Insights from Sustainability Economics on Improving Environmental Effects of Transportation

University of Manitoba

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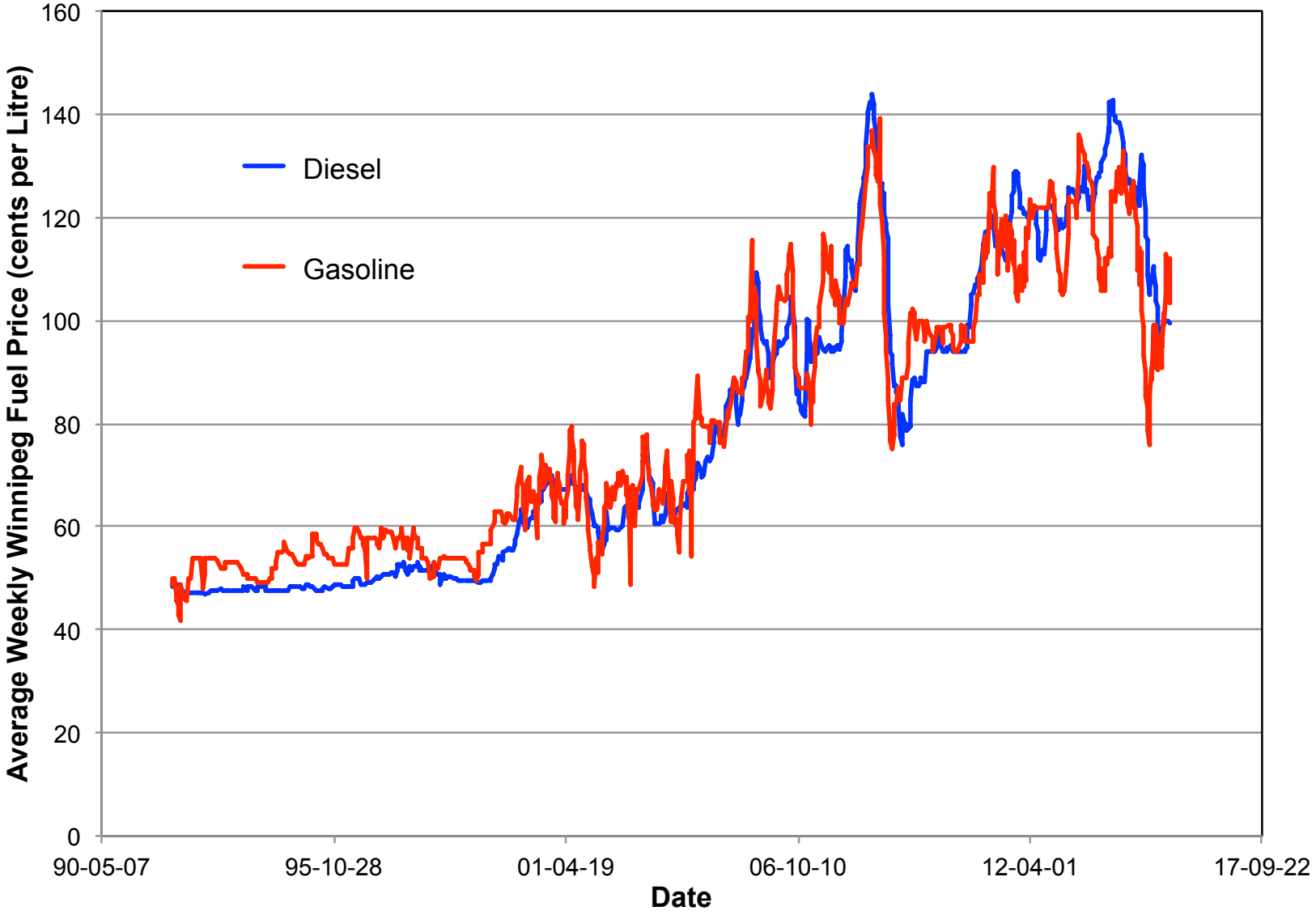
Overview of Topics

- **Diesel fuel prices** - nature and impact
- **Electric buses** - moving forward
- **Electric cars** - positives and negatives
- **Carbon pricing** - why this is such a poor policy to get emission reductions in transportation applications
- **Elevated biofuels** to get reductions
  - Topics incorporate work undertaken by students as parts of classes

Diesel Fuel Prices?

- Diesel one of the two main fossil fuels
  - It dominates overwhelmingly in heavy-duty freight transport, and specialties like buses, construction and agriculture
- On pricing aspects will acknowledge collaboration with Dr. Jeffery Cottes:
  - Important joint article submitted to **Energy Policy** in 2015, but was not accepted **:(**
  - Was entitled, “The emergence of diesel as an expensive fuel, and policy implications”

Historical Fuel Price Data (Winnipeg)



Fuel Price Implications

- Fuel prices in 1990s were pretty stable
- Starting around 2000, both gasoline and diesel prices rose steadily and dramatically till 2008 (almost doubling)
- Since then, still no clear upward or downward trend, but highly variable and with unpredictable changes
- At the same time, diesel has moved to more frequently become the more expensive “premium” fuel of the two

Diesel More Expensive More Often

Photo on November 7, 2018 on Pembina Highway

Shows diesel as 16% more expensive than gasoline (122.9¢ versus 105.9¢)

This is not just more expensive on a volumetric basis but on an energy content basis too given diesel contains about 10% more energy per Litre than gasoline

Electric Buses

Electric Buses

- Work on electric transit buses in Manitoba began in 2010, leading to formation of international consortium
- Prototype electric bus unveiled in 2012
- In-service pilot led by New Flyer began in 2014 with four second-generation buses on route with Winnipeg Transit
- Has led many to ask the question, “Why don’t we have more electric buses here now?”

Electric Buses?

- Clean Energy Canada (Simon Fraser University Think-Tank) posed the same question in their March 2019 report, “Will Canada Miss the Bus?”
- Moving forward, however, is nuanced, requiring more in-depth consideration
- Clean Energy Canada agreed to a follow-up report on this topic entitled, “Moving Forward with Transit Bus Electrification in Canada”

Electric Buses (Why not?)

Electric Buses (Here's how!)

Moving Forward with Transit Bus Electrification in Canada

A follow-up to the report "Will Canada Miss the Bus?" released by Clean Energy Canada in March 2019

May 2019

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Electric Buses!

- Significant public Manitoba documents already available and used in report
  - Manitoba Government and City of Winnipeg Joint Task Force on Transit Electrification, with final report dated 2016
  - Red River College prototype bus final report on development in 2017, and economic and environmental update report for Joint Task Force in 2018
  - Detailed work by Asper MBA students on electric transit bus externalities in 2017

Cautionary Notes from Report

- From report Introduction (pages 1-2):

  There have been many calls by many individuals in many cities across Canada to immediately jump to electric buses. Electrification is a good idea, but the principle of sustainability actually does include being business-minded and economically realistic. We do not want to short-change the effort by making it appear too easy when it is not. It is important for our transit systems to be on the “leading edge,” but not end up on the “bleeding edge.”

Cautionary Notes from Report

- Caution regarding electrification of buses has also been identified in other public sources, so the new report is not alone in emphasizing the need to proceed forward carefully
  - e.g., Marshall, A. Why electric buses haven't taken over the world - yet. WIRED Magazine, June 7, 2019.

Eight Considerations for Buses (A)

- Lifecycle economics:
  - Electrification is the trend of the future, but there is not yet any significant economic advantage, and improvement is slower
- Integration:
  - This is the big elephant in the room, but not yet well recognized in the media
  - Transit systems involve complex networks of many buses, but with nature of systems largely based on diesel characteristics

Eight Considerations for Buses (B)

- Deployment strategy:
  - Given integration, its already established that one or two new electric buses at a time is not meaningful, with instead three quantum step changes recommended
- Technical uncertainties:
  - Given newness, uncertainties remain, with most important: **realistic battery life** in actual service; and **realistic operation limits** (i.e., annual km or hour per day)

Eight Considerations for Buses (C)

- Changing ownership structures:
  - Ownership of electric buses by transit agencies imposes a number of requirements, even if leasing involved
- Electric power infrastructure:
  - Electric buses use a lot of electric energy and impose large power requirements that need planning. A new issue not typically foreseen is the potential for environmental assessment processes to be triggered with large infrastructure upgrades

Eight Considerations for Buses (D)

- Externalities:
  - Electric buses primarily result in overall net benefits, but not entirely
  - Three main benefits: GHG emission cost reductions; diesel fuel price volatility reductions; and noise-cost reductions
  - Three main costs: battery rare mineral costs and social issues; infrastructure damages; and battery final disposal costs
  - There are reduced costs for air pollutants but, unexpectedly, these are quite small

Eight Considerations for Buses (E)

- Federal funding support:
  - Canadian urban centres have been falling behind U.S. counterparts, with obvious reason being ongoing and consistent funding available in the U.S. under FTA
  - For a long time advanced transit projects in Canada have involved one-off funding
  - Important factor to note is two separate but complementary GHG reductions: (a) modal shift; versus (b) bus motive energy change - the latter is poorly addressed

Eight Considerations for Buses (F)

- Federal funding support? (KISS):
  - Key recommendation is a simple federal zero-emission transit bus purchase incentive - similar to incentive approaches used successfully across country
  - $250,000 per bus at time of registration, with value declining over time
  - Intended outcome is implementation of upwards of 600 such buses, enough to move country as a whole to the first major quantum implementation step change

Electric Vehicles - Good and Bad

Electric Vehicles?

- Over the past decade there has been pretty broad recognition that light-duty electric vehicles are a good idea for Manitoba
- But key question remains unanswered:
- What would be the broad-based effects (positive and negative) on Canada as a whole if today we were to change entirely from gasoline to light-duty electric vehicles (i.e., all BEV)?

Electric Vehicles Analysis

- Question certainly is theoretical, but analysis leads to important insights
- Parsons, Thomas, Chevrier and Touchette submitted to Conversation Canada in 2019 but turned down **:(**
- Going all-electric would reduce annual emissions for Canada by 124 million tonnes. Big value! ... but actually not enough on its own to get us to the 2030 Paris target of 512 million tonnes!

Electric Vehicles Analysis

- Going all-electric would produce some significant annual savings, both for the environment and for human health
- Annual savings more than $11 billion!
- But … what are the costs of doing this?
- This is where things get tricky
- Largely eliminating light duty liquid fuels (gasoline and ethanol too) would cause GDP loss of more than $36 billion!

Electric Vehicles Analysis

- Then there are annual economic losses for automobile manufacturing and servicing industries throughout the economy - GDP losses of $38 billion!
- Overall annual **economic losses** are thus more than $74 billion
- Plus **social dislocation** - using average GDP per employment-position, this translates to more than 640,000 full time positions lost across Canada

Electric Vehicles Analysis

- GDP losses do not represent a “Great Depression” but are worse than the 2008 economic downturn
- Results clearly show the importance of fossil fuels and internal combustion engine technologies in our economy
- Results not intended to suggest electric vehicles are evil, but rather the need for realistic transition plans, which no government in Canada is discussing

Electric Vehicles Analysis

- One important insight in building a bridge to a more electrified-future is the potential importance of conventional hybrid electric vehicles (HEV) and plug-in hybrid electric vehicles (PHEV)
- Dr. Andy Frank, the UC Davis father of PHEVs emphasized this back in 2007
- Toyota, world's largest manufacturer, has also emphasized HEV and PHEV as important transitions to the future

Carbon Taxation?

Carbon Taxation?

- As alluded to, Canada faces a harsh task in trying to meet its commitment under the Paris agreement - to reduce overall GHG emissions by 30% compared to 2005 levels
- 2005 emissions of 731 million tonnes, means the target is 512 million tonnes
- Except, Canada's forecasted 2018 emissions trajectory is already around 730 million tonnes! No real headway

Carbon Taxation?

- So how do we get to 2030 target?
- The primary policy tool of the current federal government is carbon pricing, which can also be appropriately called “carbon taxation”

- The problem is that if the intent is to reduce emissions, especially regarding transportation energy and fuels, carbon pricing (or taxation) is the wrong tool!

Carbon Taxation?

- This is not to say carbon taxation is bogus - it is a legitimate mechanism
- But at the same time carbon taxation is not magic either - it cannot create large emission reductions by mere presence
- Carbon taxation is a form of economic instrument, and its operation depends fundamentally on economic principles

Carbon Taxation?

- Applying a carbon tax on fossil fuels
  - Increases the price of the fossil fuel
  - In turn, this makes the fossil fuel less economically attractive to consumers
  - In turn, consumers use less
  - In turn, lower fuel consumption translates to reduced GHG emissions
- But reduced consumption depends on
  - Absolute magnitude of the tax
  - Consumer sensitivity to price changes

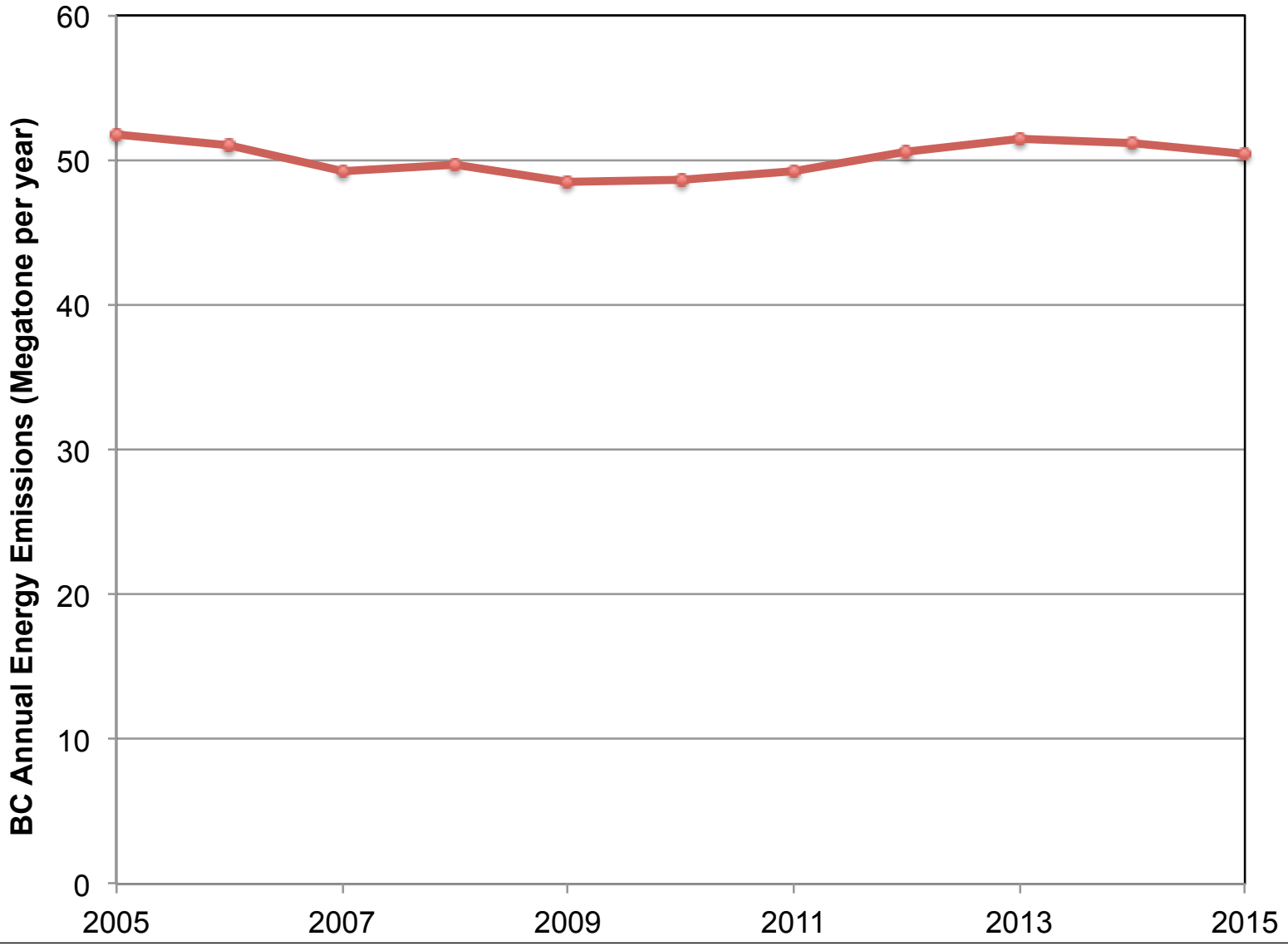
Carbon Taxation?

- Magnitude of tax (per tonne) is too low to be effective, even if optimistic about consumer sensitivity
  - Researches like Mark Jaccard suggest much higher tax levels needed (i.e., $200+)
- Consumer sensitivity (or lack thereof) to fuel price changes is the real problem
  - Consumers have become increasingly less sensitive to price changes
  - Add in greater recent fuel price volatility

Carbon Taxation?

- Essential bet by the federal government is esoteric concept of “tax saliency”
  - Suggests consumers are more sensitive to carbon taxes than base-fuel price changes
- Except, after 6 months of carbon taxes, if tax saliency is working we should see by now noticeable reductions in fuel consumption ... but we don’t!
- What about much vaunted experience in BC that “proved” carbon taxes work?

Energy-Related Emissions in BC



Energy-Related Emissions in BC

- Data is from National Inventory Report
- Clearly shows prior to and through the course of BC's carbon taxes that total energy-related emissions remained flat
- Increases in emissions may have been prevented, but it is clear BC emissions did not decline in absolute terms, while absolute reductions are what we need
- Carbon taxes are highly unlikely to yield absolute emission reductions required

Elevated Biofuels?

Elevated Biofuel Mandates

- One legitimate alternative to carbon taxes is legislating elevated biofuel renewable levels in gasoline and diesel
  - For gasoline this means ethanol
  - For diesel this means biodiesel or renewable diesel
- Manitoba has been a national leader:
  - 8.5% ethanol mandate was implemented back in 2008, and still highest in country
  - Key mark of success - we don’t notice it!

Elevated Biofuel Mandates

- Some economic groups do not like renewable fuel mandates or standards
  - Eco-Fiscal Commission; C.D. Howe
- But there is a noted role for such approaches:
  - "A case can be made ... in parts of the economy that would not be responsive to a politically acceptable emissions price" Dachis, B. 2018. Speed Bump Ahead. E-Brief, C.D. Howe Institute

Elevated Biofuel Mandates

- It is well established that consumers of gasoline and diesel are not very sensitive to price changes, so the use of mandates is indeed a good response
- More importantly, it is possible to estimate “carbon pricing equivalent values” for renewable mandates
- This means estimating what carbon tax value would be needed in order to achieve the same level of reduction

Elevated Biofuel Mandates

ecojournal

Environmental Win-Win is Possible:

Manitoba leads on renewable fuels

By Robert Parsons, Mathew Baranowski, Ken Borce and Trevor MacHutchon

MANITOBA'S CARBON TAX of $25 per tonne is coming, and will comply with Federal requirements, at least initially. At issue is what happens in 2020 when it is supposed to rise to $30, and later by 2022 to ultimately $50, while Manitoba's tax remains the same? Frictions are building, with intransigence on both sides. A confrontation appears to be looming, but is

Price elasticity of demand is the percentage change in volume consumed divided by the percentage change in price. The values for gasoline and diesel are typically different. Their

PHOTO: ROBERT PARSONS

> Within North America it has been observed that consumers of both gasoline and diesel are becoming increasingly insensitive to prices. So what then will happen with Manitoba's carbon tax?

Elevated Biofuel Mandates

- Short article by Parsons, Baranowski, Borce and MacHutchon in Fall 2018 showed that a carbon-price equivalence can be readily calculated
  - Manitoba's elevated ethanol mandate, which is 3.5% higher than national levels, yields an equivalent carbon tax level in the range of $25 to $250 per tonne
  - Calculation method is included at end of presentation so you can see how done

Elevated Biofuel Mandates

- More-ambitious biofuels project was evaluated earlier in 2019 for diesel
- Involves building a world-scale plant on the prairies supporting 10% renewables
  - Such a mandate with diesel is much higher than anything achieved in the country
  - Joint production of 220 million Litres per year of renewable diesel covers both provinces of Manitoba and Saskatchewan
  - Either province alone is simply too small

Elevated Biofuel Mandates

- Annual reductions from the renewable diesel would be 600,000 tonnes
  - Vastly higher than anything achievable using a carbon pricing approach
- Focus on canola as initial feedstock of choice, addresses current trade dispute
  - Canola trade with China (had been 40% of exports) has been dramatically impacted
- Key point of project is that it justifies Federal government waiving carbon tax

Elevated Biofuel Mandates

- Incentives from provinces are included to assist canola industry, but costs are charged to emission reductions
  - Even so, reduction costs <$15 per tonne
- Carbon pricing equivalent values are also estimated, and are very high
  - Carbon price to get same reductions is in range of $70 to $350 per tonne
  - Calculation method is included at end of presentation so you can see how done

Elevated Biofuel Mandates

Renewable Diesel Opportunity to Reduce GHG Emissions without a Carbon Tax

Synopsis of results for stakeholders from analysis undertaken for MBA course IDM 7090 G05 (Sustainability Economics - Winter 2019)

May 2019 (Report Version 1.0)

Robert V. Parsons *, Arun Antony, Adam W. Grycko and Jared D. Bunkowsky, I.H. Asper School of Business, University of Manitoba

Elevated Biofuel Mandates

- Synoptic 2019 report by Parsons, Antony, Grycko, and Bunkowski describes and evaluates the project opportunity
- Copies have been provided to the governments of both Manitoba and Saskatchewan, as well as to relevant stakeholder organizations, including canola growers and trucking industry
  - Report is not yet available at a public site

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Thank you very much!

Are there any questions?

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Carbon-Price Equivalency Basis

- Calculating carbon pricing equivalency relies on the equation used to define price elasticity of demand (measure of consumer sensitivity to price changes)

$$\varepsilon = \frac{\Delta Q/Q}{\Delta P/P}$$

- Elasticity (ε) defined as percentage change in quantity consumed ($\Delta Q/Q$) divided by percentage change in price ($\Delta P/P$)

Carbon-Price Equivalency Basis

- This equation can be rearranged to calculate the equivalent price change needed for reduction occurring as a result of a mandate (i.e., $\Delta Q/Q$)

$$\Delta P = \frac{\Delta Q/Q}{\varepsilon} \times P$$

- Calculation requires estimate of price elasticity (ε), reduction of consumption ($\Delta Q/Q$), and fuel price (P)

Price Equivalency - 8.5% Ethanol?

- Manitoba's current 8.5% mandate is 3.5% higher than national mandate of 5%. As such $\Delta Q/Q = -0.035$
- Approximate rough future price of gasoline blend, P = 120¢ per Litre
- GHG of 8.5% blend = 2,120 g per Litre
- Range of elasticity values, $\varepsilon = -0.8$ (more sensitive) to -0.08 (less sensitive),
- Necessary tax = $25 to $250 per tonne

Price Equivalency - 10% Ethanol?

- Proposed 10% mandate by Manitoba is 5% higher than national mandate of 5%. As such $\Delta Q/Q = -0.050$
- Approximate rough future price of gasoline blend, P = 120¢ per Litre
- GHG of 10% blend = 2,090 g per Litre
- Range of elasticity values, $\varepsilon = -0.8$ (more sensitive) to -0.08 (less sensitive),
- Necessary tax = $36 to $360 per tonne

Price Equivalency - 10% ReDiesel?

- Proposed 10% mandate by Parsons et al is 8% higher than national mandate of 2%. As such $\Delta Q/Q = -0.08$
- Approximate rough future price of diesel blend, P = 120¢ per Litre
- GHG of diesel blend = 2,720 g per Litre
- Range of elasticity values, $\varepsilon = -0.50$ (more sensitive) to -0.10 (less sensitive),
- Necessary tax = $70 to $350 per tonne

Price Equivalency - 5% Biodiesel?

- Proposed 5% mandate by Manitoba is 3% higher than national mandate of 2%. As such $\Delta Q/Q = -0.03$
- Approximate rough future price of diesel blend, P = 120¢ per Litre
- GHG of diesel blend = 2,720 g per Litre
- Range of elasticity values, $\varepsilon = -0.50$ (more sensitive) to -0.10 (less sensitive),
- Necessary tax = $26 to $130 per tonne

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- [Also refer to poster presentation]

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