesale prices instead of crude costs, and when replacing regular gasoline prices for premium prices. They are also very similar for diesel and for gasoline. As for the underlying factors affecting tax shifting, refinery-level constraints display a highly non-linear relationship with incidence. In fact, tax transfer is higher when constraints on refineries are more binding except for the polar case of maximum capacity production where incidence sharply falls. Finally, retail competitiveness, measured by retailers' marketing margins, does not show a clear linear relationship with incidence for both diesel and gasoline. Overall, though, cities with the thinnest margins, i.e. the most competitive cities, are associated with a lower pass-through rate. This means that people residing in more remote areas bear a greater amount of a fuel tax.

The article proceeds as follow : Section 2 summarizes existing literature on gas tax incidence and shows its importance to related fields of study. Section 3 defines the theoretical framework applied in tax incidence analysis. Since the analysis framework changes depending on market structure, both perfect competition and imperfectly competitive settings are described. Section 4 specifies the data, presents summary statistics, and explains which empirical strategy is undertaken and why it was chosen. Section 5 lays out the results. Section 6 discusses its implications on current carbon-pricing regulation and how it could be used in policy decision making. It concludes with directions for future research.

1.2 Literature Review

The first Canadian provinces to enact carbon-pricing policies did so more than a decade ago. In June 2018, the Canadian federal government adopted the Greenhouse Gas Pollution Pricing Act (GHGPPA), whose main objective was to act as a backstop in provincial and territorial jurisdictions who did not already have their own pricing systems. The GHGPPA, however, faced legal challenges in Ontario, Saskatchewan and Alberta. The case was brought to the Supreme Court in late September of 2020, and the ruling has yet to be delivered. This battle takes place despite the fact that the pricing system is designed to be revenue neutral, i.e. that all revenues are transferred back to the province or territory that generated them with households receiving 90% of it in the form of a lump-sum payment (Parliamentary Budget Officer, 2019) [1].

The reluctance of provincial jurisdictions seems contradictory to the growing evidence that carbon pricing is an easy-to-implement and effective instrument for reducing greenhouse gas emissions and for improving energy efficiency. In the manufacturing sector, Martin et collab. (2014) exploit the exogenous variation in eligibility for the carbon tax discount applied on U.K. plants and find that the tax has a strong negative effect on energy intensity and electricity use. In the transportation sector more specifically, tax-induced price changes tend to have a larger impact on demand for gasoline than equivalent market-determined price movements. This is explained by the fact that taxes can be more or less salient, i.e. they can generate a different behavioural response depending on how visible they are. Rivers et Schaufele (2015) study this question for the British Columbia carbon tax and find that such larger consumer response to the tax reduced carbon dioxide emissions by 2.4 million tonnes during the first four years following its implementation [2]. In the United States, Li et col-

1. As of June 2019, the federal pricing system applied partially or wholly in the provinces of Saskatchewan, Manitoba, Ontario, New Brunswick and Prince Edward Island and in the territories of Yukon and Nunavut (Environment and Climate Change Canada, 2019). Quebec implemented a carbon tax in 2007 and replaced it in 2013 with a cap-and-trade program developed in partnership with the Western Climate Initiative (WCI). Ontario joined WCI's cap-and-trade system in January 2018, but left it a few months later, in July of the same year. British Columbia instituted an economy-wide carbon tax in 2008 (Province of British Columbia, 2020). Alberta introduced a similar tax in Jan 2017, but repealed it May 2019, and thus was under the federal pricing system beginning in 2020 (CBC News, 2017).

2. This might seem like a modest reduction when compared to total emissions. Studies that focus on

lab. (2014) find similar results ; tax changes are associated with a larger effect on gasoline consumption and on vehicle choices than equally sized tax-exclusive price variations.

On a distributional impact basis, several studies note that environmental taxes tend to be regressive when not recycled, because poorer households spend a larger share of their income on energy. However, many of these same studies also underline the fact that appropriate recycling can countervail this effect, especially when the revenue is used to fund lump-sum transfers or to reduce payroll or personal income tax (West et Williams III, 2004; Metcalf, 1999; Bento et collab., 2009). Using a measure of lifetime income, as opposed to annual income, also suggests that environmental taxes are less regressive. Including indirect effects, i.e. not only the increased price of energy goods but also the induced price increase of all other goods in proportion of the energy used to produce them, makes the tax roughly proportional across the household distribution (Bull et collab., 1994; Parry et collab., 2006). When compared to alternative vehicle pollution control policies such as taxes on engine size or subsidies to new vehicles, gasoline taxes also appear to be more progressive (West, 2004).

Most studies looking at distributional impacts or environmental policy more broadly sit on the assumption that fuel taxes are entirely passed forward to consumers instead of being absorbed by producers. However, as mentioned earlier, there is still no consensus in the literature regarding that assumption, and especially there is no consensus as to what role play its underlying determinants.

One of the main drivers of tax incidence is market power. Moving away from a competitive framework towards an imperfectly competitive setting leads to different pass-through rates because it explicitly considers the fact that firms can adjust their price. Muehlegger et Sweeney (2017) estimate input costs pass-through in the refining industry using a non-competitive setting and discover that, while idiosyncratic cost shocks are almost entirely borne by refiners, industry-wide cost shocks (such as a carbon tax) are fully transferred to

estimating the relative reduction of carbon dioxide (CO_2) emissions resulting from excise taxes, either using applied general equilibrium models or other frameworks, indeed find relatively small emissions changes (often around 1.5% - 2%). These studies, however, point out that extensive tax exemptions in the most emitting industries considerably reduce the benefits from implementing such carbon-pricing policy (Bruvoll et Larsen, 2004; Davis et Kilian, 2011).

final consumers. Market power can be characterized by spatial isolation or vertical integration, both affecting the extent of tax shifting and price setting dynamics. Hastings (2004) studies the effect of market share of independent stations and company-operated stations on retail prices, using the acquisition of an independent retailer by a vertically integrated company in the Los Angeles and San Diego area as a random experiment. She finds that price competition in the market is softened after the merger, resulting in higher local market prices. Laws and regulations also influence market structure. Skidmore et collab. (2005) look at the effect on gasoline retail prices of U.S. States sales-below-cost (SBC) laws. SBC laws have a stated purpose to outlaw price wars and to prevent the exit of independent, smaller firms. The authors observe that, on average, gasoline prices are a cent lower five years after the law is imposed, conceivably because of higher retail competition and a greater number of outlets than would have existed otherwise. Finally, tax shifting can be affected by supply chain constraints. Supply is determined by many factors, including technology as well as the availability and cost of factors. Marion et Muehlegger (2011) look at supply constraints at different steps of the refining process and find that incidence of fuel taxes declines when the supply chain is constrained.

Studies focusing on environmental and carbon tax incidence in the petroleum industry are related to other work investigating the same question in sectors other than refining. For example, Ganapati et collab. (2016) and Miller et collab. (2017) measure carbon tax pass-through and CO_2 regulation tax incidence in the manufacturing industry, while Fabra et Reguant (2014) and Sijm et collab. (2006) do similar work for the electricity market. All this research falls in a much broader field of public finance looking at the transfer of various costs shocks - other than energy or environmental - towards final prices. Partial equilibrium models indeed have been used to study welfare impacts of corporate income tax or minimum wage requirements (Aaronson, 2001; Arulampalam et collab., 2012; Auerbach, 2006). They have also been applied extensively for studying the transfer exchange rates (Goldberg et Hellerstein, 2008; Gopinath et collab., 2010; Hellerstein, 2008).

1.3 Theory of Incidence

The approach undertaken here uses a static, partial equilibrium framework. It is a simple and effective tool to analyze the effect of a tax levied in a specific market, the taxes studied here being collected directly and only from refineries. Tax incidence analysis varies with industry structure. A perfect competition market is the first case presented, followed by the imperfect competition setting, which might be more representative of the Canadian gasoline market.

FIGURE 1.1 – Effect of excise tax on producer

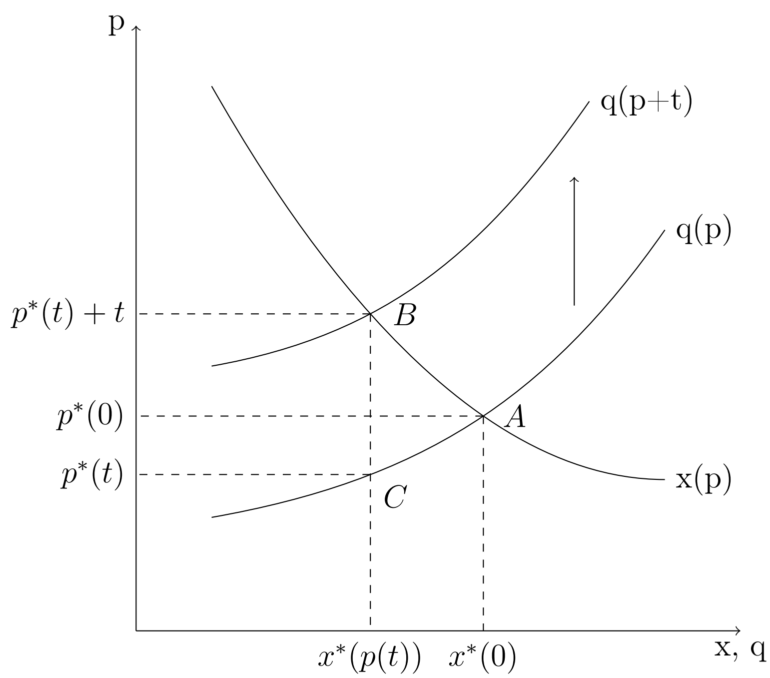


Figure 1.1 characterizes the effect of a tax imposed on producers. Since the tax is equivalent to an increase in marginal cost, aggregate supply shifts upward from $q(p)$ to $q(p+t)$. The competitive equilibrium moves from point A to point B, with lower output $x^*(p(t))$ compared to $x^*(0)$ initially, and with a new equilibrium price, $p^*(t) + t$, larger than the initial market price, $p^*(0)$. The producer receives $p^*(t)$ (point C), and the difference between B and C catches the tax wedge (Muñoz-Garcia, 2017) [3].

3. A similar unit tax, but with statutory incidence on the consumer, would have produced the same outcome on price and output as when levied on the producer (Gruber, 2011).

The equilibrium after the tax is introduced is reached when :

$$x(p^*(t) + t) = q(p^*(t)) \tag{1.1}$$

Since the point of interest is the effect of a marginal tax change, differentiation is executed to obtain :

$$x'(p^*(t) + t) \cdot [p^{*\prime}(t) + 1] = q'(p^*(t) \cdot p^{*\prime}(t)$$

With further rearrangment, we have :

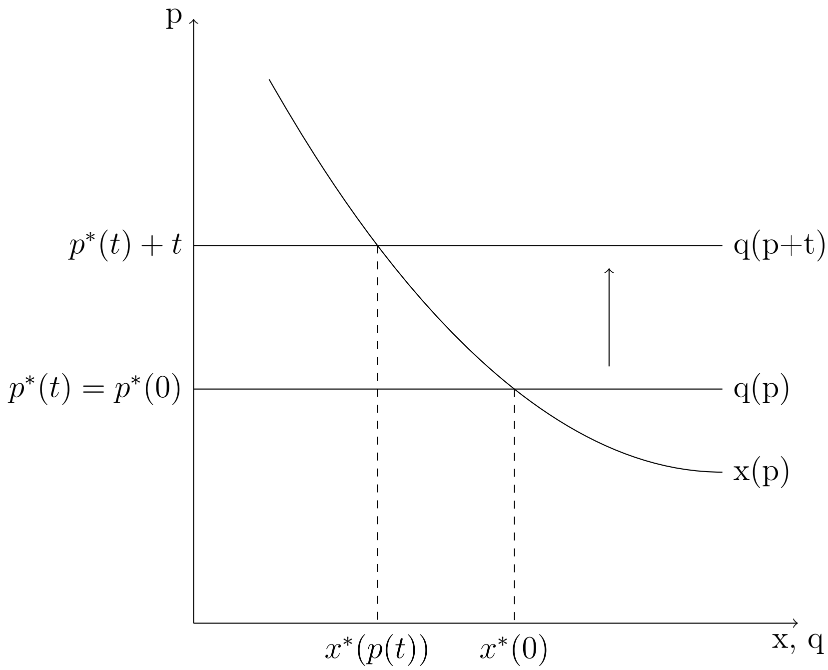
$$p^{*\prime}(t) = \frac{x'(p^*(t) + t)}{q'(p^*(t)) - x'(p^*(t) + t)} = \frac{\epsilon_D}{\epsilon_S - \epsilon_D} \tag{1.2}$$

Since $\epsilon_D \leq 0$ and $\epsilon_S \geq 0$:

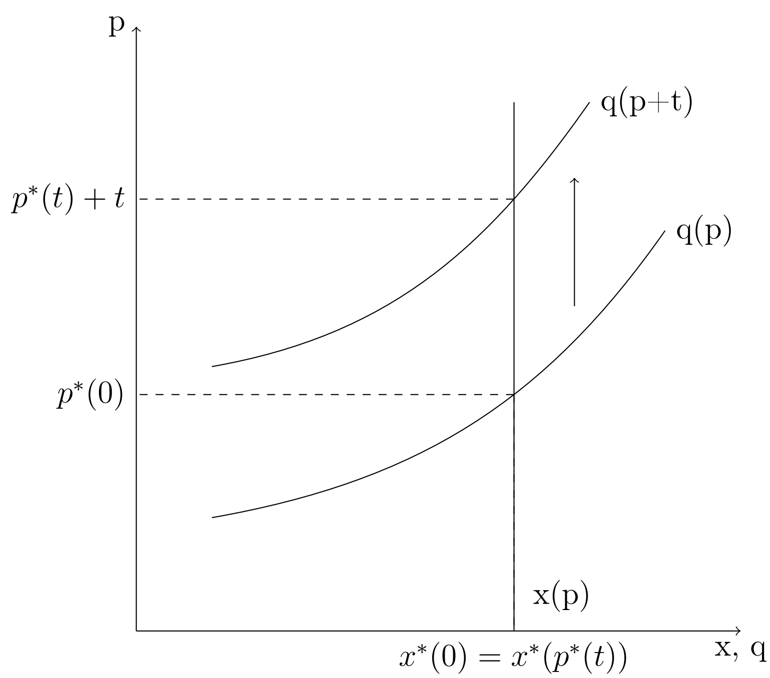
$$-1 \leq p^{*\prime}(t) = \frac{\epsilon_D}{\epsilon_S - \epsilon_D} \leq 0 \tag{1.3}$$

The expression 1.3, which lies in the interval [-1,0], shows in what proportion the tax burden is shared between consumers and producers. If supply becomes more elastic (i.e. higher ϵ_S), $\frac{\epsilon_D}{\epsilon_S - \epsilon_D}$ falls and so does the burden for the producer. In the limit case where supply is perfectly elastic, for example in the long run, the entire amount of the tax is passed forward to the consumer. Full burden on the consumer also arises when demand is perfectly inelastic, as ϵ_D and $\frac{\epsilon_D}{\epsilon_S - \epsilon_D}$ tend towards 0. These two cases are represented in Figure 1.2 (panel 1.2a and panel 1.2b, respectively). For each of them, the competitive equilibrium price after the tax is imposed is equal to the one prior to the tax introduction ($p^*(0) = p^*(t)$), and the price paid by the consumer is equal to $p^*(t) + t$.

FIGURE 1.2 – Supply and demand elasticity impact on incidence



(a) Elastic supply



(b) Inelastic demand

The analysis above is made under a perfect competition framework, where overshifting is not possible. Overshifting happens when firms increase the price by more than the tax change to compensate for the loss of quantity demanded and sometimes leads to increased economic profits for the producer (Katz et Rosen, 1985). For such market behaviour to arise, firms must have some form of market power. Imperfect competition may occur in many forms, but the Bertrand oligopoly and the Cournot-Nash oligopoly are particularly relevant here since refined petroleum products are homogeneous. For both models, a specific or *ad valorem* tax will lead to lower output and efficiency loss (Hamilton, 1999). Under the Bertrand oligopoly, however, overshifting is not possible. Since firms compete on prices, they ultimately reach marginal costs so the tax incidence analysis leads to the same outcome as the competitive model (where overshifting does not exist) (Fullerton et Metcalf, 2002). As for the Cournot model with a fixed number of firms competing by choosing output levels, tax incidence (and the degree of overshifting) depends on three components : the relative slopes of the inverse demand and marginal cost curves, the number of firms in the industry, and the convexity of the inverse demand function [4]. Finally, in monopoly markets, overshifting will never arise when the inverse demand function and the costs curve are linear but will always happen when costs are linear and demand follows a constant elasticity function (Fullerton et Metcalf, 2002).

4. Introducing free entry adds a degree of complexity, because indirect effects of the tax on industry structure (i.e. the total number of firms in the industry) affect the extent of overshifting. Other models also allow firms to make a conjecture about how their competitors will react if they change their own output or price. Stern (1987) discussed tax incidence under these settings using a conjectural-variations model of oligopoly, with and without free entry.

1.4 Data and empirical strategy

1.4.1 Data

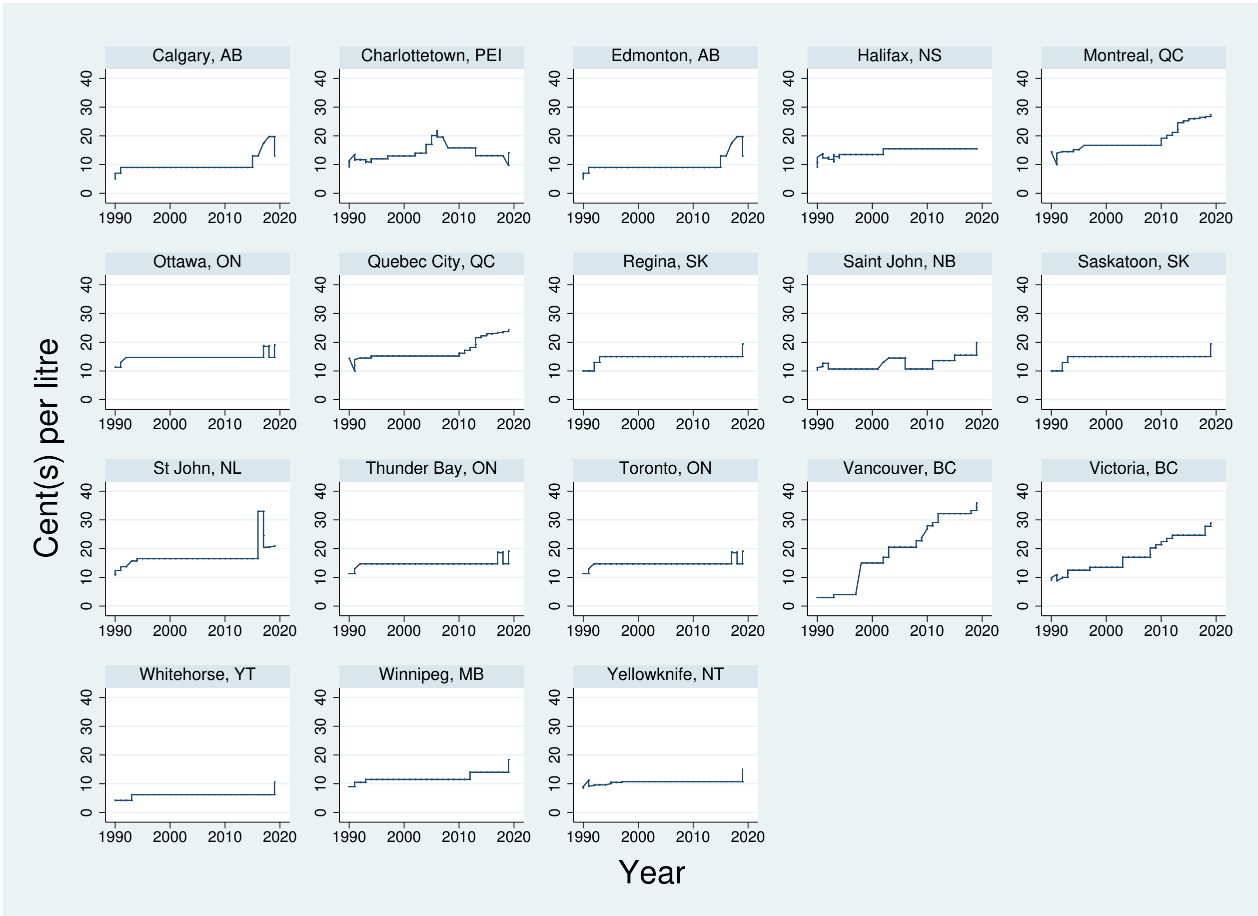
Retail prices for diesel as well as regular and premium unleaded gasoline are retrieved from Statistics Canada. Price data is collected from 1990 to 2019 for 18 cities, covering all 10 Canadian provinces plus two territories [5]. Prices consist of monthly averages at self-filling service stations within a census metropolitan area, inflation-adjusted using the national-level Consumer Price Index (CPI). A significant advantage of using a dependant variable at the city-level is that it has sufficient level of granularity to capture local market determinants. Cities in the sample vary by population density, weather, retail competition, and various other factors that affect retail prices. Using a city-level dependent variable – as opposed to one at the province-level – will allow to catch some of these regional distinctions [6].

Excise tax levels applied on gasoline and diesel for the years 1990-2019 were provided by Kent Group Ltd. These comprise taxes levied by municipal and by provincial jurisdictions plus taxes aiming at reducing carbon emissions specifically. Figure 1.3 shows the evolution of such nominal taxes for gasoline, by city. Although some cities within the same province follow identical paths (because they do not apply a city-level tax and are thus submitted to the same provincial and carbon tax rates), there is still considerable variation over time and by geography. For instance, taxes in Vancouver have increased tenfold, from 3 cents per litre (cpl) in 1990 to about 36 cpl in 2019. That makes its current rate more than 25 cpl superior to the one applied in Whitehorse. Some cities like Charlottetown and St John experienced a pike and a subsequent decrease in their tax rates. Nevertheless, most cities saw a steady

5. The eighteen cities are : Victoria (BC), Vancouver (BC), Calgary (AB), Edmonton (AB), Saskatoon (SK), Regina (SK), Winnipeg (MB), Thunder Bay (ON), Toronto (ON), Ottawa-Gatineau (ON part, QC part), Montreal (QC), Quebec (QC), Saint John (NB), Charlottetown (PE), Halifax (NS), St. John's (NL), Whitehorse (YT) and Yellowknife (NT).

6. Capturing local determinants is even more important knowing the vertical integration of the Canadian petroleum industry. Only three firms have nation-wide operations, and these are involved in every steps of the value chain, from exploration, refining to marketing (Natural Resources Canada, 2015). Apart from these, the few other companies that exist operate regionally and mostly at the downstream level. Their presence, however decreasing over time due to mergers and rationalization, helped to maintain a certain level of station density. For example, in Quebec City, the number of stations dropped by 30%, from 382 in 1991 to 283 in 2001. This resulted in increased market share for major chains (Houde, 2012)

Figure 1.3 – Nominal excise tax level on gasoline (munic., prov., carbon)



increase over the course of the period. Similar tax rates were observed for diesel [7].

Taxes evolve by discrete jumps according to fiscal policy changes. In fact, there were 294 policy-driven tax changes for gasoline and 299 changes for diesel over the data collection period. Most of these jumps come from decisions made by provincial jurisdictions, since only Victoria, Vancouver and Montreal apply a city-level tax. A more detailed breakdown of discrete jumps is shown in Table 1.1.

Besides the provinces who implemented a carbon tax, Quebec and Ontario also partici-

7. Federal excise taxes are not considered for two reasons. First, they are constant for gasoline over the course of the period and almost never change for diesel. Second, including it would have limited the options of time trend specification later in the empirical model. Indeed, a federal tax that is uniform across all provinces is equivalent to a common shock applied on these. This precludes the possibility of using province-specific, time-specific dummies as time trend specification.

Table 1.1 – Number of policy-driven tax changes

	Gasoline	Diesel
Municipal-level tax[1]	12	10
Provincial-level tax	132	139
Carbon tax	150	150
Total	**294**	**299**

1. Victoria and Vancouver apply a transit tax on diesel and gasoline, but Montreal only levies one on the latter.

pated in a cap-and-trade program. From a practical perspective, emission allowance prices agreed within this system had to be converted to their excise-tax equivalent in order to have a complete and consistent overview of pollution taxation across the country. Emission permits trade in \$/tonne, and different fuels produce different amounts of GHG emissions [8]. Conversion into ¢/litre was made using spot prices settled under trimestral auctions, using conversion rates that were obtained from the Ministry of Finance of British Columbia. Results of auctions are made public by the Ministry of the Environment, Conservation and Parks (MECP) for Ontario and from the Ministère de l'Environment et de la Lutte contre les changements climatiques (MELCC) for Quebec. Taxes have been inflation adjusted (so as all other nominal variables comprised in this study).

Data regarding other supply and demand-side determinants of gas and diesel retail prices was gathered. WTI and Brent spot prices were retrieved from the U.S. Energy Information Administration (EIA) and converted to Canadian dollars using Statistics Canada's monthly average foreign exchange rate. City-level wholesale prices for gasoline and for diesel were provided by Kent Group Ltd. Unemployment rates were obtained from Statistics Canada's Labor Force Survey. Rates were seasonally-adjusted and collected on a monthly basis, at the province-level.

Following Chouinard et Perloff (2004) and Marion et Muehlegger (2011), a climate component was also included as a control variable. Heating degree days (HDD) are a unit of measurement used to estimate the quantity of energy needed to heat buildings. HDD are

8. A price of \$40/tonne of emissions is equivalent to a tax of 8.89 ¢/litre for gasoline and of 10.23 ¢/litre for diesel (light fuel oil).

equal to the number of degrees Celsius below a base temperature (18°C in Canada), for a given day. A month with more HDD indicates colder weather and more energy used for heating. Monthly HDD was collected for each city in the sample. Environment and Climate Change Canada keeps track of Heating degree days recorded by all of its climate stations across the country. The nearest station from each city's downtown was selected. If one station did not exist for the entire data collection period, it was replaced with another one located nearby. Again, in the same vein as Marion et Muehlegger (2011), data was collected regarding reliance on heating oil as a source of energy. In fact, demand for heating oil may compete with gasoline and diesel in the refining market, since these products all share the same transformation units. Natural Resources Canada makes available the Comprehensive Energy Use Database, which details specific shares of energy use in the residential sector, by province. This data is used alongside HDD, as these two variables' interaction may portray more accurately the role of climate in determining gas and diesel retail prices.

There are 14 refineries in Canada. The Canada Energy Regulator (CER) reports their weekly capacity utilization rates, aggregated at the regional level (Western Canada, Ontario and Quebec & Eastern Canada). These rates were converted into monthly basis for the purpose of this study. Statistics Canada reports monthly, national-level closing inventories and net sales of wholesale motor gasoline and diesel fuel oil. Inventories were then divided by net sales in order to obtain the number of days of supply. Finally, Kent Group Ltd. gave access to the marketing operating margins for each city, which consist of the difference between ex-tax retail prices and wholesale prices (measured in cpl). Marketing margins represent the income available to provide for freight costs and for marketing operations, including outlet costs, dealer income, supplier costs and profitability.

Summary statistics are presented in Table 1.2. Average prices and taxes are roughly the same for gasoline and diesel. Indeed, the mean price of gasoline was 82.0 cpl over the course of the period, of which 13.3 cpl was due to excise taxes. The average price of diesel was 80.1 cpl, which comprised excise taxes of 13.6 cpl. WTI crude oil price was 51.5$ on average but reached 122.7$ at some point between 1990 and 2019. Brent crude oil price average was close

TABLE 1.2 – Summary statistics for all provinces

	Mean	Standard deviation	Minimum	Maximum
Gasoline retail price (cpl)	82.0	17.3	46.2	135.0
Diesel retail price (cpl)	80.1	19.5	48.1	141.3
Excise taxes on gasoline (munic., prov., carbon) (cpl)	13.3	4.0	3.5	27.1
Excise taxes on diesel (munic., prov., carbon) (cpl)	13.6	4.1	3.5	28.4
WTI price ($)	51.5	21.4	18.8	122.7
Brent price ($)	52.2	24.6	16.3	121.9
Wholesale gasoline price (cpl)	49.6	14.8	15.3	89.1
Wholesale diesel price (cpl)	52.3	17.3	17.3	99.8
Unemployment rate	8.2	3.2	2.3	22.1
Capacity utilization rate	85.9	9.2	48.6	103.9
Marketing operating margin for gasoline (cpl)	8.3	6.2	-10.1	40.2
Marketing operating margin for diesel (cpl)	10.9	6.4	1.1	43.1
Heating degree days	13.3	10.6	0.0	51.0
HH heating fuel as primary source (%)	15.4	18.6	0.0	70.5
Gasoline inventories (days of supply)	21.7	3.0	15.2	30.0
Diesel inventories (days of supply)	25.7	4.5	15.8	36.9
Observations	6426			

to WTI's at 52.2$. Wholesale price averages for gasoline and for diesel were 49.6 cpl and 52.3 cpl respectively. Unemployment rate was 8.2%, while refineries produced at 85.9% of their capacity on average. Marketing operating margins were around the same for gasoline and for diesel : 8.3 and 10.9 cpl respectively. Temperature varies significantly from one season to another ; a typical month had 13.3 HDD, but the coldest reached 51.0 HDD. The overall average of household's reliance on heating oil as primary source of energy was 15.4%. This hides great variability between provinces ; Territories and Eastern provinces are much more reliant on such type of energy than the rest of Canada. Nevertheless, each province significantly lowered its dependence on heating oil during the covered period. Finally, inventories of gasoline and diesel - measured in number of days of supply - were quite steady and at around 21.7 and 25.7 days of supply respectively.

1.4.2 Empirical framework

The relationship between fuel taxes and retail price can be expressed by the following equation :

$$p_{it} = \beta_0 + \beta_1 T_{it}^C + \beta_2 T_{it}^{M+P} + \beta X_{it} + c_i + \sigma_t + u_{it} \tag{1.4}$$

where p_{it} is the tax-inclusive retail price of gasoline or diesel in city i at time t, T_{it}^C is the carbon tax level, and T_{it}^{M+P} is the level of excise tax applied by municipal and provincial jurisdictions. βX_{it} is a vector of control variables, c_i catches non-observed, time-invariant characteristics inherent to each city, and σ_t controls for time-specific factors common to all cities.

When T = 2, estimating this equation using a fixed effects (FE) or a first-difference (FD) estimator yields the same outcome. When T = 3, choosing between FE and FD depends on which assumptions are made regarding the error term u_{it}. If u_{it} is not serially correlated, the fixed effects estimator is more efficient. If u_{it} follows a random walk, first-differencing removes the unit root and is more efficient (Wooldridge, 2010).

The Wooldridge test indicates which estimator is more appropriate. The test is based on the idea that if the idiosyncratic errors u_{it} are serially uncorrelated, then regressing the estimated residuals in first-difference, $\widehat{\Delta u_{it}}$, on their lags, $\Delta\widehat{u_{it-1}}$, leads to a correlation coefficient of ρ = -0.5. This test was applied using different time trend specifications. One only included a month dummy to account for time fixed effects, whereas others included, separately, a linear time trend, a quadratic time trend, and a dummy variable for each year of the covered period. For each specification, the null hypothesis that ρ = -0.5 was rejected. This implies that there is substantial serial correlation in the original model in levels, and thus the FD estimator is more appropriate [9]. The estimated residuals in first difference are not entirely independent, however, but are still close to zero. The FD estimator is still privileged since it removed most of the serial correlation from the original model (Wooldridge, 2016).

Another way to decide which estimator should be used is to look at the sensitivity of the time-varying covariates' correlation coefficients when changing the model specification. If the explanatory variables are highly autocorrelated (which is the case for excise taxes), the existence of an omitted variable that is not independent from explanatory and dependent

9. A Hausman test was also performed. It rejected the null hypothesis of exogeneity of c_i, which is required for using a random-effects model.

variables will lead to biased and highly sensible results when using the FE estimator. Marion et Muehlegger (2011) exploited this property and compared coefficients results with FE and FD for different time trend specifications. Similar regressions were run and the results are presented in Table 1.3. The time trend specifications are the same as for the Wooldridge test. A FE estimator is used for columns (1)-(4) and a FD for columns (5)-(8). Just as Marion et Muehlegger (2011) found, incidence results shift considerably more across time trend specifications for the FE than for FD. Using the first-difference estimator, tax pass-through fluctuates in a narrow band, from 0.512 to 0.523. This indicates that the tax burden is shared equally between producers and consumers.

TABLE 1.3 – Gasoline incidence sensitivity to time trend specification

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
All gasoline taxes	0.314*	0.438***	0.601***	0.497***	0.523***	0.523***	0.512***	0.522***
	(0.176)	(0.072)	(0.087)	(0.067)	(0.162)	(0.163)	(0.163)	(0.162)
Observations	6,350	6,350	6,350	6,350	6,332	6,332	6,332	6,332
R-squared	0.881	0.895	0.925	0.901	0.397	0.397	0.397	0.401
Linear time trend		X				X		
Quadratic time trend			X				X	
Year Fixed Effects				X				X

Standards errors are clustered by city.
* ** *** denote significance at the 90% 95% and 99% respectively.
A fixed effects estimator is used for specifications in columns (1)-(4), while a first-difference estimator is used for specifications in columns (5)-(8). Group variable is the city and there are 18 citites in the sample. All specifications include month fixed effects and current and lagged WTI spot price as control variables.

Such robust results in FD are reassuring regarding the potential existence of an omitted variable. In fact, for an endogeneity problem to arise, the contemporaneous change of the omitted variable would have to be correlated with current changes of the explanatory variables. Since time dummies are included for most specifications, this omitted variable would have to be city-specific as well. This reduces the risk of bias. Finally, reverse causality may also create endogeneity issues. For the case of fuel taxes, this could happen if tax decreases were implemented in response to escalating crude oil prices (or the other way around). The likelihood of such outcome is however reduced from the fact that automatic “flexible” fiscal mechanisms (consisting of reductions in specific taxes matching the rise in oil prices) alone do not appear to be a viable policy for stabilizing the price level in fuel markets (Di Giacomo et collab., 2012). In fact, Di Giacomo et collab. (2012) found that implementing such sterilization mechanism did not ensure constant prices for gasoline and motor diesel. On the other hand, policies focusing on the market structure - such as antitrust laws - would play a better role in attaining that goal. If governments make rational decisions and implement the most effective policies, we can assume excise taxes are indeed exogeneous to retail prices. The fact that tax changes are decided several months in advance (and come into effect on the next fiscal year) also reduces the likelihood of such event.

For these reasons, and because robust results in FD are also obtained with diesel, the empirical strategy undertaken here is expressed by this equation :

$$\Delta p_{it} = \beta_1 \Delta T_{it}^{C} + \beta_2 \Delta T_{it}^{M+P} + \beta \Delta X_{it} + \Delta \sigma_t + \Delta u_{it} \tag{1.5}$$

where each variable has been first-differentiated. Variables can be interpreted as monthly variations, given the frequency of the data. The dependent variable p_{it} and the independent variables T_{it}^{C} and T_{it}^{M+P} are measured in cent(s) per litre ; the coefficients β_1 et β_2 thus can be interpreted as the variation of the retail price following a 1 cpl tax increase.

1.5 Results

1.5.1 Measurement of tax transfer

Table 1.4 shows incidence results for regular gasoline when using equation 1.5. The first specification includes current and lagged changes in WTI crude oil prices as control variables plus time fixed-effects dummies for each month and each year of the covered period. Column (2) also comprises regional demand-side factors, namely unemployment rate, Heating degree days (HDD), and the interaction between HDD and the proportion of households using heating oil as their primary source of energy. Results for these two specifications suggest a 1.2 cents per litre transfer to final price for the carbon tax (more than the actual 1 cent tax change) and a 0.33 cpl and 0.31 cpl transfer for city and province-level taxes, for each column respectively. They also suggest that crude oil price changes are not passed forward immediately but are rather amortized over a period of more than one month [10]. Specifications in columns (3) and (4) include a dummy variable for each month*year combination, which allows to catch more granular, common time fixed-effects. Results point to a 0.43 and 0.44 cpl pass-through for city-level and province-level taxes and to a 0.55 cpl for the carbon tax. Carbon pass-through is considerably lower compared to the two previous specifications. This could be explained by the effective size of the sample ; carbon taxation has been introduced more recently than municipal and provincial excise taxes which have existed throughout the covered period. Adding the entire set of month*year dummies in col. (3) and (4) also makes the gap between city + prov. pass-through and carbon pass-through significantly lower. In fact, such time specification removes much of the common temporal fluctuations across cities, and thus allows to estimate the sole effect of taxes on retail prices more precisely. Results in these columns are therefore preferred over those in col. (1) and (2) [11]. The last specification

10. Lags of more than one period were statistically significant but decreasing over time. A time-delay structure of one period was favored because it minimized the Bayesian information criterion (BIC).

11. Similar regressions were performed using premium retail prices instead of regular prices in order to check for robustness. Results were virtually the same. Results were also robust when changing WTI for Brent prices, for both gasoline and diesel. Finally, incidence was also estimated using wholesale prices instead of crude's. Since wholesale prices were collected at the city-level, it was possible to keep the entire month*year set of dummies for every regression. It was also possible to add city-level marketing operating margins as an

suggests that taxes are immediately transferred into retail prices, since neither lagged carbon tax nor munic. + prov. taxes' coefficients are statistically significant. Finally, the interaction term WTI*taxes, which aims to see if tax pass-through differs for different levels of WTI prices, is near zero and not statistically significant. One could argue that the extent of tax shifting could be limited in circumstances of particularly high crude oil prices. It does not seem to be the case here.

Table 1.5 presents similar results for diesel. As for regular gasoline, carbon tax incidence is lower when the complete set of dummies is included. However, column (4) indicates that a carbon tax change that occurred at the previous period increases current retail prices by 0.30 cpl. This means that a 1 cpl carbon tax increase has a total effect of 0.81 cpl on retail prices over the two months following its implementation [12].

Hypothesis tests were executed to check whether carbon pass-through or city and province-level pass-through differed from one. For all specifications using year*month dummies, the null hypothesis of full shifting could be rejected. Also for these specifications, hypothesis testing showed that carbon pass-through is not significantly different from the transfer for municipal or provincial taxes. This finding implies that the extent of forward shifting does not depend on the type of excise tax that is levied nor on which level of government it is collected from. In other words, it means that all excise taxes are treated as similar input costs from the producer's perspective. Such reasoning, however, might not be applicable to crude oil prices. It has been demonstrated that crude oil shows an asymmetric behaviour towards retail prices, and that a positive costs shock has a stronger and more immediate impact on prices than an equivalent negative shock (Borenstein et collab., 1997; Chen et collab., 2005; Verlinda, 2008). Excise taxes, for their part, vary way less frequently than crude prices but are almost always increasing over time. This made it impossible to test for asymmetry. In fact, over the nearly 300 policy-driven tax changes that occurred between 1990 and 2019, only 35 were tax reductions.

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explanatory variable. Including these variables allowed having a much higher R-squared. Tables are presented in Annexe A – Tests de robustesse.

12. Akaike information criterion (AIC) and BIC both point to a time-delay structure of one period for the carbon tax and for city-level and province-level taxes. Tests were executed up to a four-lag period.

Table 1.4 – Regular gasoline tax incidence

	(1)	(2)	(3)	(4)
Municipal + provincial gas tax	0.327**	0.309*	0.434***	0.438***
	(0.166)	(0.164)	(0.140)	(0.133)
Gas carbon tax	1.202***	1.195***	0.549***	0.552***
	(0.224)	(0.225)	(0.171)	(0.169)
WTI price	0.410***	0.415***		
	(0.013)	(0.013)		
WTI price t-1	0.289***	0.289***		
	(0.012)	(0.013)		
Degree days		-0.001	0.027**	0.027**
		(0.016)	(0.013)	(0.013)
Degree days*HH fuel oil frac		0.001	0.000	0.000
		(0.000)	(0.000)	(0.000)
Unemployment rate		0.012	-0.042	-0.045
		(0.083)	(0.066)	(0.066)
Gas carbon tax t-1				-0.095
				(0.197)
Munic. + prov. gas tax t-1				-0.015
				(0.083)
WTI*taxes				0.002
				(0.029)
Observations	6,332	6,171	6,185	6,171
R-squared	0.403	0.408	0.741	0.741
Year and month effects	X	X		
Year*month effects			X	X

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Dependent and independent variables have been first-differenced.

More generally, incidence results are very similar for regular gasoline and diesel when using the time trend specification that allows for more flexibility - i.e. the one used in col. (3) and (4). Results point to a pass-through that is slightly above 0.50 cpl for the carbon tax and slightly below 0.50 cpl for city-level and province-level taxes. Results falling in that range mean that the tax burden is shared roughly equally between consumers and producers. There seems to be no rigidity in the transmission of municipal and provincial

Table 1.5 – Diesel tax incidence

	(1)	(2)	(3)	(4)
Municipal + provincial diesel tax	0.471**	0.490**	0.465***	0.483***
	(0.188)	(0.195)	(0.162)	(0.150)
Diesel carbon tax	0.663***	0.676***	0.512***	0.515***
	(0.116)	(0.115)	(0.115)	(0.116)
WTI price	0.262***	0.267***		
	(0.012)	(0.012)		
WTI price t-1	0.298***	0.301***		
	(0.010)	(0.011)		
Degree days		0.010	0.037***	0.037***
		(0.013)	(0.011)	(0.011)
Degree days*HH fuel oil frac		-0.000	-0.001**	-0.001**
		(0.000)	(0.000)	(0.000)
Unemployment rate		-0.113	-0.083	-0.079
		(0.078)	(0.067)	(0.067)
Diesel carbon tax t-1				0.294***
				(0.103)
Munic. + prov. diesel tax t-1				-0.019
				(0.068)
WTI*taxes				0.017
				(0.021)
Observations	5,199	5,038	5,049	5,038
R-squared	0.396	0.402	0.712	0.713
Year and month effects	X	X		
Year*month effects			X	X

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Dependent and independent variables have been first-differenced.

taxes towards final prices, which means that the shock is absorbed immediately (however such a conclusion cannot be drawn for the carbon tax). Finally, most regressions results are statistically different from one, which supports the literature suggesting an incomplete pass-through.

The starting point was to accurately measure the amount of tax shifting. The following steps aim to better understand the role of its underlying determinants.

1.5.2 Effects of supply constraints

Refinery-level constraints

Tax shifting is surely influenced by prevailing supply conditions. The focus here is on the downstream process, more specifically on constraints at the refinery-level and at the wholesale-level. As mentioned previously, Marion et Muehlegger (2011) provided some explanations on this subject, notably that incidence of fuel taxes declines when the supply chain is constrainted. The following section is an application of their work for the case of Canada.

Constraints at the refinery-level can be proxied by refineries' capacity utilization rate. As mentioned earlier, capacity utilization data was collected on a weekly basis and aggregated by region (Western Canada, Ontario and Quebec & Eastern Canada). Access to such data allowed to estimate the pass-through of taxes (taken altogether) for different levels of capacity utilization.

Table 1.6 presents separate gasoline incidence results for utilization rate below 80%, between 80-85%, between 85-90%, and above 90%. The first column acts as a benchmark and shows incidence results when using the entire sample. Looking at this table, we can see a clear ramp-up in incidence results for the first three brackets, starting from 0.44 cpl to 0.80 and reaching 0.88 cpl for the 95-90% bracket. For both the 80-85% and 85-90% brackets, we cannot rule out the null hypothesis of full pass-through. Similar ramp-up is observed for diesel, as shown in Table 1.7. Incidence is estimated at 0.67 cpl when refineries operate below 80% of their capacity but increases to 0.92 cpl and 1.04 cpl for the following brackets. For both gasoline and diesel, however, pass-through sharply falls when refineries are near their maximum capacity (to 0.44 cpl and 0.37 cpl, respectively).

The upward trend for the first brackets seems intuitive. An increasing capacity utilization rate may arise in response to growing demand for refined products. Such strong and increasing demand might be quite inelastic, at least in the short run. Refineries, for their part, are not heavily constrained at this point and can still increase output if necessary. Such relatively elastic supply, coupled with an increasingly more inelastic demand, would explain why tax

Table 1.6 – Capacity utilization and gasoline tax incidence

	Overall	<80%	80-85%	85-90%	>90%
All gasoline taxes	0.460***	0.440**	0.796***	0.877***	0.444***
	(0.078)	(0.184)	(0.303)	(0.220)	(0.102)
Observations	6,185	1,462	947	1,496	2,280
Number of cityid	18	18	18	18	18

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Dependent and independent variables have been first-differenced.

Table 1.7 – Capacity utilization and diesel tax incidence

	Overall	<80%	80-85%	85-90%	>90%
All diesel taxes	0.482***	0.667***	0.917***	1.037***	0.364***
	(0.068)	(0.138)	(0.183)	(0.173)	(0.105)
Observations	5,049	1,256	781	1,224	1,788
Number of cityid	17	17	17	17	17

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Dependent and independent variables have been first-differenced.

pass-through rises along with capacity utilization. But how to explain why the pass-through sharply falls when refineries operate near their full capacity ? One could easily expect the same pattern to hold for the last bracket as well. Producing at maximum capacity could indeed be an indicator of overheating - and even more inelastic – demand, which would lead to skyrocketing tax pass-through rates. However, part of the explanation may instead lie on the supply side.

Solely looking at supply, refiners might decide to produce at full capacity for reasons other than soaring demand. Low crude acquisition costs, reduced corporate tax, regulatory changes, or any other favorable condition making refined products easier or cheaper to produce might boost output, especially since it can be stored if demand cannot absorb everything immediately. We know that supply is quite inelastic in that scenario, given the rising marginal cost structure of refineries [13]. And in this scenario, producers have more room to bear an excise tax precisely because of these prevailing favorable conditions. This reduces the burden on consumers, and implies that a carbon tax change implemented in times of easy market conditions for refining firms would have a lower impact on consumers than in normal times. Supply conditions vary over time, so this should be kept in mind when studying fuel and carbon tax incidence.

This reasoning ultimately leads to making assumptions about which factors drive incidence for each level of capacity utilization. It is not an easy task, as supply and demand forces happen simultaneously and are interrelated. What is clear here, however, is the non-linear relationship between incidence and refinery constraints [14]. Such a pattern is observed for gasoline as well as for diesel, which reinforces the findings brought forward by Marion et Muehlegger (2011).

Storage constraints

The effect of storage constraints on tax incidence was also examined using the same method as Marion et Muehlegger (2011). Monthly national level of inventories is reported for gasoline and diesel separately. The number of days of supply were calculated by dividing inventory levels by each month's respective net sales in order to obtain an appropriate measure of storage constraints.

The intuition is that different levels of inventories could have a varying effect on supply elasticity, and thus could affect fuel tax incidence.

Table 1.8 presents results for the case of diesel. Following the idea of the previously mentioned authors, the number of days of supply has been split into deciles. Specifications (2) and (3) allow for a varying effect of incidence, whether the change in tax occurs when

13. Griffin (1972) estimated short-run cost functions for U.S. refineries and found that marginal costs slope upward and increase significantly when refineries operate near their full engineering capacity. The rising marginal cost structure can be explained by the process of switching between and within process equipment as output expands and infringes on the capacities of various process units.

14. Regressions have also been performed by splitting capacity utilization into quartiles. For every quarter, the pass-through was not significantly different from the benchmark. This suggests that incidence has a considerable non-linear relationship towards capacity utilization.

inventory levels are in the bottom 10% or in the top 10%. From a practical perspective, however, the data was not rich enough to allow dividing the actual number of policy-driven tax changes into 10 different groups and still have plausible results.

TABLE 1.8 – Inventories and diesel tax incidence

	(1)	(2)	(3)
All diesel taxes	0.426**	0.648***	0.627***
	(0.214)	(0.232)	(0.227)
Inventories	-0.248***	-0.170***	-0.113***
	(0.030)	(0.034)	(0.034)
Taxes * bottom 10% inventories		9.922**	9.717**
		(4.033)	(3.948)
Bottom 10% inventories		0.710***	0.822***
		(0.266)	(0.262)
Taxes * top 10% inventories		-1.581***	-1.330**
		(0.581)	(0.570)
Top 10% inventories		-1.386***	-1.697***
		(0.303)	(0.298)
Inventories t-1			-0.322***
			(0.030)
Observations	2,476	2,476	2,462
Number of cityid	17	17	17

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$
Dependent and independent variables have been first-differenced.

1.5.3 Retail competitiveness

Tax incidence might also be influenced by the level of competition in the retail market. In a non-competitive environment, retailers enjoying market power may be able to pass forward a larger extent of a tax change than their counterparts operating in perfectly competitive settings. As discussed earlier, they could even possibly transfer more than the tax change itself.

The idea of measuring the relationship between competition in the retail market and tax incidence has been tested by Alm et collab. (2009). The authors used urbanicity – estimated with the proportion of the population residing in urban areas - as a proxy for states' retail market competition level. Here, a more direct measure of retail competition is used : city-level marketing operating margins. Marketing margins are calculated as the difference between ex-tax retail prices and wholesale prices. Margins catch two main components : distribution costs and markup. Intuitively, these components are both inversely correlated with competition. First, markup systematically goes down when competition increases. Second, distribution costs tend to be higher for distant, more remote cities. Such geographically isolated cities might be less urbanized and therefore be less competitive [15].

The cities in the sample were then classified into three different groups according to their average marketing margins, and incidence for each bracket was estimated separately. Table 1.9 shows the regression results for excise taxes applied on gasoline (munic., prov. and carbon). Tax pass-through appears to be steadily increasing along with marketing margins, from 0.257 cpl for cities with the lowest margins to 0.416 cpl for cities in the mid-range bracket and 0.471 cpl for cities with the highest margins. Burden transfers for the two latter brackets are larger and much closer to the overall result including all 18 cities [16]. Similar results for diesel are presented in Table 1.10. Pass-through rates are 0.243, 0.728, and 0.454 respectively. These results do not point towards a linear relationship between pass-through and marketing margins as it is for gasoline. Nevertheless, for both types of fuel, pass-through is significantly lower for cities with the thinnest marketing margins.

Population size could also be indicative of the level of competition in the gasoline retail market. By definition, a larger city represents a larger market, and larger markets typically have lower transaction costs, since these have more developed supply infrastructure such as

15. One drawback of using marking operating margins as a proxy for retail competitiveness is the possible endogeneity problem arising from the correlation between markup and taxes. It is important to note that this issue might be limited because the markup represents only a certain proportion of overall marketing margins. As mentioned earlier, these comprise of many costs' components, such as freight and outlet costs which are themselves plausibly exogenous.

16. In fact, cities in the highest margin category include Whitehorse, Yellowknife and St John's, all of which are less urbanized and geographically isolated.

Table 1.9 – Marketing operating margins and gasoline tax incidence

	Overall	Low margin	Medium margin	High margin
All gasoline taxes	0.460***	0.257**	0.416**	0.471***
	(0.078)	(0.123)	(0.180)	(0.124)
Observations	6,185	2,131	2,110	1,944
Number of cityid	18	6	6	6
Year*month effects	X	X	X	X

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Dependent and independent variables have been first-differenced.
All specifications include unemployment rate, degree days and degree days*HH fuel oil fuel oil frac as control variables.

Table 1.10 – Marketing operating margins and diesel tax incidence

	Overall	Low margin	Medium margin	High margin
All diesel taxes	0.482***	0.243***	0.728***	0.454**
	(0.068)	(0.092)	(0.124)	(0.185)
Observations	5,049	1,775	1,860	1,414
Number of cityid	17	5	6	6
Year*month effects	X	X	X	X

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Dependent and independent variables have been first-differenced.
All specifications include unemployment rate, degree days and degree days*HH fuel oil fuel oil frac as control variables.

ports, railways, and bulk terminals.

Similar regressions were thus performed by dividing cities in the sample according to their average population estimates. Estimations results are presented in Table 1.11 and 1.12. They are remarkably in line with the ones found when dividing by marketing margins. For gasoline, the estimated pass-through is 0.58 and 0.61 cpl for medium-sized and small-sized cities while being much lower (at 0.34 cpl) for large cities. For diesel, medium and small cities also have higher pass-through rates (0.65 cpl and 0.53 cpl, respectively) compared to

0.32 cpl for the largest cities.

Table 1.11 – Population size and gasoline tax incidence

	Overall	High pop	Medium pop	Low pop
All gasoline taxes	0.460***	0.340***	0.576***	0.607***
	(0.078)	(0.125)	(0.125)	(0.198)
Observations	6,185	2,131	2,110	1,944
Number of cityid	18	6	6	6
Year*month effects	X	X	X	X

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Dependent and independent variables have been first-differenced.
All specifications include unemployment rate, degree days and degree days*HH fuel oil fuel oil frac as control variables.

Table 1.12 – Population size and diesel tax incidence

	Overall	High pop	Medium pop	Low pop
All diesel taxes	0.482***	0.319***	0.654***	0.529***
	(0.068)	(0.086)	(0.159)	(0.204)
Observations	5,049	2,131	1,572	1,346
Number of cityid	17	6	6	5
Year*month effects	X	X	X	X

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Dependent and independent variables have been first-differenced.
All specifications include unemployment rate, degree days and degree days*HH fuel oil fuel oil frac as control variables.

Such findings are not surprising. In fact, marketing margins and population size are strongly interrelated. Figure 1.4 and Figure 1.4 display their correlation estimates : -0.60 for gasoline and -0.43 for diesel. It means that a bigger population size is associated with lower marketing margins, and that these two characteristics presumably translate into more retail competition. This would explain why pass-through rates are lower for these cities. In fact, cities in the low-margin, high-population brackets include Toronto, Vancouver, Calgary, and Montreal. These are all densely populated and offer competitive public transport infrastructure. It is known that city dwellers drive less than suburban households, who in turn drive less than their rural counterparts (Schmalensee et Stoker, 1999; Yatchew et No, 2001; Hughes et collab., 2008). Less dependence on motorized vehicles for urban households can be interpreted as a relatively more elastic demand compared to people residing in suburban or rural areas.

FIGURE 1.4 – Correlation between marketing margins and populationtion size, for gasoline

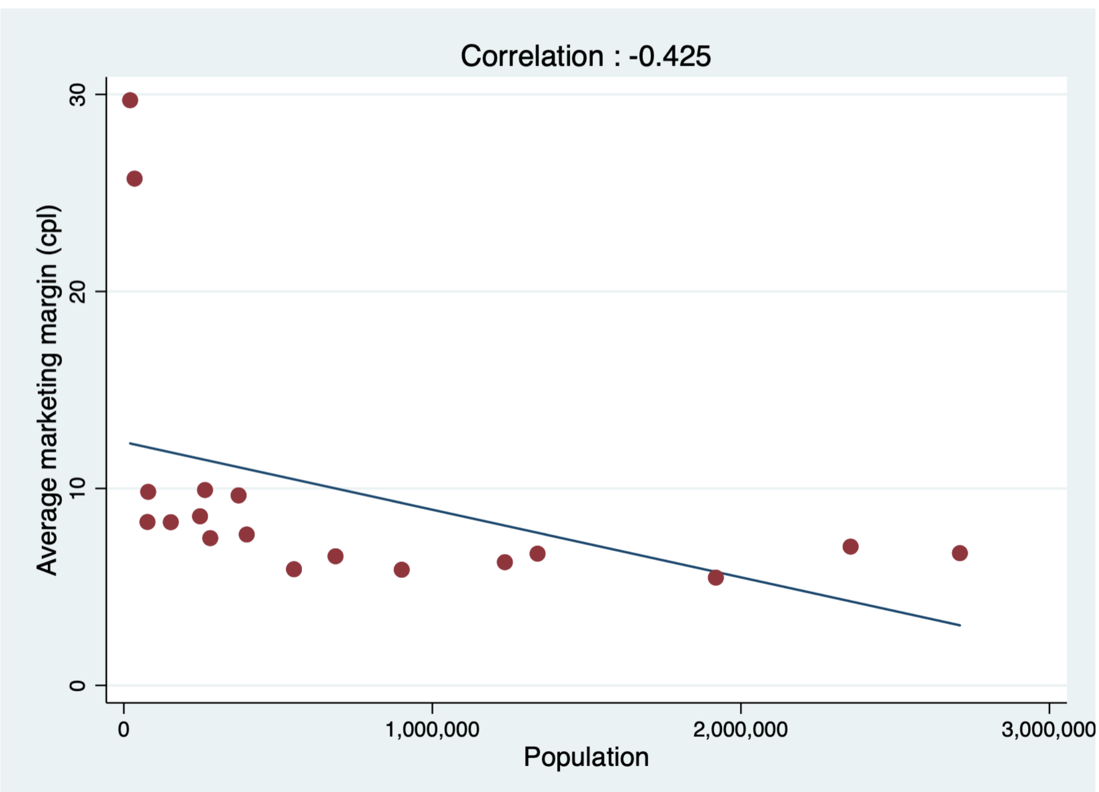
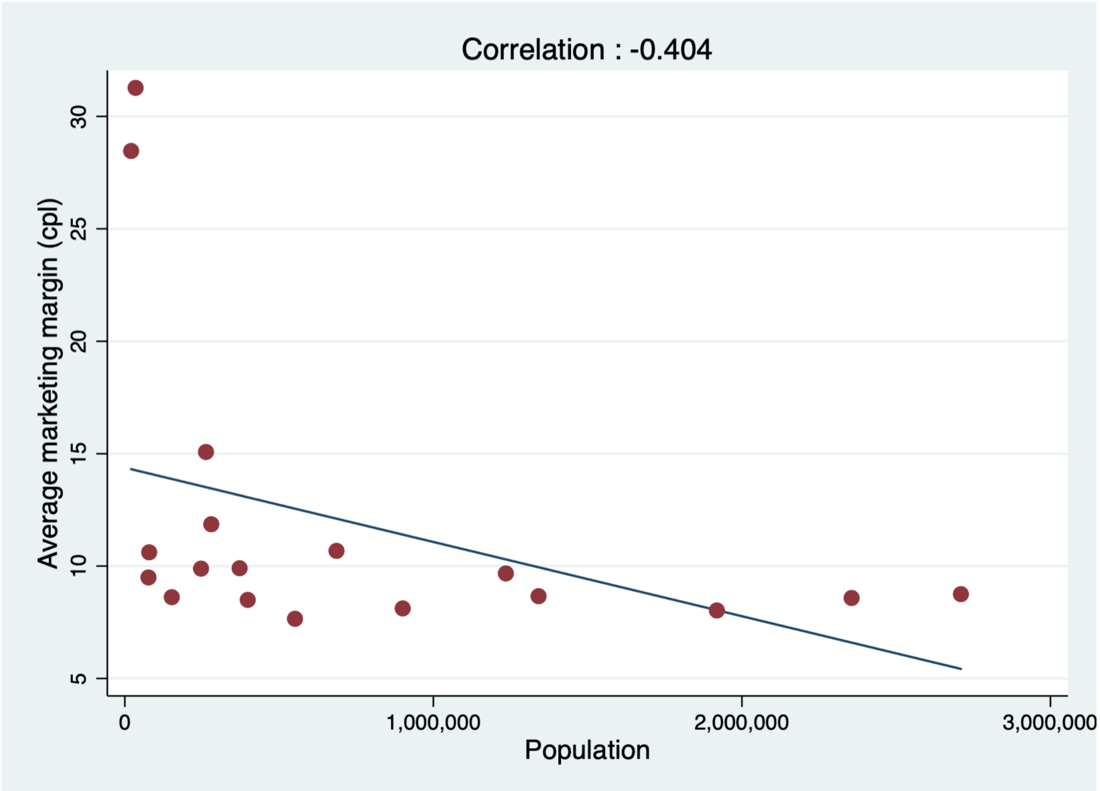


Figure 1.5 – Correlation between marketing margins and population size, for diesel



On the supply side, however, the advent of high-volume outlets in urban areas might play a confounding role in estimating the pass-through. In fact, Silvia et Taylor (2016) studied the incidence of fuel taxes in the United States and found that the pass-through was incomplete - but biased downward - when not considering the expansion of hypermarkets. If the same dynamics existed in Canada, for example if large, high-volume retail stores expanded in cities but not in rural areas, the gap between high and low population cities' pass-throughs could be overestimated. Future work should take this into consideration.

1.6 Conclusion

This study examined the extent of excise tax shifting towards gasoline and diesel retail prices across Canada. This was achieved by using carbon tax levels coupled with emission allowance prices for provinces under a cap-and-trade program, alongside conventional fuel excise taxes applied at the city and province-level. The analysis explored two main underlying factors of tax incidence that are usually studied separately : supply constraints and retail competitiveness. By doing so, this paper sheds some light on the implications of carbon pricing policy in Canada. Empirical fuel tax incidence analysis is sparse for this country, even though carbon taxation has become a central mechanism used to curb emissions stemming from the transportation sector.

The empirical results show that fuel taxes behave in very similar ways for gasoline and for diesel : slightly less than half of city-level and province-level taxes are passed through to final prices, while slightly more than half of carbon taxes are. This indicates that final consumers do not bear the entire weight of fuel taxes. These results are, however, subject to some degree of variability ; over time, depending on prevailing refinery constraints. In fact, pass-through increases when refineries ramp-up production but falls when they operate near full capacity. It also varies over space, depending on a city's retail competition level. Outlets located in cities with a larger population or with particularly low marketing margins, i.e. cities facing more competition in the retail gasoline market, have less ability to pass forward excise taxes than their counterparts located in more remote, less competitive areas.

These empirical findings have significant policy implications. The most obvious is that households are more compensated than the amount they actually pay, leastwise when not considering who owns refining firms. Consumers take roughly 50% of the tax bill but receive back 90% thanks to the existing revenue recycling mechanism. Such redistribution is not necessarily unwanted. In fact, the Parliamentary Budget Officer explicitly stated that households would receive higher transfers than the average amounts they pay in fuel charges (Parliamentary Budget Officer, 2019). The results found in this study simply demonstrate that this objective was met. Another implication is that fuel tax incidence differs depending on a household's residing area ; people living in less urbanized cities bear a greater amount of the tax than they would if they lived in densely populated cities. Thus, lump-sum transfers should be adjusted to account explicitly for this geographical dimension in order to compensate for potential regressive distributional impacts.

A potential direction for future research would be to use a more precise indicator for retail competitiveness. This could be achieved by estimating the Lerner index for each city or by using station-specific data to measure local station density or vertical integration. Having more than 18 cities in the sample could also allow for a better differentiation between large, medium-sized, and small-sized cities. Finally, it was recently announced that the carbon tax would increase to 170$ a tonne in 2030. It is set at 30$ as the writing of this paper (up from 20$ when implemented in 2019). If actually put into legislation, such ramp-up will have profound impacts on consumer choices, including vehicle choice, distance from work, and transportation behaviour more generally. It will likely induce significant public transit infrastructure investment. Such structural changes are not considered here and are left for future work.

Conclusion générale

Traduction littérale de la conclusion en version anglaise, afin de satisfaire aux exigences de la M.Sc. Pour la correction du mémoire, se référer à 1.6 Conclusion.

Cette étude avait pour but de mesurer le degré de transfert des taxes sur le carburant vers le prix de vente de l'essence ordinaire et du diesel. Cet objectif a été rempli en consolidant les niveaux de taxe carbone avec les prix des permis d'émission de CO_2 pour les provinces fonctionnant avec un tel système, de même qu'en utilisant les autres taxes d'accises sur les carburants appliquées par les paliers de gouvernement municipaux et provinciaux. Le présent travail a également exploré deux déterminants de l'incidence fiscale qui sont normalement regardés de manière séparée : les conditions de l'offre ainsi que le niveau de compétition dans le marché du commerce de détail. Les études empiriques à ce sujet sont rares pour ce pays, même si la taxation du carbone s'affiche comme un mécanisme incontournable pour limiter les émissions de gaz à effet de serre provenant du secteur des transports.

Les résultats démontrent que les taxes sur les carburants se comportent de manière similaire pour l'essence et le diesel : légèrement moins de la moitié des taxes municipales et provinciales sont transférées vers les prix finaux, alors que légèrement plus de la moitié des taxes carbone le sont. Cela indique que les consommateurs ne supportent pas à eux seuls le poids de ces taxes. Ces résultats sont toutefois sujets à certaines variabilités ; à travers le temps, selon les contraintes existant au niveau des raffineries. En fait, le transfert des taxes s'accentue lorsque les raffineries augmentent leur production, sauf dans le cas extrême où elles produisent à capacité maximale. Le transfert varie aussi de manière géographique, selon le niveau de compétition dans le marché de détail. Les stations-essence situées dans les villes densément peuplées ou caractérisées par des marges d'opération particulièrement faibles ont une capacité plus limitée à transférer un changement de taxe vers le prix de vente que les stations-essence situées dans les régions moins urbanisées et moins compétitives.

Ces résultats empiriques soulèvent d'importantes implications. La principale est que les ménages sont compensés plus largement que le montant déboursé, du moins si on ne considère pas qui détient les firmes pétrolières. En effet, les consommateurs supportent environ 50% de la facture fiscale, mais reçoivent 90% en retour grâce au mécanisme de recyclage des recettes actuellement en place. Cette redistribution n'est toutefois pas indésirable. En fait, le Directeur parlementaire du budget a explicitement mentionné que les ménages recevraient des transferts plus importants que les montant déboursés au cours d'une année (Parliamentary Budget Officer, 2019). Les résultats trouvés dans la présente étude démontrent simplement que cet objectif est atteint. Une autre implication est que l'incidence fiscale diffère selon le lieu de résidence des ménages ; ceux demeurant dans des régions moins urbanisées supportent un plus gros poids de la taxe que ceux en milieux urbains. Les transferts aux ménages devraient être ajustés pour prendre en compte de manière explicite cette composante géographique, afin de réduire les risques potentiels d'effets distributionnels régressifs.

Une voie de recherche future serait d'utiliser un indicateur plus précis du niveau de compétition dans le marché de détail. Cela pourrait être réalisé en estimant l'indice de Lerner pour chacune des villes étudiées, ou encore en utilisant des données spécifiques aux stations-essence pour mesurer la densité locale ou l'intégration verticale. Le fait d'avoir plus de 18 villes dans l'échantillon permettrait également une meilleure différentiation entre les villes de petite, moyenne et grande taille. Finalement, il a récemment été annoncé que la taxe carbone augmenterait à 170$ en 2030. Elle est de 30$ au moment d'écrire ces lignes. Si ces ambitions se traduisent réellement sous forme de réglementation, cela aura des impacts profonds sur le choix des consommateurs, incluant le choix des véhicules et la distance parcourue jusqu'au travail. Cela entrainera aussi sûrement d'importants investissements en infrastructure de transports publics. L'effet de tels changements structuraux sont laissés pour recherches futures.

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Annexe A – Tests de robustesse

A.1 – Premium gasoline tax incidence

	(1)	(2)	(3)	(4)
Municipal + provincial gas tax	0.431**	0.423**	0.451***	0.457***
	(0.169)	(0.167)	(0.124)	(0.120)
Gas carbon tax	1.227***	1.220***	0.583***	0.585***
	(0.219)	(0.221)	(0.166)	(0.165)
WTI price	0.409***	0.413***		
	(0.013)	(0.013)		
WTI price t-1	0.283***	0.284***		
	(0.012)	(0.013)		
Degree days		0.007	0.036***	0.036***
		(0.017)	(0.013)	(0.013)
Degree days*HH fuel oil frac		0.001*	0.001**	0.001**
		(0.000)	(0.000)	(0.000)
Unemployment rate		0.070	0.003	0.000
		(0.083)	(0.068)	(0.068)
Gas carbon tax t-1				-0.074
				(0.194)
Munic. + prov. gas tax t-1				-0.027
				(0.082)
WTI*taxes				0.003
				(0.028)
Observations	6,313	6,171	6,185	6,171
R-squared	0.395	0.399	0.740	0.740
Year and month effects	X	X		
Year*month effects			X	X

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Dependent and independent variables have been first-differenced.

A.2 – Regular gasoline tax incidence, with Brent

	(1)	(2)	(3)	(4)
Municipal + Provincial gas tax	0.333*	0.311*	0.434***	0.437***
	(0.174)	(0.172)	(0.140)	(0.135)
Gas carbon tax	1.146***	1.141***	0.549***	0.552***
	(0.246)	(0.245)	(0.171)	(0.169)
Brent price	0.413***	0.419***		
	(0.013)	(0.013)		
Brent price t-1	0.295***	0.296***		
	(0.011)	(0.011)		
Degree days		-0.010	0.027**	0.027**
		(0.016)	(0.013)	(0.013)
Degree days*HH fuel oil frac		0.001*	0.000	0.000
		(0.000)	(0.000)	(0.000)
Unemployment rate		-0.020	-0.042	-0.045
		(0.080)	(0.066)	(0.066)
Gas carbon tax t-1				-0.095
				(0.197)
Munic. + prov. gas tax t-1				-0.015
				(0.083)
Brent*taxes				0.001
				(0.028)
Observations	6,332	6,171	6,185	6,171
R-squared	0.429	0.435	0.741	0.741
Year and month effects	X	X		
Year*month effects			X	X

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$
Dependent and independent variables have been first-differenced.

A.3 – Regular gasoline tax incidence, with wholesale price

	(1)	(2)	(3)	(4)
Municipal + Provincial gas tax	0.477***	0.479***	0.549***	0.589***
	(0.184)	(0.181)	(0.189)	(0.186)
Gas carbon tax	0.510***	0.511***	0.529***	0.703***
	(0.169)	(0.172)	(0.159)	(0.099)
Wholesale gasoline price	0.961***	0.962***	0.925***	1.033***
	(0.011)	(0.011)	(0.025)	(0.014)
Wholesale gasoline price t-1	0.309***	0.310***	0.247***	0.063***
	(0.011)	(0.011)	(0.024)	(0.015)
Degree days		0.025*	0.046***	0.030***
		(0.013)	(0.013)	(0.008)
Degree days*HH fuel oil frac		-0.001***	-0.001***	-0.001***
		(0.001)	(0.000)	(0.000)
Unemployment rate		0.004	-0.049	-0.003
		(0.094)	(0.079)	(0.042)
Marketing operating margin for gasoline				0.945***
				(0.016)
Observations	3,605	3,600	3,600	3,592
R-squared	0.810	0.811	0.881	0.958
Year and month effects	X	X		
Year*month effects			X	X

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$
Dependent and independent variables have been first-differenced.

A.4 – Diesel tax incidence, with Brent

	(1)	(2)	(3)	(4)
Municipal + Provincial diesel tax	0.489**	0.504**	0.465***	0.492***
	(0.195)	(0.202)	(0.162)	(0.148)
Diesel carbon tax	0.657***	0.673***	0.512***	0.522***
	(0.122)	(0.119)	(0.115)	(0.119)
Brent price	0.261***	0.266***		
	(0.011)	(0.011)		
Brent price t-1	0.286***	0.289***		
	(0.010)	(0.010)		
Degree days		0.001	0.037***	0.037***
		(0.013)	(0.011)	(0.011)
Degree days*HH fuel oil frac		-0.000	-0.001**	-0.001**
		(0.000)	(0.000)	(0.000)
Unemployment rate		-0.143*	-0.083	-0.079
		(0.077)	(0.067)	(0.067)
Diesel carbon tax t-1				0.295***
				(0.103)
Munic. + prov. diesel tax t-1				-0.019
				(0.068)
Brent*taxes				0.014
				(0.022)
Observations	5,199	5,038	5,049	5,038
R-squared	0.403	0.410	0.712	0.713
Year and month effects	X	X		
Year*month effects			X	X

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Dependent and independent variables have been first-differenced.

A.5 – Diesel tax incidence, with wholesale price

	(1)	(2)	(3)	(4)
Municipal + Provincial diesel tax	0.975***	0.973***	1.079***	1.060***
	(0.158)	(0.160)	(0.187)	(0.136)
Diesel carbon tax	0.547***	0.547***	0.430***	0.602***
	(0.089)	(0.087)	(0.096)	(0.090)
Wholesale diesel price	0.669***	0.671***	0.579***	0.890***
	(0.013)	(0.013)	(0.026)	(0.023)
Wholesale diesel price t-1	0.445***	0.443***	0.503***	0.202***
	(0.012)	(0.012)	(0.024)	(0.021)
Degree days		-0.038***	-0.016	-0.004
		(0.013)	(0.012)	(0.010)
Degree days*HH fuel oil frac		-0.000	-0.000	-0.000
		(0.001)	(0.000)	(0.000)
Unemployment rate		-0.074	-0.066	-0.002
		(0.087)	(0.079)	(0.059)
Marketing operating margin for diesel				0.750***
				(0.027)
Observations	2,850	2,845	2,845	2,841
R-squared	0.762	0.763	0.865	0.909
Year and month effects	X	X		
Year*month effects			X	X

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Dependent and independent variables have been first-differenced.