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Carbon Pricing and Consumer Myopia

Abstract

When faced with making economic trade-offs between lower upfront purchase costs and lower operating costs, many consumers experience "capital bias", a phenomenon that is tantamount to discounting future costs excessively. Consumers may therefore end up with investments that are sub-optimal on a life-cycle cost basis. Capital bias can affect the purchase of many goods that could lower greenhouse gas emissions such as electric vehicles, heat pumps, or more efficient appliances. The benecial effect of carbon pricing can be thwarted by capital bias when technology usage is price-inelastic and benecial environmental gains occur mostly at the extensive margin (replacements) rather than the intensive margin (usage). Policies other than carbon pricing may be needed to induce consumers to shift to product choices that are superior on a life-cycle cost that includes external costs from greenhouse gas emissions (or other negative externalities). This paper provides a novel theoretical micro-economic analysis of the problem coupled with an investigation about competing policy interventions. Conventional carbon pricing can be ineffective in the presence of consumer myopia, while subsidy (or penalty) schemes that influence the purchase decision can be effective especially when they are conditioned on a usage threshold and/or offer incentives proportional to usage. There is scope for alternative policy designs that can overcome consumer myopia as a hurdle to adopting energy-ecient durable goods. The theoretical analysis is rounded out with empirical simulations focusing on electric vehicle adoption.

JEL-Codes: Q58, Q48, D11, D83

Keywords: Carbon pricing; internalities; capital bias; environmental policy

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1. Introduction

Capital bias is a classic problem about consumer choice in environmental economics. When faced with a buying decision, consumers focus more on the purchase price while putting too little weight on the operating cost during the lifetime of the product. When consumers face a choice about an investment that has higher upfront purchasing cost combined with lower operating costs and/or longer lifetime, they often end up buying the product with the higher overall life-cycle costs.

The cause of capital bias is in part attributable to behavioural traits of consumers—notably misperceptions, inattention, and myopia, which are commonly summarized by the term internalities. An internality is the long-term benefit or cost to an individual that they do not consider when making the decision to consume a good or service. The consequences of internalities are often the same as for externalities: underconsumption of a beneficial product or overconsumption of a polluting product. In some cases internalities may be related to market failures, for example when a purchase decision is based on incomplete information or an information asymmetry between buyer and seller.

This decision problem exacerbates consumer response to carbon pricing. Consumer myopia (a term that will be used as a more intuitive term for capital bias and this specific type of internality) may diminish the intended effect of carbon pricing greatly. This paper provides a simple theoretical model that captures the essence of this problem, and explores why conventional carbon pricing may be less effective than alternative approaches.

For households' carbon dioxide emissions, the success of climate action depends crucially on the ability to replace internal combustion engine vehicles with battery-electric vehicles as well as using heat pumps to replace natural gas and oil furnaces. Both face the same dilemma: higher upfront costs coupled with lower operating costs, and the need for consumers to evaluate full life-cycle costs to make an informed purchase decision. Carbon pricing is meant to incentivize lower carbon emissions, and while such pricing is effective at the intensive margin, it can be confounded at the extensive margin because of internalities. This paper investigates how alternative policies that are aimed at the purchase decision compare against conventional consumer-side carbon pricing, with the theoretical discussion complemented by empirical simulations that investigate the effect of distributions of myopia, usage, and heterogeneous preferences.

This paper finds that conventional consumer-side carbon pricing has a much-reduced effect in the presence of pervasive consumer myopia, and that other policy options may provide greater environmental dependability, albeit with efficiency trade-offs. Alternative policies that make full use of available information about usage can improve policy outcomes.

2. What do we know about consumer myopia?

The seminal paper by Hausman (1979) is among the first that have clearly articulated the problem that there appears to be significant heterogeneity in discount rates when it comes to the purchase and utilization of energy-using durable goods. The paper found that consumers used a discount rate equivalent to about 20% when making the trade-off decision between capital costs for the purchase and the benefits from lower operating costs throughout the lifetime of the durable good. The paper further found that the discount rate varied inversely with income, suggesting that more affluent households are less subject to consumer myopia. Hausman (1979) wrote:

> Yet this finding of a high individual discount rate does not surprise most economists. At least since Pigou, many economists have commented on a "defective telescopic faculty." A simple fact emerges that in making decisions which involve discounting over time, individuals behave in a manner which implies a much higher discount rate than can be explained in terms of the opportunity costs of funds available in credit markets.

The insights from this early work on air conditioner purchases were subsequently studied for other types of energy-using durable goods. Busse et al. (2013) investigated whether buyers are myopic about future fuel costs when buying cars with different levels of fuel economy. However, these authors found little evidence of consumer myopia; many of the implicit discount rates they found were near zero, and most were less than 20 percent. Nevertheless, there is consumer heterogeneity and at least some people are subject to consumer myopia. Dubin and McFadden (1984) studied households' choices of heating systems, which similar to Hausman (1979) found implied discount rates in the 15–25 percent range.

An argument was also made that observed high discount rates can be explained as risk aversion. Hassett and Metcalf (1993) argue that apparently high discount rates of consumers who make energy conservation investments are not subject to economic irrationality, and that the observed hesitancy is not the result of a market failure. The authors attribute the hesitancy of investors to the presence of sunk costs and uncertainty over future conservation savings or energy prices. Thus, they conclude, consumers should indeed use a higher hurdle rate for investments than under full certainty.

Gillingham et al. (2009) survey various types of behavioural biases in the energy efficiency literature in light of behavioural economics frameworks including prospect theory, bounded rationality, and heuristic decision making. There is research pointing towards the presence of loss aversion, anchoring effects, status quo bias, and other anomalous behaviour. The authors conclude that available evidence suggests that systematic biases may exist in consumer decision making that could lead to overconsumption of energy and underinvestment in energy efficiency.

Allcot and Greenstone (2012) introduce a simple model of investments in energy efficiency and explore the issues surrounding the so-called energy efficiency gap, and related investment inefficiency. They also survey the existing literature on consumer myopia and discuss the extent to which observed implied high discount rates may also be attributable to unobserved product characteristics. The authors imply that such unobserved characteristics can bias the present-discounted value of energy costs. They also suggest that product prices will often be correlated with product (quality) attributes, thus leading to simultaneity bias in estimating price elasticities.

Consumer myopia was also explored in a different context by Gabaix and Laibson (2006). They suggest that optimizing firms exploit myopic consumers through marketing schemes that shroud high-priced add-ons. While sophisticated consumers can exploit these marketing schemes, myopic consumers may fall into the trap of buying goods that have lower purchase costs but higher operating costs (e.g., printers and ink). In the energy-efficiency context the problem tends to be reversed and consumers don't fully appreciate the future lower operating costs of an investment.

Perhaps the most influential paper in recent years that finds clear and compelling evidence of a behavioural effect is Gillingham et al. (2021). They address the issue of consumer myopia empirically through a natural experiment in the context of vehicle purchases. They find that consumers act myopically: consumers are indifferent between \$1.00 in discounted fuel costs and \$0.16–0.39 in the purchase price when discounting at 4 percent. This undervaluation persists under a wide range of assumptions. Because of the careful design of this study, the results are particularly compelling.

Houde and Myers (2019) point out that consumers are prone to errors when making choices about investments and other economic choices. Policy makers need information not just about the average level of misperceptions, but also about the full distribution. This is a crucial point echoed in this paper here. Knowing the distribution of consumer myopia is crucially important to design smart public policies. In their study they find substantial heterogeneity in consumer perceptions of energy costs. Whereas about half of consumers seem to have only modest to no misperceptions, a large share undervalue energy costs with implied discount rates greater than 12%.

My paper shares traits with Farhi and Gabaix (2020), who have worked on optimal taxation with behavioural agents who are subject to misperceptions, inattention, and internalities, also looking at Pigouvian taxes. More specifically, Allcott et al. (2014) address energy policy with internalities. The authors find that consumers who undervalue energy costs are insufficiently responsive to energy taxes, and thus an optimal policy will tend to involve an energy tax below marginal damages coupled with a larger subsidy for energy efficient products. While the exact optimal policy depends on the distribution of unobservables, the authors develop formulas to closely approximate optimal policy and welfare effects based on reduced form "sufficient statistics". My paper is very much in the spirit of this type of analysis. The analysis in my paper is directed at the underlying distributions, getting closed-form solutions with specific assumptions to characterize optimal policy.

In a similar vein, Gerster and Kramm (2024) explore how a benevolent policymaker should optimally tax (or subsidize) product attributes when consumers are behaviourally biased. They demonstrate that market choices are informative about biases, which can be exploited for targeting biased consumers via a nonlinear tax schedule. They show that the properties of this schedule depend on few parameters of the joint distribution of consumer valuations and biases.

The difficulties turning theory into policy is highlighted in Rodemeier and Löschel (2023). Correcting information and attention deficits requires policies that combine monetary incentives with improved information. Giandomenico et al. (2022) review the outcomes of various energy efficiency home retrofit programs. Retrofit programs tend to have a high implied carbon price, as Fowlie et al. (2018) found in their study of a weatherization assistance program in the United States.

This paper is also related to the choice of efficient policy instruments. Bhardwaj et al. (2022) explore policy trade-offs among second-best instruments in the context of EV policies in Canada, focusing on a carbon price, a vehicle emission standard, an zero-emission vehicle mandate, and combinations. Jenn et al. (2018) investigates the effectiveness of EV incentives int he United States. More broadly, this paper also relates to the heterogeneous effects of purchase incentives, in particular for electric vehicles; see Haan et al. (2025). As Hardisty et al. (2012) observe, dealing with intertemporal trade-offs in environmental policy design requires careful exploration of economic dimensions along with a deeper understanding of consumer psychology.

The above discussion makes clear that internalities (consumer myopia) matters, regardless of the sources. Environmental policy that does not take its presence into account will underdeliver.

3. Model Setup

Work by Allcott et al. (2014), Farhi and Gabaix (2020), and Gerster and Kramm (2024) have reveaed the general economic problems related to internalities. The model here attempts to take some of the underlying insights and translate them into an algebraically tractable model with specific assumptions about consumer heterogeneity. This approach helps identify the differences in policy choices more clearly. The aim of the model is to bridge the gap between foundational theoretical insights and specific choices of policy instruments. The second aim of the model is to focus specifically on the shortcomings of carbon pricing. The third aim of the model is to focus on the information requirements for policy makers in terms of consumer heterogeneity. What information is observable and can be leveraged for policy design? Which information is unobservable and needs to be modelled with empirically calibrated assumptions? Allcott et al. (2014) referred to these as "sufficient statistics", but this is something that needs to be translated into suitable empirical modelling to design public policy. While the algebraically-tractable model below generates new policy design insights, it also develops a framework for the empirical (simulation) modelling in the following section.

Algebraic tractability comes at the cost of generality, but it helps identify economic mechanisms more clearly. Which particular distributional assumptions are simple enough to generate tractability while still preserving the essence of the economic decision problem? Starting out with a simple uniform distribution for usage and a triangular distribution for myopia can do this job with a minimum of parameters. It turns out that these choices are highly suitable to characterize the effect of different policies. Later, these assumptions will be relaxed for an empirical simulation.

3.1. Consumers

Consider a set of consumers, distributed on the continuous line $\omega \in [0, 1]$ with mass N. Consumers are subject to quasi-hyperbolic discounting of future costs so that costs in period $t = 0$ are not discounted and future costs $t > 0$ are discounted at $(1 - \beta) \exp(-\rho t)$, where $\beta \in [0, 1]$ is the myopia factor and $\rho > 0$ is a common timeconsistent discount rate.[1] Then the present-discounted value of a constant stream of payments over the lifetime T of a product is given by

$$\delta(\beta, \rho, T) \equiv (1-\beta)[1-\exp(-\rho T)]/\rho = (1-\beta)\delta^* \in (0, T] \tag{1}$$

The value of δ is measured in years; think of it as a metric of "perceived lifetime" compared to the actual lifetime T. A consumer with high myopia thus treats future costs equivalent to a perceived short product life. As $\beta \to 1$, consumers increasingly discount the future and in the extreme case focus on purchase costs alone.[2] The parameter δ^* is constant given ρ and T; it is the myopia-free discount rate.

For simplicity of exposition, the myopia factor β is assumed to be distributed triangular in the $[0, 1]$ interval with mode zero and $0 < \mu \leq 1$. This is a particularly simple form of the triangular distribution with mean $1/3$. It assumes that most consumers have low myopia and fewer consumers have high myopia. The corresponding probability density function is $\phi(x) = 2(1-x)/1^2$ and the cumulative distribution function is $\Phi(x) = 1-(1-x)^2$. This distributional assumption makes the analysis below algebraically tractable without compromising economic intuition. Of course, empirically any other distribution can be used that is a better approximation of the empirical reality, but here the emphasis is on finding clean algebraic solutions and insights.[3]

The mean myopia factor of the triangular distribution assumed here is $1/3$. This is a rather defensible numerical parameterization as myopia of $1/3$ coupled with a conventional discount rate of 5% and a ten-year time horizon is equivalent to observing an implied 15% discount rate, which is well within what numerous studies have observed. The following algebraic analysis is therefore empirically plausible.

3.2. Product Choice

Consumers face the choice between products A and B, with purchase costs $f_A > f_B$, fixed lifetime T, and operating costs $c_A < c_B$ throughout the lifetime of the products. In other words, good A has higher fixed costs but lower variable costs. Thus consumer ω will purchase A rather than B if

$$f_A + \delta(\omega)c_A u(c_A) < f_B \delta(\omega) c_B u(c_B) \quad \rightarrow \quad \delta(\omega) > \frac{f_A - f_B}{c_B u(c_B) - c_A u(c_A)} \tag{2}$$

Here, $u(c)$ is the per-period use of the good that depends on the cost of marginal cost of the good, as the use decision is made in each period. Using the myopia-free

[1] Consumers may also experience heterogeneity for intertemporal discounting and may thus exhibit variation in ρ. To keep the model algebraically tractable, this heterogeneity is set aside but is easy to put into empirical simulations.

[2] The presence of capital bias is empirically equivalent to observing heterogeneity in discount rates. For a given discount value δ it is possible to find a $\tilde{\rho}$ with $\beta = 0$. The algebraic solution is somewhat unwieldy and involves the Lambert-W function.

[3] Empirically, the two-parameter beta distribution is a suitable and very flexible approximation for empirical work and is used at a later stage in this paper.

discount rate δ^*, introduce the cost ratio

$$\xi(\omega) \equiv \frac{f_A - f_B}{\delta^*[c_B u(c_B) - c_A u(c_A)]} \in [0,1] \tag{3}$$

and note that $\delta(\omega) = (1-\beta(\omega))\delta^*$. Thus consumers prefer good A over good B if

$$\xi \leq 1 \quad \text{and} \quad \beta(\omega) < 1 - \xi(\omega) \tag{4}$$

The first and second condition in (4) state that good A is chosen if it is economically advantageous *and* perceived as such. The share of consumers that buys good A is thus the product of two shares: the proportion of consumers that would benefit from the product choice in the absence of myopia, and the proportion of consumers that perceives the benefit correctly in the presence of myopia. Consumer ω perceives A as superior to B when myopia is sufficiently low: $\beta(\omega) < 1 - \xi(\omega)$. When $\xi(\omega) > 1$, these consumers will prefer B because vehicle B will be more economical, regardless of myopia.

3.3. Usage

The choice of how much products are used depends on their marginal cost. We assume here that the demand for usage is highly price-inelastic, which is typical for services such as vehicle use and home heating. Specifically, we use linear demand $u(c_i) = u^\circ - \gamma c_i$ and stipulate that consumers operate on the inelastic portion; i.e., $\gamma c_i < u^\circ/2$. Essentially, this rules out the Jevons Paradox.

As good A is cheaper to use than good B (as $c_A < c_B$ by construction), consumers experience a rebound effect due to the lower cost. With linear demand, the rebound effect equals $u(c_A) - u(c_B) = \gamma(c_B - c_A)$, and depends crucially on the price sensitivity γ.

Our cost ratio (3) can now be refined and becomes

$$\xi(\omega) \equiv \frac{1}{\delta^*}\left[\frac{f_A - f_B}{(c_B - c_A)[u^\circ(\omega) - \gamma(c_A + c_B)]}\right] \tag{5}$$

where it must hold that the rebound effect cannot overpower the cost advantage, i.e., $\gamma < u^\circ/(c_A + c_B)$. Note here that increasing cost c_B, for example by putting a tax on use of good B, decreases ξ; i.e., $\mathrm{d}\xi/\mathrm{d}c_B < 0$. Such a tax makes it more likely that ξ falls below 1, where it will trigger switching from product B to product A.

3.4. Economical Choice

Consumers all have different usage demand; u° is a function of ω. For the sake of expositional simplicity, we assume that the distribution is uniform over the interval $[0, \bar{u}]$. We need to know when $\xi(u^\circ) < 1$ to see who switches to using product A. The benefit from lower operational costs accrue preferentially to the high-volume users. Consumers for which good A is economical are those with sufficiently high usage

$$u^\circ(\omega) > \gamma(c_A + c_B) + \frac{f_A - f_B}{\delta^*(c_B - c_A)} \equiv u^* \tag{6}$$

where $u^* < \bar{u}$ denotes the break-even point where product A becomes economical. As the purchase cost difference goes up, only more usage-intense buyers will pick product A. The myopia-free share of good A is therefore:

$$\sigma^* \equiv 1 - u^*/\bar{u} \in [0, 1] \tag{7}$$

3.5. Choice Under Myopia

The actual choice depends on the myopia distribution $\beta(\omega)$. We had seen in (4) that good A is bought if $\beta(\omega) < 1 - \xi(\omega)$. Using the definition of u^* in (6) and noting that $\xi(\omega) = u^*/u(\omega)$ when $\gamma = 0$, the consumer decision can also be written as $\beta(\omega) < 1 - u^*/u(\omega)$. Going forward, I assume that the rebound effect is negligible and thus $\gamma \to 0$.

The share σ^* of consumers identifies the consumer segment that would benefit from purchasing good A, but many may not if they evaluate the future benefits incorrectly. We are interested in determining the share σ of consumers that will end up buying good A. Recall that the distributions of β and u are not correlated, and thus we can integrate over the user segment covered by $[u^*, \bar{u}]$, together with the CDF of the triangular distribution that tells us the share of consumers with sufficiently low myopia:

$$\sigma = \frac{1}{\bar{u}} \int_{u^*}^{\bar{u}} \Phi\left(1 - \frac{u^*}{u(\omega)}\right) \mathrm{d}u = \left(1 - \frac{u^*}{\bar{u}}\right)^2 \tag{8}$$

With a mass of N consumers in total, σN will buy good A, while $(1-\sigma)N$ consumers will stick to good B.

3.6. Emissions

Assume that goods A and B have radically different emission intensities. Let good B be the dirty good with emission intensity z, and let good A be completely clean.[4] Thus it is necessary to track the emissions from good B, which can be decomposed into two parts: the emissions $Z^\bullet$ from the consumers for which option A is always uneconomical, below usage level u^*; and the emissions Z° from the consumers for which option A is economical but who fall victim to their myopia.

$$\begin{aligned} Z^\bullet &= zN\frac{u^{*2}}{2\bar{u}} && (9)\\ Z^\circ &= zN\int_{u^*}^{\bar{u}} u\left[1 - \Phi\left(1 - \frac{u^*}{u}\right)\right]\mathrm{d}u = zN\frac{u^{*2}}{\bar{u}}\ln\left(\frac{\bar{u}}{u^*}\right) && (10)\\ Z^\bullet + Z^\circ &= zN\frac{u^{*2}}{\bar{u}}\left[\frac{1}{2} + \ln\left(\frac{\bar{u}}{u^*}\right)\right] && (11) \end{aligned}$$

The ratio of the two emission sources is $Z^\circ/Z^\bullet = 2\ln(\bar{u}/u^*)$, which reveals that the emissions induced by myopia are non-trivial. If the threshold for making good A

[4] This assumption simply puts z on the side of good B. In fact, the model holds true for any fixed emission intensity difference $z = z_A - z_B$.

economical is at the midpoint of the usage distribution, then $2\ln(2) \approx 1.39$, which means that emissions induced by myopia are larger than the emissions from the low-usage fleet that prefers good B. The intuition is simple: the high-usage types account for larger emissions, and as they benefit the most from good A, their non-adoption due to myopia is hugely costly in environmental terms.

4. Policy Framework

4.1. Carbon Pricing

Now introduce a carbon price ψ, which can be expressed in units of use as $z\psi$. Without the option to switch from good B to good A, carbon pricing only affects the intensive margin of using good B. In this case the emission change is given by

$$\Delta Z = z[u(c_B + z\psi) - u(c_B)]N = -z^2\,\gamma\,\psi N \tag{12}$$

Emission changes are linear in the tax rate but are attenuated by the demand slope γ, which is small when usage demand is inelastic. If usage demand is perfectly price-inelastic, emissions will remain unchanged and the carbon policy fails at the intensive margin. Then the beneficial effect of the policy is completely dependent on changes at the extensive margin.

The effect of carbon pricing at the extensive margin hinges crucially on its effect on the threshold u^* at which good A becomes economical. The elasticity of the usage threshold to carbon price is

$$\frac{\mathrm{d}u^*}{\mathrm{d}\psi} = -\frac{zu^*}{c_B + z\psi - c_A} < 0 \tag{13}$$

The effect that a shift in u^* has on total emissions is given by

$$\frac{\mathrm{d}(Z^\bullet + Z^\circ)}{\mathrm{d}u^*} = 2zN\left[\frac{u^*}{\bar{u}}\right]\ln\left(\frac{\bar{u}}{u^*}\right) > 0 \tag{14}$$

Unambiguously, carbon pricing decreases emissions. But the effect is not linear. First, the expression in square brackets becomes smaller as u^* decreases. This is apparent because the low-usage consumers have the lowest emissions. Second, the log-ratio on the right starts at zero when $u^* = \bar{u}$ and then grows as u^* decreases as a result of carbon pricing. This effect is caused primarily by myopia as at first only consumers with low myopia convert to using A, and only as the apparent economical choice is more and more perceived as such (with a wider range of β), more and more consumers opt to buy A. The two effects combine to make the change in emissions an inverse-U-shaped function. It is easy to find that the maximum sensitivity of emissions to change in usage threshold occurs at $\bar{u}/\exp(1) \approx 0.368\,\bar{u}$. The non-linear behaviour means that carbon pricing becomes gradually more effective until it reaches this inflection point.

4.2. Welfare Considerations

Using goods A and B creates utility $\mathcal{U}$. Setting aside demand responses and rebound effects, consider $\mathcal{U}$ fixed. Social welfare $\mathcal{W}$ can be calculated as

$$\mathcal{W} = \mathcal{U} - \mathcal{C} - \Psi\delta^*\mathcal{Z} \tag{15}$$

with the total cost $\mathcal{C}$ of purchasing goods A and B along with the discounted operating cost, and $\Psi\delta^*\mathcal{Z}$ the present value of the future emissions with $\mathcal{Z} = Z^\bullet + Z^\circ$ and Ψ as the *social cost of carbon* (SCC). The private cost of ownership is

$$\mathcal{C} = \sigma\,[f_A + \delta^* c_A] + (1-\sigma)\,[f_B + \delta^* c_B] \tag{16}$$

where σ is a function of u^*, and in turn u^* is a function of $z\psi$. Note, however, that the private cost does not contain the carbon tax that is collected because this is eventually redistributed and is thus not part of $\mathcal{W}$. We can thus maximize $\mathcal{W}$ with respect to ψ, and usually this gives us the result $\psi = \Psi$ when no myopia is present: the optimal carbon price is equal to the social cost of carbon.

In the presence of consumer myopia, the effect of carbon pricing is diminished at the extensive margin, just as it is diminished at the intensive margin by price-inelastic usage demand. Carbon pricing has to overcome the resistance from consumer myopia. It is possible to find a closed-form algebraic solution for the optimal carbon price. We introduce two more helpful simplifications: the usage threshold u^Ψ implied by the social cost of carbon, and the usage threshold $u^\varnothing$ implied by a zero carbon price.

$$u^\Psi = (f_B - f_A)/[\delta^*(c_B + z\Psi - c_A] \tag{17}$$

$$u^\varnothing = (f_B - f_A)/[\delta^*(c_B - c_A)] > u^\Psi \tag{18}$$

Then the optimal carbon price can be determined as

$$\psi = \frac{c_B - c_A}{z}[\Gamma(\Psi) - 1] \tag{19}$$

$$\Gamma(\Psi) \equiv \frac{u^\varnothing}{u^\Psi}\Theta\left(\frac{u^\Psi}{\bar{u}}\right) > 1 \tag{20}$$

$$\Theta(x) \equiv -\mathbf{W}_{-1}(-x\exp(-x)) > 1, \quad x \in]0,1] \tag{21}$$

where $\Theta(x)$ is a mathematical function derived from the lower branch of the Lambert-W function, $\mathbf{W}_{-1}(\cdot)$ on the interval $[-\exp(-1), 0[$, that generates values larger than one for $x \in]0,1]$.[5] As a result, $\Gamma(\Psi) - 1$ is guaranteed to be positive. Then it can be shown that $\psi > \Psi$ holds for many real-life applications such as electric vehicles or heat pumps.

The analysis above shows that the efficacy of carbon pricing is significantly diminished in the presence of consumer myopia. With myopia, the optimal carbon price increases proportional to the cost gap between goods B and A: the larger the gap, the higher the carbon price needs to be so that myopic consumers are swayed

[5] Note that $\Theta'(x) < 0$, and $\Theta(1) = 1$. Roughly, $\Theta(x) \approx 1 - \ln(x)$.

towards buying the 'greener' good A.

A numerical illustration about the adoption of electric vehicles may be helpful, with $f_A - f_B$ as the price difference between electric and conventional cars.[6] The table on the right shows social cost of carbons equal to the current Canadian carbon price of \$80/tonne, the 2030 target of \$170/tonne, and the estimated SCC of \$250/tonne.[7] For three different purchase price differences the implied usage points $u^{\varnothing}$ and u^{Ψ} are shown in kilometres per year. The higher the purchase cost difference, the higher are the usage limits, and the lower are the required carbon prices to entice myopic consumers to purchase electric vehicles. When usage thresholds are low when electric vehicles are not all that more expensive, consumer myopia provides a formidable level of resistance and would require heroic levels of carbon pricing to overcome. Some of the implied carbon prices are well over \$1000/tonne, equivalent to \$2.22/L of gasoline. When even the \$80/tonne level of carbon pricing induces formidable political resistance, it is hard to imagine fuel prices rising to the level needed to induce consumers to overcome their internalities.

Table 1: Optimal carbon price vs. SCC

Ψ	$f_A - f_B$	$u^{\varnothing}$	u^{Ψ}	ψ
80	5,000	4,459	3,949	1,550
80	10,000	8,918	7,898	956
80	15,000	13,376	11,847	620
170	5,000	4,459	3,499	1,947
170	10,000	8,918	6,998	1,275
170	15,000	13,376	10,496	891
250	5,000	4,459	3,177	2,310
250	10,000	8,918	6,354	1,569
250	15,000	13,376	9,531	1,143

4.3. Purchase Interventions

The above derivations have shown that the effect of myopia-induced emissions can be sizeable. The obvious policy conclusion is that carbon pricing is a flawed instrument to achieve the socially-optimal outcome. Overcoming consumer myopia can only be effective at the time of purchase, when consumers do not face myopia for the purchase prices as well as any monetary inducements or penalties, i.e., anything that lessens the gap between f_A and f_B. From an efficiency point of view, it is equivalent if a purchase incentive is offered for good A so that the purchase price is $f_A - \Lambda$ or whether a purchase penalty is put on good B so that its price becomes $f_B + \Lambda$. From the consumer perspective they are the same as the resulting price gap is $f_A - f_B - \Lambda \geq 0$ either way (but with potentially different implications for distributional outcomes). In what follows the explicit carbon price is also set aside in order to focus on the exclusive effect from purchase interventions in the absence of another policy instrument.

It is immediately apparent that the highest feasible purchase intervention is $f_A - f_B$ that would convert absolutely everyone to buying good A. For this reason it is useful to normalize the intervention intensity to be captured by $\lambda(\omega) \in [0, 1]$ so that $\Lambda = \lambda(\omega)(f_A - f_B)$. Note that $\lambda(\omega)$ can be varied by consumer type. When

[6] Assume electric cars require 25kWh/100km at a cost of \$0.15/kWh, while gas-powered cars consume 10L/100km at \$1.80/L and emit 2.3kg/L of carbon dioxide. Vehicle life time is assumed as 10 years with a discount rate of 5%. Usage range is assumed as 24,000km.

[7] Note that 1 Canadian Dollar is worth about 0.70 U.S. Dollars in 2025.

such an intervention is put into place, consumers will prefer A if:

$$\begin{aligned}\Lambda &> f_A - f_B - \delta^*[1-\beta(\omega)](c_B - c_A)u(\omega)\\ \lambda(\omega) &> [1-\beta(\omega)][u(\omega)/u^{\varnothing}] > 0\\ \beta(\omega) &< 1-[1-\lambda(\omega)](u^{\varnothing}/u(\omega))\end{aligned} \tag{22}$$

Which policy scheme $\lambda(\omega)$ is effective in addressing consumer myopia? Which scheme maximizes welfare? The next sections will explore various alternatives: an undifferentiated "flat" subsidy, a flat subsidy that is conditioned on a minimum usage threshold, and a subsidy scheme that offers a usage-based incentive. The socially optimal choice for consumers is easy to see by setting $\beta = 0$ (suppressing myopia) and pricing carbon correctly, which gives rise to the usage threshold u^{Ψ}. If all consumers buy good A with usage $u(\omega) > u^{\Psi}$, then the welfare maximum is achieved.

4.4. Flat Subsidy

The most common type of subsidy is a flat (undifferentiated) intervention to anyone who purchases good A. Myopia is not addressed specifically through such a scheme; life-cycle operating costs remain subject to myopia. The policy is $\lambda(\omega) = \bar{\lambda}$ in the context of inequality (22). The intervention has a differential effect on different consumers, depending on their usage. The effect of the intervention is lower for high-usage types and higher for low-usage types. Overall, $\bar{\lambda}$ draws in more people to buy good A, but at least some will be the wrong type for which it is not socially optimal. To see this, consider a myopia-free consumer. They will buy good A if

$$u(\omega)|_{\beta=0} > (1-\bar{\lambda})u^{\varnothing} \equiv \underline{u} \tag{23}$$

where $\bar{u}$ defines this lower threshold. All consumers with $u(\omega) < \underline{u}$ will continue to prefer good B. This lower threshold will play a significant role below. Now recall that the social optimum is achieved when all consumers with $u(\omega) > u^{\Psi}$ buy good A. So when it is the case that $\underline{u} < u^{\Psi}$, some consumers end up buying good A when it is not socially optimal. This in turn is the case when $\bar{\lambda} > 1 - u^{\Psi}/u^{\varnothing}$. Because $u^{\varnothing} > u^{\Psi}$, a sufficiently large $\bar{\lambda}$ will push some consumers to buy A that is not optimal. But when $\bar{\lambda} < 1 - u^{\Psi}/u^{\varnothing}$, the purchase intervention simply draws in more consumers to buy good A while it is still socially optimal.

The share of consumers who will buy good A requires integrating myopic consumer behaviour over the range $[\underline{u}, \bar{u}]$, which gives

$$\sigma = \left[1-(1-\bar{\lambda})(u^{\varnothing}/\bar{u})\right]^2 \tag{24}$$

We can also determine total emissions, noting that below $\underline{u}$ all consumers buy good B.

$$\mathcal{Z} = z\left[\underline{u}^2/2 + (1-\bar{\lambda})^2 u^{\varnothing 2}\ln(\bar{u}/\underline{u})\right]/\bar{u} \tag{25}$$

The first summand is from the low-usage B consumers, and the second summand captures the effect of the subsidy on the myopic consumers who stay with B. As welfare is given by equation (15), it is possible to obtain the optimal policy rate $\bar{\lambda}$

from the first-order condition for the welfare maximum:

$$\bar{\lambda} = 1 - 1/\Gamma(\Psi) \tag{26}$$

where $\Gamma(\Psi) > 1$ was defined in equation (20). We can compare this optimum to the case without myopia, which has the solution

$$\bar{\lambda}|_{\beta=0} = \left(1 - \frac{u^{\Psi}}{u^{\varnothing}}\right) \frac{u^{\varnothing} + (\delta^* - 1)\bar{u}/2}{u^{\varnothing} + (\delta^* - 1)u^{\Psi}} \tag{27}$$

The first expression in round parentheses is smaller than one, and this dominates the result. Again, as in the case of the carbon price, the policy is doing double duty. Here it again must overcome the resistance from consumer myopia to be effective.

Using the same numbers for illustration as for the carbon price, table 2 shows the calculation of optimal $\bar{\lambda}$s without and with myopia present. Naturally, the subsidies for the myopia-free case are much lower. Keep again in mind that $\bar{\lambda}$ is expressed as a fraction of $f_A - f_B$, so the actual dollar figures are obtained by multiplying $\bar{\lambda}$ with $(f_A - f_B)$. Subsidy rates decline with $f_A - f_B$ for a given social cost of carbon. The intuition is that as the price gap grows, it is less beneficial to make consumers adopt product A as the private cost disadvantage weighs increasingly against the public externality reduction. The difference in the subsidy rates between the myopia case and myopia-free case are rather large. The resistance from myopia is again rather expensive to overcome.

Table 2: Optimal subsidies

Ψ	$f_A - f_B$	$\bar{\lambda}\|_{\beta=0}$	$\bar{\lambda}$
80	5,000	0.315	0.714
80	10,000	0.165	0.607
80	15,000	0.116	0.500
170	5,000	0.657	0.759
170	10,000	0.345	0.673
170	15,000	0.241	0.590
250	5,000	0.951	0.789
250	10,000	0.500	0.717
250	15,000	0.349	0.649

4.5. Conditional Maximum Subsidy

Next consider the case where a government offers an intervention $\lambda^{\Diamond}$ only to consumers for whom purchasing good A would be economical when the social cost of carbon is factored in, but are hindered by myopia to perceive it correctly, i.e.,

$$\lambda^{\Diamond}(\omega) = 1(u(\omega) > u^{\Psi}) \tag{28}$$

The government determines the eligibility threshold u^{Ψ} from available cost data and offers a subsidy $f_A - f_B$ to consumers above the threshold. For this group the socially optimal subsidy rate is indeed the full cost difference $f_A - f_B$ because it eliminates all internalities and externalities.

Because the funds for the subsidy do not constitute a welfare loss, this scheme would be very appealing. Obviously there is a catch—the scheme is hugely expensive as it means paying all buyers of A a significant subsidy, and many would have bought good A even without the subsidy (the low-myopia types). This subsidy scheme generates a significant redistribution of income, and it is easy to appreciate that a policy of this type would meet significant political resistance. The catch is that raising tax revenue to pay for a scheme of the above type is not costless. There are costs of raising revenue, and opportunity costs for alternative uses of raised revenue.

4.6. Usage-Based Intervention

The two subsidy interventions considered above were flat. If usage information can be observed, it is also possible to offer a purchase intervention that is proportional to usage. The flat subsidy schemes suffer from the disadvantage that their effect in the consumer choice problem (22) diminishes with usage. One way to correct this problem is to design a subsidy scheme that is proportional to usage and capped so that the maximum subsidy does not exceed $f_A - f_B$. Then the subsidy scheme with rate

$$\lambda^{◀}(\omega) = \min\{\, u(\omega)/u^{◀}, 1\} \tag{29}$$

offers an incentive that rises proportional to use $u(\omega)$ and reaches the cap at usage level $u^{◀}$. The objective is to find $u^{◀}$ that maximizes welfare. Revisiting (22), consumers adopt product A if

$$\beta(\omega) < \begin{cases} 0 & \text{if } u(\omega) \leq u^{\triangleleft} \\ 1 - u^{\varnothing}/u(\omega) + u^{\varnothing}/u^{◀} & \text{if } u^{\triangleleft} < u(\omega) < u^{◀} \\ 1 & \text{if } u(\omega) \geq u^{◀} \end{cases} \tag{30}$$

where $u^{\triangleleft} \equiv 1/(1/u^{\varnothing} + 1/u^{◀})$ is the threshold below which consumers always adopt product B, while consumers above $u^{◀}$ always adopt product A. Consumers in the mid region experience a cap on myopia that is equal to $u^{\varnothing}/u^{◀}$. This means the myopia distribution is effectively capped at this ratio. Note that the threshold for always-B adopters lies below the ordinary threshold for making good A economic: $u^{\triangleleft} < u^{\varnothing}$.

The share of consumers that will purchase good A can be shown to be

$$\sigma^{◀} = 1 - 2\frac{u^{\varnothing}}{\bar{u}}\left[1 - \frac{u^{\varnothing}}{u^{◀}} \ln\left(1 + \frac{u^{◀}}{u^{\varnothing}}\right)\right] \tag{31}$$

It is essentially determined by the policy parameter $u^{◀}$ that defines the subsidy scheme and the threshold $u^{\varnothing}$ at which good A becomes economical (without SCC). $\sigma^{◀}$ decreases as the policy $u^{◀}$ is increased (and thus incentives weaken).

It is also possible to determine total emissions and total ownership costs for consumers. Total emissions from users of good B are the sum of the always-B users and the myopic-B users:

$$Z^{◀} = z\delta^{*}\frac{u^{\varnothing 2}}{\bar{u}}\left[\ln\left(1 + \frac{u^{◀}}{u^{\varnothing}}\right) - \frac{u^{◀}}{u^{◀} + u^{\varnothing}}\right] \tag{32}$$

An analytic expression for the total ownership cost can be obtained as well, and thus it is again possible to calculate welfare and find the welfare maximum. Let $\eta \equiv 1 + u^{◀}/u^{\varnothing} > 1$ be a shorthand expression, then the welfare maximum is given by the equation

$$\frac{u^{\varnothing}}{u^{\Psi}} = \frac{2\eta[1 + \eta(\ln(\eta) - 1)]}{(\eta - 1)^3} \tag{33}$$

which unfortunately cannot be solved for $u^{◀}$ algebraically.

However, equation (33) can be solved numerically. Table 3 uses the same parameters as in tables 2 and 1 to illustrate the range of optimal solutions. The first four columns are identical to those in table 1. The last column shows the optimal usage-based incentive threshold $u^{\blacktriangleleft}$ for a given social cost of carbon Ψ and purchase cost difference $f_A - f_B$. The incentive limit $u^{\blacktriangleleft}$ decreases with the social cost of carbon and increases with the purchase cost difference. The optimal threshold is sufficiently high to show that only the most usage-intense consumer receive a subsidy at $\lambda^{\blacktriangleleft} = 1$. Thus it is rather apparent that this scheme is going to cost less than the previous flat-rate subsidy that is conditional on the threshold u^{Ψ} for the socially-optimal adoption threshold.

Table 3: Optimal Usage-Based Subsidies

Ψ	$f_A - f_B$	$u^{\varnothing}$	u^{Ψ}	$u^{\blacktriangleleft}$
80	5,000	4,459	3,949	7,072
80	10,000	8,918	7,898	14,144
80	15,000	13,376	11,847	21,216
170	5,000	4,459	3,499	5,896
170	10,000	8,918	6,998	11,791
170	15,000	13,376	10,496	17,687
250	5,000	4,459	3,177	5,118
250	10,000	8,918	6,354	10,235
250	15,000	13,376	9,531	15,353

4.7. Mandates

Recently governments have embraced zero-emission vehicle (ZEV) mandates to set targets for the transition to electric vehicles (Collantes and Sperling, 2008; Axsen et al., 2022a,b). These policies are seen as a potentially effective way of reaching the desired targets. Such mandates, if binding, have a very similar effect to purchase subsidies except that the cost is borne by the consumer rather than the government. Car makers that fail to achieve the targeted quote will pay a fixed penalty for each excess non-electric vehicle. This policy creates a price wedge that forces more adoption. The mandate has an exogenous target that adjusts every year. In the presence of consumer myopia we had seen that the optimal subsidy rate is substantially higher than without myopia. Likewise, a ZEV mandate will need to induce a much higher price response from consumers to achieve the desired outcome.

Given a mandate proportion $\bar{\sigma}$, we can work backwards to what optimal λ is implied. Solving equation (24) for λ^{ZEV} given $\bar{\sigma}$ yields

$$\lambda^{\text{ZEV}} = 1 - (\bar{u}/u^{\varnothing})\left(1 - \sqrt{\bar{\sigma}}\right) \tag{34}$$

Note that $\lambda^{\text{ZEV}} \to 1$ as $\sigma \to 1$; if the mandate aims to replace all B-goods, the only way to accomplish this is to cover the entire price gap between good A and good B. No mandate is needed as long as $\bar{\sigma} < (1 - u^{\varnothing}/\bar{u})^2$. This means a mandate would not be binding below this level. For example, if $u^{\varnothing}/\bar{u} = 0.5$, then any $\bar{\sigma} < 0.25$ will not be binding. Manufacturers will be forced to adjust their pricing to create a price wedge λ^{ZEV} that generates the required $\bar{\sigma}$. How this comes about requires a market model that is beyond the scope of this paper. Nevertheless, in the presence of myopia, the required price gap that achieves the required $\bar{\sigma}$ is much larger than without. In the myopia-free case, the required price gap is $\lambda^{\text{ZEV}}_{\beta=0} = 1 - (\bar{u}/u^{\varnothing})(1 - \bar{\sigma})$. Note the absence of the square root in comparison to (34). For any given $\bar{\sigma}$, the required $\lambda^{\text{ZEV}}_{\beta=0}$ will thus be much smaller, and the mandate becomes non-binding when $\bar{\sigma} < 1 - u^{\varnothing}/\bar{u}$, which is obviously a much higher threshold than the same expression squared as above in (34). To summarize, myopia continues to pose a formidable obstacle even when a mandate is used. A mandate ultimately is not different form a flat subsidy—the mandate just shifts the burden fully to consumers.

A mandate's downside is that the price wedge λ^{ZEV} works its way through the market for goods A and B. If this market is characterized by some degree of market power and oligopolistic structure, this may affect overall demand. This may not necessarily be bad if there is an outside good that is even superior with fewer externalities—for example switching people from using fewer cars to using more public transit or other forms of personal mobility.

A mandate's upside that it is environmentally dependable, and its behind-the-scenes transmission mechanism may insulate it better against political backlash—especially if the mandate does not move too aggressively to make price changes too obvious to buyers.

5. Policy Discussion

The theoretical discussions above shine a bright light on the shortcomings of conventional carbon pricing. Our first-best instrument is no longer first-best when consumers act myopically. This insight has profound policy implications. The discussions also shines a bright on existing research and knowledge deficits.

This section explores several implications and additional dimensions. The theoretical analysis reveals that knowledge of the empirical distributions of myopia and usage are paramount for understanding policy outcomes. Numerous studies have identified average discount rates, but most do not identify the full distribution of observed myopia factors clearly. An imperative for future research is therefore identifying the precise nature of the distribution. In the absence of such information, a simulation exercise in the next section will shed light on the importance of understanding the myopia distribution.

5.1. Usage Observations, Usage Distributions, and Policy Design

Consumer heterogeneity of energy usage can vary significantly across different types of durable goods. Usage of motor vehicles—annual mileage—has rather large variation. Energy use for home heating has a narrower range but is specific to location and local weather conditions. Understanding the source of variation has important implications for policy design.

First consider the extreme case where all consumers have the exact same usage. Then, given a fixed-cost difference, the environmentally-desirable good is either always better, or not at all. When good A is always economically preferable, the adoption is solely determined by the myopia distribution. As usage is fixed, there is no scope for a usage-based policy instrument. However, when there is large variation of usage, there will be consumers who benefit from adoption of the environmentally beneficial good, and those who don't. The larger the distribution, the more likely it is that consumer myopia will affect a significant portion of that distribution. If usage can be identified reliably, the fact that environmental benefit is proportional to usage provides a strong economic rationale to condition eligibility for incentives on usage.

What's the catch? Policy design that relies on usage data could become subject to "gaming"—purposeful misrepresentation of usage to trigger eligibility for taking advantage of available incentives. For motor vehicles, usage can be determined by annual odometer readings. However, odometer readings can be manipulated (often referred to as "clocking"). Odometer fraud is typically conducted to lower mileage in order to improve the resale price of a vehicle. Here, clocking works in reverse, as higher mileage would trigger eligibility for incentives. The resale-value/eligibility trade-off may dissuade manipulation. Legal provisions against clocking are also strong. In the United States, odometer tampering is a federal crime under Title 49 U.S. Code 32703. In Canada, odometer tampering is illegal under section 27(1) of the *Weights and Measures Act* of 1985. Civil and criminal penalties can be substantial. Therefore, relying on reported usage information from owners, for example collected at the time of insurance renewal, may provide the basis for establish eligibility, perhaps covering multiple years rather than a single year, or perhaps even average annual mileage since the start of ownership.

5.2. Product Heterogeneity and Product Attributes

Consumer choice typically involves multiple alternatives, not just A versus B. The choice set may be large. Consider motor vehicles, where there is a plethora of different choices to consider, each with additional product characteristics and attributes. Only when a consumer has narrowed down choices to a final set of a single A product and a single B product does the above analytic framework apply.

In the discussion above, the purchase cost gap $f_A - f_B$ and the variable cost gap $c_B - c_A$ were fixed for expositional simplicity. If they vary, then $\xi(\omega)$ in (3) may vary considerably more with ω. This additional variation also means that the threshold $u^{\varnothing}$ will not be a constant but a draw from a statistical distribution. Nevertheless, this distribution will be narrowed by the positive correlation between the fixed and variable cost gaps: a larger home needs more heating, for example, or a bigger vehicle has higher fuel consumption. Empirically, this effect can be modelled by drawing the four cost parameters from the distribution of observable choices that the consumer faces. It merely requires determining which choice pairs are the most viable substitutes for each other.

5.3. Complementary Products and Services

Some energy-use durable goods have complementary products (or services) that are required for their deployment or use. For example, heat pumps require installation (a service), and electric vehicles require private charging infrastructure (a product) or public charging station (effectively a service). Costs from complementary products or services need to be taken into consideration for life-cycle ownership costs. These complementary products and services can also be subject to the effects of consumer myopia.

Consider EV charging infrastructure. Private chargers would typically be installed soon after acquiring an EV, if not already present. The extra cost would be taken into account by an EV purchaser at face value. However, the cost of using public EV chargers is subject to operational costs that accrue over the lifetime of vehicle ownership, and therefore are subject to consumer myopia. This can have competing effects. On one hand, use of public charging stations could be more expensive over the lifetime of ownership than paying for a private charging station, especially if the time cost of spending time at public charging stations is taken into account in addition to the higher cost per kilowatthour. On the other hand, such a higher cost may be misperceived in the presence of consumer myopia, and actually lead to a reduction of the perceived cost gap. Consumer myopia may also bias the decision of the appropriate choice of complementary infrastructure.

Ultimately, the need for complementary products and services may add to the purchase cost gap. The perceived availability (or scarcity) of public complementary infrastructure may also add additional uncertainty to the purchase decision.

5.4. Private Benefits and Public Benefits: Internalities vs. Externalities

Any policy that aims at correcting consumer myopia in the context of environmental externalities generates both private and public benefits. The public benefits arrive in the form of emission reductions. The private benefits arrive in the form of lower realized costs to the consumer as consumer myopia was preventing the consumer from making the beneficial choice of adopting good A that has a lower life-cycle cost than good B, but was not correctly perceived as such.

There is a compelling case for public policy aimed at correcting negative externalities such as pollution. However, the case for using public policy to correct private internalities is much weaker. The case hinges on the link between internalities and the negative externalities that they generate. If internalities only had private consequences, the case for corrective policies would still be present but would likely only focus on informational or educational interventions. The case for correcting internalities is much easier to make if the objective is focusing on externalities at the same time.

5.5. From Subsidies to Penalties: Feebates and Bonus-Malus Systems

From a political point of view, governments will prefer subsidizing (fewer) early adopters rather than penalizing (many more) early resisters. The total sums involves tend to be small at first, with limited budgetary impact. When the environmentally-clean good A becomes more attractive—either because continued innovation drives down the purchase cost gap, or because of the the subsidies—the fiscal strain may jeopardize the policy.[8] Subsidies will become fiscally unaffordable. Switching to penalizing purchases of good B becomes politically more attractive when the pool of buyers of good B shrink.

As discussed earlier, the policy intervention Λ is indifferent about which side it is applied to from an efficiency point of view: as a subsidy for buying A or a penalty for buying B. Switching from subsidizing good A to penalizing good B can be gradual, rather than one or the other. This principle has been applied already effectively. In North America, it is mostly known as a "feebate" (Rivers and Schaufele, 2017; Ramji et al., 2024), while in Europe is often referred to as a "bonus-malus scheme" (D'Haultfœuille et al., 2014; Kühlert and Schlüter, 2024). There is an extensive literature that explores the economic dimensions of these schemes. The point is that feebates and bonus-malus schemes can be designed so as to balance rebates/bonus

[8] In Canada in early 2025, popular EV subsidies exhausted the allocated budget.

and fees/malus to make the schemes revenue-neutral. The level can also be tweaked to address particular distributional outcomes.

Zero-Emission Vehicle (ZEV) mandates bypass the fiscal impact issue altogether as they work through the market. Non-compliant manufactures are required to purchase compliance credits from compliant manufacturers, or alternatively pay the mandated penalty. Compliance costs can be expected to be passed on to their customers as a combination of lower prices for ZEVs and higher prices for conventional vehicles. ZEV mandates solve the bonus-malus allocation problem through market forces.

5.6. Political Economy: The Cost of Raising Revenue

Subsidies require financing through taxes or increased public debt. There is an attached cost to raising this revenue both in term of administrative overhead as well as opportunity costs for other uses. For the government the welfare maximization problem[9] then includes an additional term that puts a weight on the required revenue $\mathcal{X}$. This weight is $\Upsilon \in [0, 1]$. Therefore:

$$\mathcal{W} = \mathcal{U} - \mathcal{C} - \Psi \mathcal{Z} - \Upsilon \mathcal{X} \tag{35}$$

The magnitude of Υ will depend on the financing scheme. If general revenue is used, Υ will tend to be higher than when a revenue-neutral feebate scheme is used, or a mandate that puts the burden on car manufacturers to create the required price gap through price changes. Modelling an adjusted welfare function is straight-forward as $\mathcal{X}$ can be quantified readily. Essentially, welfare losses associated with the volume $\mathcal{X}$ of redistribution are non-negligible economically, but they may also express a political cost.

5.7. Biofuel Mandate

Carbon pricing can have an effect on the intensive margin not only through reduced use of combustion engine vehicles. A carbon price also makes biofuels more cost effective. Using biofuels, either blended or directly (as “blend-in” or “drop-in” fuels), reduces the average carbon intensity of motor fuels. This policy is immune to consumer myopia. If consumer myopia renders (consumer-side) carbon pricing ineffective with respect to adopting electric vehicles and heat pumps, biofuels are an effective alternative solution because they apply to the entire existing fleet of conventional vehicles.

An effective biofuels policies must take into full account the life-cycle emissions of production, linking incentives to outcomes. For example, British Columbia’s *Low Carbon Fuel Standard* mandates a 30% reduction in carbon intensity of motor fuels by 2030, and a 10% reduction for aviation fuel. A compliance mechanism with tradable compliance credits ensures economic efficiency. Compliance credits are based on the life-cycle carbon intensity of each product stream. In the U.S., section

[9]The positive utility $\mathcal{U}$ from using the energy-using durable good, such as transportation services from motor vehicles or thermal comfort from heating systems, is proportional to usage, and thus (relatively) constant if assumed to be price-inelastic.

45Z of the *Inflation Reduction Act* provides subsidies for some biofuel products (renewable diesel, sustainable aviation fuel) that are also conditioned on life-cycle greenhouse gas emission reductions. Subsidies remain an expensive fiscal proposition as the biofuels industry scales up, and will likely become subject to partisan political battles. Biofuel mandates, by comparison, pass on higher costs to motorists without impact on government budgets. An attached compliance credit market provides economic efficiency and reveals the implied carbon price.

5.8. Consumer Affluence and Purchase Decisions

It has been observed for some time that rebate programs or incentive schemes subsidize many consumers who would have bought an emission-reducing capital good even without the incentive; see for example Chandra et al. (2010) for the early generation of hybrid vehicles. Free-ridership has been studied intensely, recently by Burra et al. (2024) for EV subsidies in Germany.

Linn (2022) also explores the trade-off between equity and effectiveness of EV subsidies, and finds that income-based subsidies are more effective and equitable than uniform subsidies. The EV subsidy schemes in British Columbia has an income eligibility test. Eligibility for the \$4,000 maximum subsidy requires an annual household income below \$80,000 (US\$56,000), and incentives are phased out for household incomes over \$100,000 (US\$70,000).

Rapson and Muehlegger (2023) review EV adoption broadly. They observe that many market failures associated with vehicle use are location-specific and time-specific, which makes one-size-fits-all policies (such as flat EV subsidies) unlikely to create efficient incentives for EV adoption, use, or environmental benefits.

In the context of this paper, an unexplored question is how consumer myopia correlates with consumer affluence. Are higher-income households less prone to consumer myopia, and if yes, is this a function of higher education, fewer liquidity constraints, or different time preferences? Some of these questions have been studied in the economic literature, but not in the context of purchasing capital goods with environmental externalities, or linking these to broader sets of internalities. More research is needed.

6. EV Adoption and the Distributions of Usage and Myopia

The foregoing analysis has shown the importance of two distributions of consumer heterogeneity: usage and myopia. The distribution of usage can be observed quite readily for many types of energy-using durable goods, and in particular for automobiles. The distribution of consumer myopia can be surveyed, but tends to be somewhat imprecise due to differences in study designs, and in any case cannot be readily attributed to specific individuals making purchases. When designing policy, available information can be exploited effectively when choosing among policy options, while information that is only known in aggregate needs to be reflected in the policy intensity. In this section, the adoption decision of electric vehicles is modelled, across a number of different policies and distributions. This question has been explored extensively in the economics literature (Xing et al., 2021).

6.1. Simulation Parameterizations

All simulations are based on a set of constants for the choice between EVCs and ICEVs. Parameterizations are as follows: purchase costs are f_A=\$55,000 for the EVC and f_B=45,000 for the ICEV; variable costs are c_A=(\$0.25/kWh)(25kWh/100km) and c_B=(\$1.75/L)(9L/100km); emission intensity is z=(2.3kg/L)/(1000kg/tonne)(9L/100km); the nominal discount rate is ρ=0.05; and the vehicle lifetime is 10 years. Fuel and electricity consumption are based on representative vehicles. The fuel cost is based on a multi-year average in British Columbia, Canada, and includes taxation. Electricity is assumed to be carbon-free. Non-carbon emissions are ignored in this simulation study. Holland et al. (2016) have shown clearly that the spatial heterogeneity in emissions matters hugely for any policy scheme.

Usage distributions can be modelled explicitly from observations. Usage of automobiles tends to follow a log-normal distribution where there is a "fat tail" of long-distance drivers. If empirically a mean U_μ and standard deviation U_σ have been observed, the parameters L_μ and L_σ of the log-normal distribution are given by $L_\mu = \ln(U_\mu) - \ln(U_\kappa)/2$ and $L_\sigma = \sqrt{\ln(U_\kappa)}$ with $U_\kappa \equiv 1 + (U_\sigma/U_\mu)^2$. Alternatively, mean U_μ and median U_λ of the distribution may be available, in which case the parameters of the distribution are $L_\mu = \ln(U_\lambda)$ and $L_\sigma = \sqrt{2\ln(U_\mu/U_\lambda)}$.

The distribution of consumer myopia is not well known but empirically would be best captured by a beta distribution on the [0,1]-range with two shape parameters. This distribution is rather flexible. Given shape parameters B_α and B_β, the mean of the beta distribution is $B_\mu = B_\alpha/(B_\alpha + B_\beta)$ and the mode is $B_\kappa = (B_\alpha - 1)/(B_\alpha + B_\beta - 2)$. When the mode is zero, then $B_\alpha = 1$ and $B_\beta = 1/B_\mu - 1$, and the probability density function of the Beta distribution decreases monotonously. The Beta distribution can cover a wide range of outcomes, convex and concave shapes, and can be calibrated by estimating the distribution's shape parameters.

6.2. Baseline Simulation Results

Results of the baseline simulation are shown in table 4, based on one million draws of vehicle owners. Five policies are evaluated. The first row shows results without any policy. The second row shows the policy with a socially optimal carbon price of Ψ. Note that in Canada, the SCC at \$250/tonne is more than three times as high as the prevailing carbon price \$80/tonne. The third row, "cond./max. subsidy," shows the result of paying every EV buyers the full purchase price difference $f_A - f_B$, conditional on usage exceeding usage level u^Ψ at which EV ownership is optimal in the absence of myopia. This approach eliminates myopia completely, and thus serves as a useful comparison point. The fourth row, "flat-rate subsidy," shows the optimal flat subsidy $\bar{\lambda}$, which is found through numerical optimization.[10] The optimal rate is shown as a fraction of the $f_A - f_B$ difference. The fifth and last row, "usage-based subsidy," finds the usage level $u^\blacktriangleleft$ (reported in kilometers) at which the full $f_A - f_B$ subsidy applies, whereas at usage levels below only the fraction $u(\omega)/u^\blacktriangleleft$ of the maximum subsidy is paid. Recall that the usage-based subsidy is proportional to usage but cannot exceed $f_A - f_B$.

[10]The code is implemented in the R language, and the `optimize` function in the stats package is used for determining optimal policy levels.

The first and second data columns in table 4 show the percentage share of EV buyers and the percentage share of buyers who are myopic—for whom buying the EV is objectively optimal but who end up buying an ICEV instead. Column $\mathcal{C}$ shows total average life-time ownership cost (i.e., fixed cost plus variable cost). Column $\mathcal{Z}$ shows the lifetime carbon emissions in tonnes per vehicle. Column $-\mathcal{W}$ shows the welfare implication, defined as $\mathcal{C} + \Psi\mathcal{Z}$. Column $\mathcal{X}$ shows the cost to government, per vehicle, of the policy scheme. This can be thought of as the effective per-vehicle subsidy (or tax)—but across the entire vehicle fleet, not simply the subsidized EVs. Also recall that with the base parameterization, $f_A - f_B$=\$10,000.

Table 4: Simulation of EV Adoption Under Myopia

Policy	Buyers [%]	Myopic [%]	$\mathcal{C}$ [\$]	$\mathcal{Z}$ [tonne]	$-\mathcal{W}$ [\$]	$\mathcal{X}$ [\$]	Rate
Without Policy	15.8	14.4	58,104	12.24	61,164		
Carbon Pricing	31.4	20.7	57,896	8.38	59,991	2,095	
Cond./Max. Subsidy	52.1	0.0	57,995	4.08	59,016	5,210	8,659
Flat-Rate Subsidy	54.0	22.2	58,382	4.52	59,512	3,281	0.6079
Usage-Based Subsidy	54.1	10.0	58,108	3.90	59,082	4,780	14,044

The baseline results in table 4 tell an interesting story. Without policy only one in six people would buy an EV. With carbon pricing, this share rises to over one in three, but roughly one in five buyers ends up buying an ICEV even though an EV would be cheaper on a life-cycle basis. Emissions drop from about 12 to about 8 tonnes.[11] The conditional maximum subsidy is, naturally, the most expensive policy, eliminates myopia completely, and brings EV adoption to over one-half. The optimal flat-rate subsidy turns out to be at about 61% of the purchase cost difference, and boosts the number of EV buyers to 54%. Emissions are slightly higher than in the maximum subsidy case because the flat rate allows for more myopic buyers with high mileage (and emissions). Lastly, the usage-based subsidy has the highest proportion of EV buyers and the lowest emissions, as it is more effective at reducing the number of myopic buyers than the flat-rate scheme. The cut-off point at which subsidies reach the full cost differential occurs at about 14,000 km, 17% higher than the 12,000 km mean, and 55% higher than the median. Still, this scheme is more expensive than the flat-rate scheme, but by construction less expensive than the maximum subsidy scheme.

Which policy is best? Carbon pricing clearly under-delivers. The conditional maximum subsidy scheme turns out to be the best overall choice in terms of the welfare metric—but only if the unit cost of redistribution Υ is nil. Recall that this scheme is conditional on eligibility threshold u^{Ψ} defined in (17). This conditional subsidy is expensive, but keeps the life-cycle ownership cost low while delivering very substantial emission reductions. The usage-based subsidy reduces myopia the most and emissions the most, and comes in with a better welfare metric compared to the flat-rate subsidy. On the other hand, the flat-rate subsidy has a lesser distri-

[11] Observe that the row "Carbon Pricing" assumes that the carbon price is set a the socially-optimal SCC. Actual carbon prices in Canada are much lower and thus achieve far fewer emission reductions.

butional burden than either the usage-based subsidy and the maximum/conditional subsidy. In the end, there is no clear winner if there is an administrative or political cost Υ to the size of redistribution implied by $\mathcal{X}$.[12] From the perspective of redistribution volume, carbon pricing is the "cheapest" option because it is relatively ineffective. Among the other options, the flat-rate subsidy has lower redistribution volume than the usage-based subsidy. All three alternative policies are reasonably effective environmentally.

The bottom line, then, is that all three subsidy schemes are viable policy alternatives if all decision parameters are taken into consideration. There is unfortunately no clear winner here. At least in the base case, a flat-rate subsidy scheme remains quite defendable—although it remains subject to the spatial heterogeneity critique by Holland et al. (2016).

6.3. Different Distributional Myopia and Usage Assumptions

Turning to exploring the effect that myopia and usage distributions have on the outcome, using a simulation model has the advantage of being able to isolate the effect of changing specific set of parameters.

Figure 1: Simulation Distributions

(a) Myopia

(b) Usage

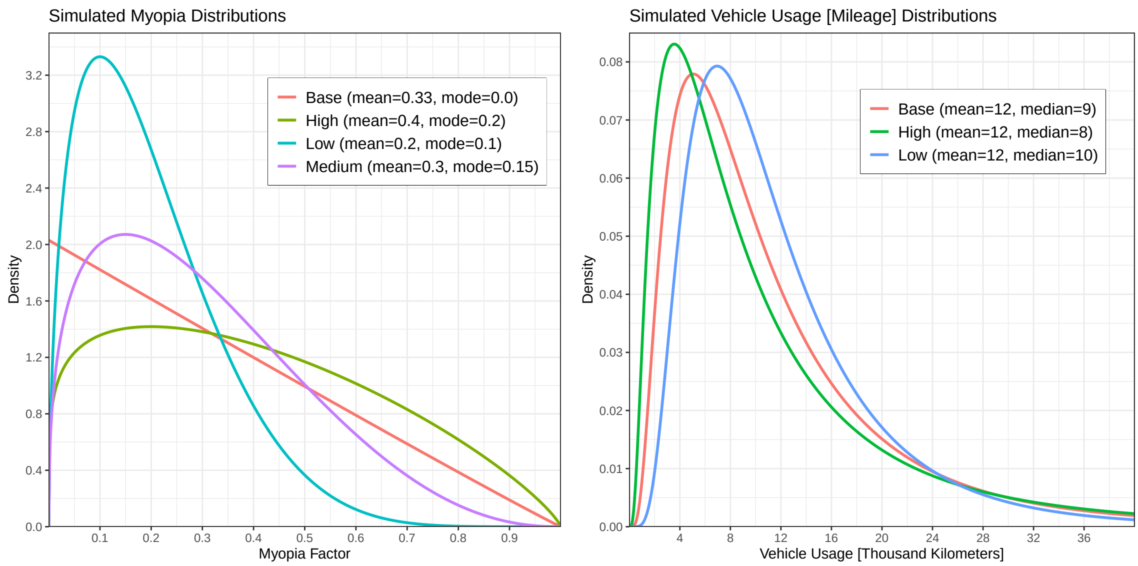

Figure 1 shows the set of myopia and usage distributions that will be explored. Panel (a) shows the four myopia distributions, all of them Beta distributions with the mean and mode shown. The "base" case follows the simple theoretical structure of a triangular distribution (which can be mimicked by a Beta distribution as well),

[12]The astute reader is encouraged to re-calculate welfare with some positive Υ. The administrative cost, embedded in Υ, may depend on the scheme. The flat-rate subsidy is administratively simple as it only depends on observing EV purchases. The usage-based policy and the conditional maximum subsidy both require information about usage, which entails the administrative burden of collecting this information for determining eligibility or calculating the subsidy.

while the "low", "medium", and "high" distributions have myopia factor means of 0.2, 0.3, and 0.4, respectively, with a mode that is one-half of the mean. Thus the "low" distribution has the bulk of consumers with low myopia.

Panel (b) in figure 1 shows the set of three log-normal usage distributions, all with a fixed mean of 12,000 kilometers per year. The "low", "base", and "high" distributions have increasingly larger standard deviations (7,960km; 10,583km; and 13,416km) that correspond to observed medians of 10,000km, 9,000km, and 8,000km. So "low" and "high" identifies variance, and is inversely related to the median.

Table 5: Simulation of Different Myopia Distributions

(a) Low Myopia, mean=0.2, mode=0.1

Policy	Buyers [%]	Myopic [%]	$\mathcal{C}$ [\$]	$\mathcal{Z}$ [tonne]	$-\mathcal{W}$ [\$]	$\mathcal{X}$ [\$]	Rate
Without Policy	20.9	9.2	57,738	10.34	60,322		
Carbon Pricing	40.0	12.1	57,729	6.16	59,269	1,540	
Cond./Max. Subsidy	52.1	0.0	57,987	4.08	59,008	5,206	8,659
Flat-Rate Subsidy	52.8	12.1	58,074	4.12	59,104	2,622	0.4968
Usage-Based Subsidy	52.7	6.5	58,025	4.02	59,030	4,268	17,340

(b) Medium Myopia, mean=0.3, mode=0.2

Policy	Buyers [%]	Myopic [%]	$\mathcal{C}$ [\$]	$\mathcal{Z}$ [tonne]	$-\mathcal{W}$ [\$]	$\mathcal{X}$ [\$]	Rate
Without Policy	16.7	13.5	57,984	11.78	60,931		
Carbon Pricing	33.4	18.8	57,782	7.70	59,708	1,926	
Cond./Max. Subsidy	52.1	0.0	57,996	4.08	59,016	5,214	8,659
Flat-Rate Subsidy	53.7	19.5	58,235	4.26	59,301	3,103	0.5780
Usage-Based Subsidy	53.6	9.2	58,075	3.94	59,060	4,645	14,871

(c) High Myopia, mean=0.4, mode=0.3

Policy	Buyers [%]	Myopic [%]	$\mathcal{C}$ [\$]	$\mathcal{Z}$ [tonne]	$-\mathcal{W}$ [\$]	$\mathcal{X}$ [\$]	Rate
Without Policy	13.1	17.0	58,269	13.20	61,569		
Carbon Pricing	26.9	25.1	57,970	9.53	60,353	2,383	
Cond./Max. Subsidy	52.0	0.0	57,984	4.09	59,006	5,204	8,659
Flat-Rate Subsidy	54.1	27.4	58,471	4.70	59,646	3,565	0.6589
Usage-Based Subsidy	54.1	11.9	58,101	3.89	59,074	4,922	13,009

The effect of variations in consumer myopia are explored with simulations whose results are reported in table 5, corresponding to the distributions shown in figure 1, panel (a). The three panels (a), (b), and (c) in table 5 show results in increasing order of consumer myopia (and myopia dispersion). Unsurprisingly, there are more myopic buyers in the high myopia case (17%) than the low myopia case (9%), and inversely, fewer EV buyers when myopia is high. Carbon pricing becomes less effective as myopia increases. Higher degrees of myopia are inevitably linked with higher overall emissions without policy, and even with carbon policy.

The cond./max. scheme performs equally in all three scenarios because it only depends on constants and not the level of myopia. The cost of the policy is therefore the same across scenarios (allowing for a tiny bit of statistical noise across simulations). The flat-rate policy requires ever more aggressive subsidy rates to overcome increasing myopia, and the usage-based subsidy requires lower and lower usage points at which the full cost gap is subsidized.

Comparing welfare cost and government transfers across the three policy alternatives to carbon pricing, switching from a flat-rate subsidy scheme to a usage-based subsidy scheme becomes more attractive as myopia increases. The usage-based scheme has lower private cost and noticeably lower emissions, and the welfare gap grows from \$73 per vehicle to \$570 per vehicle. Whereas in the low-myopia scenario the government transfers for the two policies have a 1.61 ratio, that ratio shrinks to 1.36 in the high-myopia scenario. The bottom line, then, is that moving from a flat-rate subsidy scheme to a usage-based incentive scheme may be worth considering. Recall that the government transfers $\mathcal{X}$ are neither welfare gains nor losses—they are merely redistribution. Which policy is superior thus depends on the magnitude of Υ, the unit cost of redistribution. The numbers also show that a usage-based subsidy scheme is much more effective at reducing consumer myopia than the alternatives (except the cond./max. scheme which eliminates myopia by construction).

Table 6: Simulation of Different Usage Distributions

(a) Low Mileage Dispersion, mean=12,000km, median=10,000km

Policy	Buyers [%]	Myopic [%]	$\mathcal{C}$ [\$]	$\mathcal{Z}$ [tonne]	$-\mathcal{W}$ [\$]	$\mathcal{X}$ [\$]	Rate
Without Policy	14.7	16.8	58,624	13.64	62,033		
Carbon Pricing	33.8	25.6	58,445	9.08	60,715	2,270	
Cond./Max. Subsidy	59.4	0.0	58,628	3.91	59,606	5,937	8,659
Flat-Rate Subsidy	62.0	24.7	59,080	4.32	60,160	3,833	0.6180
Usage-Based Subsidy	61.9	11.8	58,767	3.67	59,685	5,419	13,903

(b) High Mileage Dispersion, mean=12,000km, median=8,000km

Policy	Buyers [%]	Myopic [%]	$\mathcal{C}$ [\$]	$\mathcal{Z}$ [tonne]	$-\mathcal{W}$ [\$]	$\mathcal{X}$ [\$]	Rate
Without Policy	16.0	12.3	57,563	11.04	60,323		
Carbon Pricing	29.2	17.2	57,350	7.71	59,276	1,926	
Cond./Max. Subsidy	46.4	0.0	57,404	4.07	58,422	4,642	8,659
Flat-Rate Subsidy	47.9	19.6	57,738	4.48	58,858	2,889	0.6035
Usage-Based Subsidy	47.9	8.7	57,491	3.95	58,477	4,255	14,210

The results in table 6 explore the effects of variation in the usage distribution. Holding the mean constant at 12,000km, the two panels (a) and (b) show low and high dispersion, respectively. The base case in table 4 sits right in between. In the high-dispersion scenario, there are many more motorists with very high mileage.[13] In the absence of a public policy, EV adoption is roughly the same, but the high-dispersion case has fewer myopic buyers because the high-usage types have a much easier time judging the benefits of EV adoption. Therefore, emissions are also lower in the high-dispersion case. Carbon pricing reduces emissions by roughly a third regardless of mileage dispersion.

Looking at the three policy alternatives to carbon pricing, there is a stark difference. When usage dispersion is high, these policies deliver far fewer EV buyers (48% versus 62%). These policies also deliver slightly fewer emission reductions as

[13] In a log-normal distribution, the log of the mean-to-median ratio constitutes a measure of dispersion.

a result. On the other hand, higher usage dispersion reduces the policy intensity (lower subsidy rate or higher usage threshold), and thus reduces the redistribution burden $\mathcal{X}$.

The bottom line is that the three policy alternatives to carbon pricing are particularly attractive when mileage dispersion is low (despite their higher redistribution burden). Comparing flat-rate subsidies to usage-based incentives, higher welfare gains can be achieved when usage dispersion is low ($477/vehicle) compared to when usage dispersion is high ($384/vehicle). It is perhaps intuitive that larger consumer heterogeneity weakens the efficacy of policy instruments, even with better (i.e., usage-based) targeting.

6.4. Purchase Cost Heterogeneity

The analysis above was predicated on the assumption of a given set of fixed and variable costs. However, at the time of purchase, consumers may consider a large variety of choices before set; see section 5.2 above.[14] Here, controlling the data generation process in a simulation allows for exploring the effect of heterogeneity on policy systematically.

Table 7 shows result for varying the purchase cost f_A with a coefficient of variation of 0.3 (a standard deviation of $3,300 relative to f_A of $55,000). The true f_A is known to the buyer, but the regulator can only observe the average $\bar{f}_A$ when designing the policy. This means that incentives remain capped at $\bar{f}_A - f_B$.

Table 7: Simulation of Purchase Cost Heterogeneity

Policy	Buyers [%]	Myopic [%]	$\mathcal{C}$ [$]	$\mathcal{Z}$ [tonne]	$-\mathcal{W}$ [$]	$\mathcal{X}$ [$]	Rate
Without Policy	13.5	13.0	58,279	12.91	61,506		
Carbon Pricing	28.1	19.7	58,094	9.06	60,359	2,265	
Cond./Max. Subsidy	51.7	0.3	58,395	4.15	59,433	5,172	8,659
Flat-Rate Subsidy	48.5	22.6	58,579	5.31	59,905	3,110	0.6410
Usage-Based Subsidy	48.5	10.5	58,303	4.72	59,482	4,341	14,681

The results in table 7 show that there are overall fewer buyers of EVs, and public policies become less effective. Higher purchase cost heterogeneity reduces the number of motorists who would consider buying an EV when their preferred EV is more costly upfront.

Because for some buyers $f_A > \bar{f}_A$, the conditional maximum subsidy scheme ends up with some myopia-constrained buyers. The policy is no longer able to eliminate myopia completely. The flat-rate subsidy needs to work harder (with a higher rate) to achieve the highest welfare improvement. The presence of purchase cost heterogeneity improves the usefulness of usage-based information, as this information is more readily observable. This allows pushing out the usage threshold $u^{\blacktriangleleft}$ at which the usage-based subsidy is capped. In turn, this makes this policy approach

[14] With empirical data, consumer choices would be modelled with a random utility model and estimated through the Berry-Levinsohn-Pakes estimator, which would allow for capturing product heterogeneity and identifying the effect of particular product attributes, along with prices.

cheaper than in the base case in table 4, and overall the usage-based subsidy generates almost the same welfare benefits as the more expensive conditional-maximum subsidy.

7. Limitations and Extensions

This study has traded-off algebraic tractability and simplicity for empirical realism. The point of this study is to understand the mechanisms that link carbon pricing (and its alternatives) to consumer myopia. This study highlights numerous knowledge gaps in the existing literature on environmental policy design. Simply put, we need to know much more about consumer behaviour when analyzing the efficacy and efficiency of environmental policy.

The simulation approach in this study can be extended in numerous ways. To keep the analysis concise, only single-parameter subsidy schemes were analyzed (u^{Ψ}, $\bar{\lambda}$, $u^{\blacktriangleleft}$). There are numerous environmental policies that involve two or more parameters. For example, a usage-based policy could have minimum and maximum subsidies, and a slope in between. Multi-parameter policies may be better able to optimize the outcomes, if sufficient empirical information is available to the regulator.

The theoretical treatment in this paper treats the myopia and usage distributions as independent. It would be possible to analyze what happens if there is a positive or negative correlation, or both distributions are correlated with a third distribution (e.g., household income). The simulation tool developed in this paper can be tweaked easily to explore such relationships.

The model also does not allow for spatial variation. As has been shown extensively (Holland et al., 2016; Rapson and Muehlegger, 2023), this matters greatly because it influences both the variable cost gap $c_a - c_b$ as well as the emissions intensity gap $z_b - z_a$, which in this paper was held fixed as a single z. However, spatial variation does not impede the generality of the links between carbon pricing and consumer myopia explored in this paper. Exploring a richer set of cost parameters and emission intensities is possible, calibrating these costs to observed vehicle fleet data.

8. Conclusions

Consumer myopia is a familiar theme for environmental economists. Investments into environmentally beneficial durable goods are hampered by heavy discounting of the future. Some have argued that this behaviour is merely a reflection of rational caution in the presence of uncertainties about future energy prices or usage decisions. Such behaviour could also be a reflection of product characteristics or consumer preferences that are difficult to observe, or imperfect information or information costs, about the future. It may reflect liquidity constraints. And it can also be true myopia in the sense of high present bias. Whatever the reasons, observationally they may look very similar and reveal themselves as a focus on upfront costs rather than life-cycle costs. The outcome is insufficient uptake of energy-efficient or environmentally beneficial investments. In turn, this means that conventional carbon pricing runs into considerable limitations.

The theoretical framework in this paper employs simple assumptions about the distribution of myopia and usage across consumers, and delivers analytically-tractable results that characterize emissions and the effect of carbon pricing. Carbon pricing has rather limited environmental benefit when at the intensive margin usage decisions are highly price-inelastic, and when at the extensive margin adoption of cleaner technologies faces substantial consumer myopia. There are important policy implications. If consumer-side carbon pricing is largely hampered by the aforementioned obstacles, alternative policies should be considered that are environmentally effective and as economically efficient as possible. Information policies will be insufficient to overcome capital cost bias, and effective policies need to aim at front-loading future environmental gains, thus influencing the purchase decision. Fortunately, numerous policies of this type already exist around the world.

The discussion in this paper also points to the need to study consumer myopia more deeply empirically, allowing policy makers to quantify the extent of myopia and take that into full account when designing policies. Similarly, better usage data is needed and is readily observable.[15] The results from simulations in this paper reveal that policy efficacy varies along with the empirical distributions of consumer myopia and usage.

This paper has investigated three policy alternatives to conventional carbon pricing in the realm of durable goods. In addition to a familiar flat-rate subsidy, two usage-based approaches are explored: one with a full (but conditional) cost gap subsidy for whom adoption of the clean alternative is socially optimal, and another one where incentives are proportional to usage but capped at a maximum rate. Usage-based incentive schemes are better at reducing consumer myopia and emissions, and generate higher welfare improvements. However, usage-based schemes require a higher fiscal burden. The policy choice is therefore ambiguous depending on the additional administrative burden or overhead.

Policies to overcome consumer myopia are all costly, but a policy scheme that makes full use of available information on usage of the emission-intensive good that is being replaced will provide the best welfare outcomes in practice. How such a policy is financed matters, as the use of general government revenue for direct subsidies increases significantly as the policy scales up. Revenue-neutral schemes (feebates, bonus-malus schemes) and ZEV mandates may be more desirable politically.

Consumer-side carbon pricing remains politically controversial. There is a legitimate concern about the environmental efficacy of the policy in the presence of consumer myopia when meaningful emission reductions depend on investment rather than consumption decisions. Climate action on the consumer side needs to be aimed squarely at influencing purchase decisions, which the analysis in this paper shows as more effective than carbon pricing. In addition, biofuel mandates can lower the carbon intensity of fuels for the existing fleet of conventional vehicles or heating infrastructure. Well-calibrated biofuel mandates and zero-emission vehicle mandates,

[15] For motor vehicles, usage-based policy interventions may become more feasible in conjunction with other usage-based measures such as usage-based insurance or vehicle-mile traveled taxes. See Holzapfel et al. (2023) for a discussion of usage-based insurance as an emerging new approach to automobile insurance, and Langer et al. (2017) for a discussion of VMTs.

supported by efficiency-enhancing compliance credit markets, appear as the most viable policies that neither create new burdens on government budgets nor create the appearance of new taxation.[16] Continued purchase incentives will need to embrace revenue neutrality to remain fiscally viable.

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[16] Of course, biofuel and ZEV mandates are not perfect. For a discussion of pros and cons of biofuel mandates see Antweiler (2024); for a discussion of ZEV mandates in Canada and California, respectively, see McKitrick (2024) and McConnell and Leard (2021).

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