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Environmental policy, decision making, and rebound effects in the U.S. trucking sector

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ABSTRACT

New technologies and policies have improved the efficiency of heavy-duty vehicles operating in the United States. These improvements reduce transportation costs ($/mile) for firms and raise questions about firm-level responses to these lower costs. Of particular concern are potential *rebound effects* on energy consumption that would partially offset the benefits these new technologies and policies aim to achieve. Although recent quantitative research has suggested that rebound effects in the U.S. trucking sector are negligible, very little has been done to "ground-truth" these results through discussions with transportation firms in the trucking sector. Based on interview results with eight trucking firms, this paper discusses the key factors that influence firm-level decision making within energy efficiency policy regimes. In particular, we focus on elements of the rebound effect and the elasticity of travel activity with respect to fuel efficiency. We find that both direct and indirect rebound effects may be small for reasons discussed in the paper. These results help validate recent empirical studies that point to an inelastic relationship between transportation costs and vehicle miles traveled and help expand our understanding of rebound effects in the trucking sector, thereby providing important information for impact analysis and future policy development.

1. Introduction

Heavy-duty vehicles (HDVs), including large trucks and vocational vehicles such as buses, dump trucks and utility vehicles, consume a significant and increasing share of fuel in the US. For example, HDV Class 7–8[1] energy consumption was ~17.6% of total transportation energy use in 2013,[2] and is projected to reach almost 30% of transportation energy use by 2040 (U.S. Energy Information Administration, 2016; Oak Ridge National Laboratory, 2015). This increasing use of energy in the trucking sector has obvious impacts on emissions of greenhouse gases (GHG) and criteria pollutants, and the US government has been active in promoting technologies and policies that would promote more efficient vehicle operations (EPA & NHTSA, 2011). In particular, the U.S. Environmental Protection Agency (EPA) and the National Highway Transportation and Safety Administration (NHTSA) have promulgated regulations aimed at improving HDV fuel efficiency. EPA now regulates GHG emissions from trucks (e.g., with performance standards for gCO_2/ton-mile), and NHTSA regulates fuel consumption (in gallons/1000 ton-mile). These regulations are being implemented in stages, with Phase I standards affecting trucks produced between model years 2014 and 2018 (The White House, 2014a) and Phase II standards affecting trucks produced between model years 2019 and 2025 (The White House, 2014b).

The ability of these new standards to meet energy and GHG reduction goals is dependent not only on the stringency of the standards themselves, but also on the response to these standards by firms operating in the trucking sector. Researchers are now trying to understand how decision-making by trucking firms are influenced by these standards, which have the interesting impact of possibly *lowering* the operating costs of trucking firms. Of particular interest is the extent of the *rebound effect*, which has been studied extensively in the light-duty vehicle (LDV) sector, but is a nascent area of research for HDVs (De Borger & Mulalic, 2012; Matos & Silva, 2011; Winebrake et al., 2012; Berkhout, Muskens, & Velthuijsen, 2000; Greene, 2012; Greene, Kahn, & Gibson, 1999; Greening, Greene, & Difiglio, 2000; Small & Van Dender, 2005; Sorrell & Dimitropoulos, 2007; Winebrake et al., 2015a, b). A positive rebound effect suggests that as vehicles become more efficient and their operational costs per mile decrease, firms will increase fuel

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[1] We use the US truck classification system in this paper, with Class 7 trucks having gross vehicle weight ratings between 26,001 and 33,000 lb; and Class 8 trucks having a gross vehicle weight rating over 33,000 lb.

[2] Note that this percentage increases when medium duty vehicles (Class 3–6 trucks) are included to 22.7%.

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consumption either directly (through additional travel or behavioral modifications) or indirectly (by passing along fuel savings to customers and inducing greater demand for HDV services) (Winebrake et al., 2012).

Empirical research to quantify the rebound effect for the HDV sector has shown mixed results, with some studies pointing to high rebound effects and others implying negligible effects in both the US (Winebrake et al., 2015a, b; Leard et al., 2015) and in other countries (De Borger & Mulalic, 2012; Matos & Silva, 2011; Wadud, 2016; Wang & Lu, 2014). The variety of results is due to several factors, including the geographical elements of each study; the heterogeneity of the sector; the application of different statistical models; the difficulty in separating direct and indirect effects; and the lack of detailed, disaggregated data on HDV travel behavior, to name a few.

This paper takes a qualitative approach to understanding the basis of the rebound effect in the US trucking sector by considering more generally firm decision making in light of changing policy and fuel price landscapes. In addition to presenting a review of the literature on this topic, we have conducted eight (8) in-depth interviews with trucking fleets to explore how they make decisions with respect to: (1) responses due to fuel price changes or energy efficiency improvements in their fleet; (2) the pass-through of fuel cost savings to customers or others (e.g., shareholders); (3) the management of vehicles; and (4) the management of driver behavior. We also explore their responses in the context of their key objectives (e.g., profit maximization; service quality; safety; etc.) and competitive advantage to better understand how incentives/disincentives might affect firm behavior, recognizing that market share is not based on costs alone. Note that for certain firms or services, there is no need for increased service by customers (i.e. waste management or other services).

Our goals are to use these interviews to gain greater understanding of decision making in the trucking sector to validate existing theory or quantitative findings, suggest new theoretical models for future empirical testing, or identify where additional research is needed. Although our focus is on the US trucking sector, we believe many of our results may also be applied in other international contexts.

The next section provides additional background information related to the rebound effect in the HDV sector, followed by a discussion of our methods and results. The final section places our results in the context of new policies and proposed research necessary to better understand and quantify the rebound effect in the trucking sector.

2. Background and literature review

2.1. Firm decision making in the U.S. trucking sector

Trucking is a complex component of any country's transportation sector, and this is especially true in the US, where companies of different sizes, types, and ownership characteristics help move goods from ports, to manufacturing facilities, to distribution centers, and ultimately to retail outlets and households. The trucking sector is energy intensive, especially compared to other modes of transportation such as rail and ship (Comer et al., 2010; Winebrake & Corbett, 2010; Winebrake et al., 2008), and the sector operates on tight margins where fuel costs can make up 30–40% of total operating costs (Torrey & Murray, 2014).

Adding to this complexity is the fact that trucking carriers are only part of a larger supply chain that includes shippers and receivers who are involved in contractual and market relationships defining not only the prices of transported goods, but also shipment sizes, levels of service, and other supply chain management conditions (Vadali et al., 2007). Thus, trucking firms are faced with making critical, real-time, multi-objective decisions in an environment that is constrained by suppliers, receivers, competitors, and even external conditions (e.g., traffic and weather). These decisions can have meaningful effects on fuel consumption (and therefore profit), and so they must be made carefully. Table 1, adapted from Demir et al. (2014), demonstrates the types of factors under the control of trucking firms that may affect fuel consumption in response to changing fuel costs.

Table 1
Factors that affect fuel consumption in the trucking sector, as adopted from (Demir, Bektaş, & Laporte, 2014) with additions by the authors shown in *italics*.

Category	Factors affecting fuel consumption
Vehicle related	Vehicle curb weight
	Vehicle shape
	Engine size/type
	Fuel type/composition
	Trailer aerodynamics
	Tire rolling resistance
	Hybrid propulsion
	Other (maintenance, age, accessories, etc.)
Traffic/travel related	Speed
	Acceleration/deceleration
Driver related	Driver aggressiveness
	Gear selection
	Idle time
Operations related	Fleet size and mix
	Payload
	Empty miles
	Vehicle miles traveled
	Number of stops

Overlaid on this already complex system is the role of regulation. In the US, new regulations affecting truck fuel efficiency will at the very least change the vehicle attributes mentioned above, especially through manufacturers' application of fuel saving technologies that range from light-weighting, to improved aerodynamics, to hybrid propulsion systems (Guerrero, 2014). These improvements have cost implications, both positive and negative. Vehicle modifications will typically come at a price, either as additional capital costs for vehicle add-ons or through higher initial costs as manufacturers pass along at least some of the costs of fuel saving technologies to trucking firms through higher vehicles prices. But these modifications also reduce fuel consumption at the firm level, lowering operating costs ($/mile) and saving the firms' money. The question we explore in this paper is how these cost implications affect firm decision making and whether those decisions have the potential to create rebound effects in the sector.

2.2. Understanding the rebound effect in the context of firm decision making

The "rebound effect" has received ever-increasing prominence in energy and environmental policy discussions over the past decade (Font Vivanco, Kemp, & van der Voet, 2016). In general, the rebound effect refers to an increase in energy demand resulting from improved energy efficiency. This increased demand could be due to (1) the decreased cost of the energy service, or (2) the increased consumption of other goods and services stemming from the reallocation of energy cost savings. There are various manifestations of the rebound effect in the context of vehicle efficiency examined in the literature (Winebrake et al., 2012; Sorrell, 2007, 2009). These emerge from the idea that vehicle efficiency improvements lower the costs of providing energy-related services (such as freight delivery). Three particular types of effects stand out for the trucking sector:

(1) The *direct rebound effect*, which we define as the increased consumption of energy services by carriers in the trucking sector due to vehicle efficiency improvements; for example, trucks traveling longer routes or at greater speeds because efficiency improvements have reduced their fuel costs per mile.
(2) The *indirect rebound effect*, which we define as the increased consumption of energy services in the trucking sector by customers (i.e., shippers and receivers) due to the pass-through of fuel cost savings from carriers to their customers in the form of lower freight rates due to energy efficiency improvements,

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where these customers thereby increase demand for these services; and,

(3) The *economy-wide rebound effect*, which we define as the increased consumption of energy services outside the trucking sector due to economy-wide market effects caused by energy efficiency improvements in the trucking sector. These effects can be of several different types. For example, such effects are captured if consumers or firms redirect savings due to energy savings on goods and services in other sectors leading to increased energy consumption; or if national efficiency improvements place downward pressure on oil prices generally, thereby stimulating additional demand at a macroeconomic level.

Our distinction between direct, indirect, and economy-wide is determined by where the "consumer response" occurs, understanding that we have defined "consumers" as actors in the context of a trucking sector where consumers (e.g., carriers as consumers of energy) are also "producers" (e.g., carriers as supplying transportation services to shippers and receivers). We define direct and indirect effects as having impacts within the trucking sector (i.e., shipper, carrier, or receiver); whereas we define economy-wide effects as having impacts across other sectors of the economy that may ultimately influence energy consumption patterns. Understanding that carriers and shippers are also "producers" provides opportunities to explore substitution effects for different factors of production – for example, the substitution of labor for energy by carriers if fuel prices rise; or the substitution of one mode of transportation by another if transportation service costs of one mode proves more advantageous than another. Distinctions like this are not often made in the literature, and readers are cautioned to understand each author's definition of the rebound effect prior to interpretation of any results (Winebrake et al., 2012).

Because these definitions are sometimes "muddled" in the literature, a more precise illustration of these effects is depicted in Fig. 1. The top right of the figure shows how fuel prices ($/gal) and vehicle efficiency (gal/ton-mile) lead to transportation costs ($/ton-mile) as observed by "1st Level Consumers" (which in our case represent trucking companies, or "carriers"). Those carriers consume energy (gal) in order to deliver transportation services to "2nd Level Consumers" (i.e., shippers and receivers). The carriers make decisions that affect how much energy is demanded. Those decisions involve issues such as routing, speed, loading capacity, backhauls, etc. When those decisions are influenced directly by transportation costs, we have a direct effect; and a direct rebound effect would occur if efficiency improvements led to carrier decisions that increased energy consumption for those carriers, all else equal.

However, carriers may also make decisions that influence shippers and receivers by passing through reductions in transportation costs through a lower price of transportation services (P_{TS}). Theoretically, those shippers and receivers would be influenced by P_{TS}, and therefore may demand additional transportation services when P_{TS} decreases. Because this effect is not a direct outcome of efficiency improvements (but is indirect through the pass-through of lower costs from 1st level consumers to 2nd level consumers), we call this an indirect rebound effect.

Additionally, there are "3rd Level Consumers" (i.e., actors in the overall economy) who may be affected by decision-making by the carriers *or* by the shippers and receivers. In the former case, carriers who share cost savings with other beneficiaries (e.g., by paying drivers more given shortages in US labor markets, or by sharing additional profits with shareholders) may stimulate economy-wide activity as these beneficiaries spend these savings on other goods and services in the economy. In the latter case, shippers and receivers may pass through any cost savings shared with them by carriers to their customers (consumers) in the form of lower prices for goods (P_G) – potentially leading to additional consumption of these goods and associated energy usage. We call effects that involve a larger set of economic actors economy-wide rebound effects. We also show in the figure a third type of economy-wide effect, and that is when a policy intervention, such as an efficiency standard, reduces the demand for energy by such an extent that the economy-wide price of fuel is reduced, thereby stimulating additional consumption of fuel and/or goods in the economy by 3rd level consumers. (This is shown to the right of the figure with the arrow connecting fuel prices with the economy.)

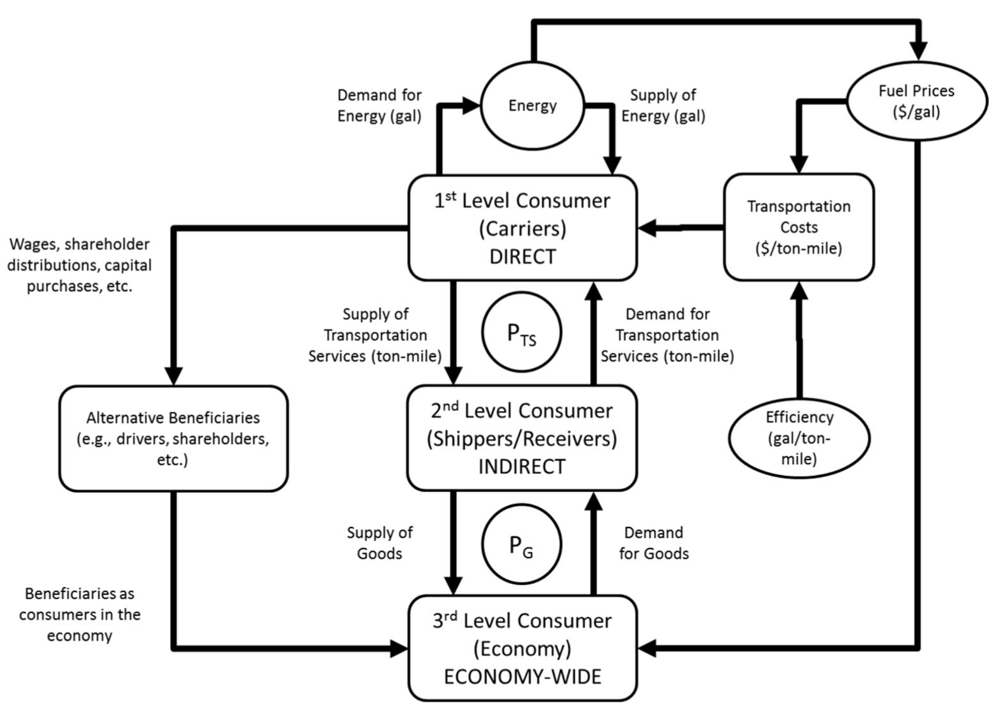

Fig. 1. System diagram of the potential influences of fuel prices and vehicle efficiency on actors in the trucking sector, with special identification of direct, indirect, and economy-wide rebound effects.

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For a more concrete example, consider a national policy that improves the fuel efficiency of trucks within a firm such that the average cost per mile traveled decreases from $0.60/mile to $0.50/mile. If this reduction in transportation cost results in less efficient operations – for example, the trucking firm (i.e., carrier) increases its empty backhauls or the vehicles are driven less efficiently (e.g., at greater speeds) – then a direct rebound effect occurs. If this reduction in cost is passed onto the firm's customers (i.e., shippers or receivers) in the form of lower freight rates, and these lower rates increase customer demand for freight services, then an indirect rebound effect occurs. A trucking firm may also use fuel savings to make investments in labor (drivers) or equipment; drivers now have more money to spend on goods and services,[3] while equipment is associated with embedded energy; both may increase energy use throughout the economy in ways that are not directly related to energy use from increased trucking activity and is what we consider an economy-wide rebound effect. An economy-wide rebound effect may also exist if reductions in fuel consumption depress the overall market price of fuel oil such that demand for fuel oil increases. This paper concentrates primarily on direct and indirect effects, as defined here, recognizing where economy-wide effects may occur.

Compared to the LDV sector, literature on the HDV rebound effect is relatively sparse. What literature exists tends to focus on the direct rebound effect, although often it is difficult to distinguish across rebound categories (see above). Additionally, because publicly available data on in-use operational efficiencies of HDVs are difficult to find, most HDV rebound studies use fuel prices as a proxy for efficiency, since both efficiency (miles/gal) and fuel prices ($/gal) directly affect transportation costs ($/mile). Therefore, what is often taken to be an energy efficiency "rebound effect" in the trucking sector is really an estimate of the fuel price elasticity of freight service demand [either in vehicle miles traveled (VMT) or ton-miles]. For these reasons, estimates for the direct rebound effect in the HDV sector demonstrate quite a bit of variability (Winebrake et al., 2015a, b, 2012; Wadud, 2016; Matos & Silva, 2011; Leard et al., 2015). In this paper we include qualitative analysis on firm-level behavior in response to both fuel price changes and vehicle efficiency changes in order to understand these relationships more clearly.

Empirical studies aimed at quantifying the rebound effect should be framed and validated by theory and assumptions regarding the actual behavior and decision making of key agents in the trucking sector. When quantitative results do not align with these assumptions, one either needs to reframe the quantitative analysis or examine one's assumptions (or both). Some examples of assumptions that may have (mis)directed previous empirical studies or the interpretation of their results include:

1) Firms will exhibit symmetric responses to changes in fuel prices and fuel efficiency, since both affect costs per mile similarly;
2) Fuel cost savings due to efficiency improvements are immediately passed on to customers in the form of reduced freight or transportation service rates.
3) Firms behave solely as cost-minimizers and will implement new technologies if they reduce net costs; firms also treat reductions in capital costs similarly to reductions in operating (e.g., fuel) costs.
4) Drivers will adjust their behaviors (e.g., increase idling, drive faster) such that they consume more fuel when fuel prices decrease.

These assumptions are explored in the following sections.

[3] This is typically described as the *indirect* rebound effect; here we include this in economy-wide, as we distinguish between rebound effects occurring at the driver or firm level as direct – where we look at energy as an input to "production" of VMT for carriers – and those occurring in response to increased demand for trucking VMT by shippers or receivers as indirect.

3. Methods

We conducted detailed phone interviews with eight (8) trucking firms identified through consultation with the U.S. Environmental Protection Agency (USEPA), which assisted in identifying firms for the interview process based on guidelines provided by the authors. We selected firms in order to represent a range of service types [truckload (TL), less-than-truckload (LTL), specialized, rental, parcel]; ownership type (private carrier, for-hire carrier, contract carrier, owner-operator); and fleet sizes.[4] The general characteristics of each firm are shown in Table 2. In most instances, we interviewed a single representative knowledgeable about fleet operations, purchase decisions, and the setting of freight rates. This typically was a manager at a mid-level or higher working in fleet services or operations, although we interviewed the owners of the two smaller firms (Firms E and F), and two representatives from one firm. Interviews were conducted between November 2015 and February 2016.

We asked a series of identical questions to each firm (see Appendix A) taking a semi-structured interview approach. Although more than 20 questions were asked each firm, the questions can be categorized into four areas as shown in Table 3.

4. Results and discussion

4.1. Fuel prices and vehicle efficiency – exploring direct rebound effects

A key question for researchers revolves around the direct response of firms to changes in fuel prices and fuel efficiency. In both instances, transportation costs ($/mile) are affected and the question is whether these changes stimulate behavior by firms that would lead to direct rebound effects. We explored this issue through a series of questions that focused on the following areas:

- How do lower/higher fuel prices affect your operations in terms of trucking activity (e.g., miles traveled)?
- How do more/less efficient vehicles in your fleet affect your operations in terms of trucking activity (e.g., miles traveled)?

Contrary to assumptions implied in other studies, we found that in most cases firms did not see fuel price changes as a major factor affecting how they actually operated. That is, the fuel price elasticity on VMT was inelastic. This was attributed to the fact that given the competitiveness in the sector, firms are aiming for efficient operations *regardless* of fuel price. This general sentiment was summed up by several respondents who providing the following responses when asked if their operations have changed due to recent changes in fuel prices:

- "*[B]ehavior is not changed in regards to operations as this is our business and we do not drive for recreation…[O]ur customers sell products whether fuel prices are up or down, and we must cater to our customers.*"
- "*Fuel prices have not affected behavior and operations are basically the same…[T]he business philosophy is to maximize every minute the driver is out there, so a drop in fuel costs does not cause [the firm] to be more lax with behavior*".
- "*[B]usiness as usual…[W]e haven't changed at all…[D]espite lower fuel prices, there has not been a reduction in [our] desire to reduce fuel usage…*".
- "*I've been doing this for 20+ years. Seen fuel costs at 75 cents/gal and can't say we would do anything less than trying to get good fuel economy and getting good driver behavior. Constantly watch all fuel types, technologies, etc. Always looking at fuel gains. Won't change behavior at all. Monitoring to get better.*"

[4] Given the US EPA's role in helping to select firms, these firms may be more likely interested in efficiency measures – or at least more aware of those measures – compared to the general population of trucking firms; however, we are unable to say for sure whether this is the case and readers are cautioned about possible bias in this sample.

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Table 2
Characteristics of participating firms.

Firm ID	Fleet size and type	Type of ownership	Type of service or distance
Firm A	Approximately 18,000 HDV Class 8 vehicles.	Publicly traded.	Specialized service with short distances.
Firm B	Approximately 200,000 vehicles for lease; 8000 vehicles operated as dedicated contract supply; and 35,000 trucks for commercial rental.	Publicly traded.	Lease, commercial rental, and dedicated contract supply. 100,000–200,000 miles per year.
Firm C	Approximately 6500 Class 8 tractors and 7600 reefer carriers; own 65,000 trailers.	Publicly traded.	Private carrier. ~100,000 miles per year per truck; serves own, integrated operations.
Firm D	8500 vehicles for LTL services; 3000 for TL services.	Publicly traded.	LTL and TL operating as common carriers. TL vehicles operate 100,000–200,000 miles per year and LTL between 80,000–100,000 miles per year. Medium duty trucks range ~35,000–40,000 miles per year. Annual VMT near 1 billion miles.
Firm E	Small (~5 trucks)	Private owner.	Typically short-haul (under 200 miles per route).
Firm F	1 truck	Single owner-operator.	TL one way and LTL on return trip, with total about 100 k miles per year.
Firm G	~4700 trucks and ~12,000 trailers.	Publicly traded.	~100 k miles per year per truck under TL conditions
Firm H	~150,000 owned and contracted vehicles	Publicly traded.	Freight LTL and parcel delivery.

- "*Incremental savings do not matter in the long run and profit margin is not a constant from one truck to another. You operate to the best of your ability in the most efficient way possible*."

Overall these responses tend to validate some of the more recent empirical studies showing low fuel price elasticities of VMT demand (Winebrake et al., 2015a, b; Wadud, 2016). The general sentiment of the firms we interviewed was that they were constantly working to improve operational efficiency – whether fuel prices were high or low. Firms recognized that they operate on slim margins, and that any opportunity to squeeze greater efficiency from their operations should be pursued. Regardless of fuel price, there is an incentive to conserve fuel and reduce miles. As summarized by one respondent: "*There is a huge incentive to reduce empty miles no matter what the costs of fuel*."

Nevertheless, several firms identified other responses to fuel prices that could have some direct rebound implications in terms of energy consumption impacts. These responses are associated with expectations related to service speed, driver performance, new technologies, and vehicle loading. For example, one firm which leases HDVs to other firms noted that as fuel prices increase, firms become more interested in telematics and driver performance, while another noted the importance of fuel price on investment decisions related to new technologies or alternative fuels: "*With fluctuation of fuel price, operations don't change. Just what initiatives become viable is what happens. Certain technologies or fuel make sense when prices go up*."

Table 4 includes quotes related to the types of activities that may increase fuel consumption (or may create lost opportunity for improving efficiency) in times of lower fuel prices. Based on our analysis, we have grouped these quotes into "activity types" (or major issue areas), shown in the first column of the table. Some of the comments from firms indicate a clear (although perhaps modest) direct rebound effect. For example, "service speed" is an area that may be affected by fuel prices. When fuel prices increase, firms are more inclined to control for speed (Boriboonsomsin, 2015). Speed can present an important aspect of the rebound effect, as has been recently shown for certain LDV operations (Galvin, 2016). Speed has been shown to have an important influence on, and is considered a key factor in HDV fuel consumption (Demir et al., 2014; Deng et al., 2016; Walnum & Simonsen, 2015).

Interestingly, Table 4 also illustrates a type of "lost opportunity" associated with fuel price changes. For example, one firm expressed interest in alternative fuels when diesel prices are high, but that interest

Table 3
Categorization of interview questions.

Category	Questions related to…
Fuel prices and vehicle efficiency	Behavioral changes due to changes in fuel prices and vehicle efficiency, and the symmetry of these responses.
Freight rates and the use of fuel savings	Establishing freight rates and the influence of fuel costs and vehicles costs on these rates, the use of fuel savings, and the role of fuel surcharges.
Vehicles	The management of vehicle capital costs and the secondary market.
Drivers	Managing driving behavior and the payment of drivers.

Table 4
Types of activities that may result from changes in fuel prices, fuel efficiency, and fuel costs, with illustrative quotes from interviewed firms.

Activity type	Illustrative quote(s)
Service speed	"*People are not as interested in setting speed limiters at lower speed. [But this is] not an enormous change. If they were set at 65 before…set at 67 now, not 75*."
	"*When we saw fuel at $4.50, the only lever once you have the vehicle is speed…but, sometimes you can actually degrade your fuel economy when you reduce it [too] much*."
	"*When fuel costs are high we might drop the maximum speed from 70 to 65 mph*."
Driver performance	"*As fuel prices come down…going in and fighting over driver performance is not worth it*."
Interest in alternative fuels or fuel saving technology	"*We would look at things that have a better ROI [return on investment]. For example, natural gas we wouldn't look at for $2/gallon, but would at $4/gallon*."
Asset management and route planning	"*[In high fuel price environment], we've seen lots of efficiency gains through technology in asset management and route planning. The LTL market closed 80 facilities and relocated others which saved 185,000 miles/day*."
Vehicle loading	"*When prices are low, we still try to keep the trucks loaded…to make money. But it's not such a bother to get a re-load as it is when prices were high*".
	"*Even though your truck is getting 25% better fuel mileage, when the price of fuel goes up you're still going to try and keep trucks loaded and limit deadheading*".
Trade cycle	"*You have a truck with potential on a new technology to get 8 mpg and the oldest is getting 6.5 mpg. The higher fuel costs may change your trade cycle if there is enough margin to offset capital costs. You may want to bring in new faster*."

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evaporates when prices are low due to low returns on investment (ROI). Thus, fuel efficiency improvements in a vehicle fleet may reduce a firm's interest in pursuing other types of environmentally-friendly activities (such as the use of alternative fuels). Lastly, Table 4 also illustrates some of the temporal asymmetry associated with responses to fuel price shifts. In particular, a firm may respond to a spike in fuel prices through asset management adjustments. These responses may be long-lasting or permanent. If permanent, then the benefits attributed to these adjustments remain, even when fuel prices decrease (or efficiency improves).

A related question we explored was how trucking firms respond to fuel cost savings resulting from fuel efficiency improvements, and if those responses are similar or equivalent to responses to fuel price changes. Firms had different opinions on this, as the benefits from vehicle efficiency improvements are not always immediately obvious (or trusted). Fuel cost savings from improved vehicle efficiency may not actually result in expected cost savings for the firm, due to the increased capital costs or maintenance costs for the vehicles. Because fuel efficiency improvements are often tied to new technologies, firms are cautious regarding how savings are measured and expended, with firms expressing an interest in "saving" or "reinvesting" those funds to meet capital or maintenance expenses associated with new ("unproven") technologies. According to one respondent, fuel efficiency improvements are associated with higher costs in terms of maintenance and repairs, so any fuel cost savings are either set aside in anticipation of these expenses, or are used to pay for these expenses. This type of decision also influences the potential "indirect" rebound effects that would occur under an assumption that fuel savings are automatically passed along to customers in the form of lower freight rates (which then – the assumption goes – stimulates greater demand for freight services). However, if fuel savings were offset by other increased costs, or if savings were set aside or reinvested, then this would offset or eliminate any anticipated reductions in freight rates due to fuel cost savings.

It should also be stated that in no case did a firm say that vehicle efficiency improvements would incentivize them to drive more miles (direct rebound) or to use vehicles in an inefficient manner. As stated by one firm: "*If the fuel economy changed, the behavior would ultimately be the same. Fuel [price] is a bigger concern… Even though your truck is getting 25% better fuel mileage, when the price of fuel goes up you're still going to try and keep trucks loaded and limit deadheading*."

In terms of symmetry, respondents indicate that: (a) the response to fuel price changes is not necessarily the same (equal and opposite) to fuel efficiency changes; and, (b) the response to low fuel prices and high fuel prices is not necessarily symmetric. Firms also indicated that the behaviors taken in response to high fuel prices do not necessarily reverse once fuel prices are reduced; for example, one firm stated: "*When fuel prices go up we look to save in other areas, but you don't let up when the price of fuel goes down*".

Our findings suggest that any fuel cost savings are very unlikely to result in increased VMT driven by HDVs at the firm level – what we call a direct rebound effect. Savings are likely to be reinvested in other areas including driver wages or passed through to retail customers or shippers (see next section); and we recognize that these savings may result in an indirect rebound effect. Nevertheless, our interviews generated some anecdotal evidence of a direct rebound effect – however modest – in terms of energy usage, as lower fuel costs may induce certain behaviors, including speed limiters and alternative fuels (although to what degree remains uncertain). Similarly, lower fuel prices may induce higher speeds through increasing speed settings on speed limiters. However, it should be noted that such effects have not been born out in recent empirical work (Winebrake et al., 2015a, b).

Table 5
Uses of savings due to fuel price decreases or energy efficiency improvements related to indirect rebound effects, with typical quotes from interviewed firms.

Use of savings category	Illustrative quote(s)
Pass savings to shareholders	"*The 'bucket' called earnings-per-share or expansion of business designed to improve shareholder value.*"
Pass savings to shippers	"*When the price of fuel goes down, the firm receives a lower fuel surcharge, so really the shipper gets the savings.*"
Pass savings to retail customers	"*All savings go back to the customer because we are a retailer and we are just an expense (as transportation service). We charge stores transportation costs. All savings go to (retail) customers.*"
Increase driver pay	"*With increased competition in the trucking industry, any fuel savings are directed at driver pay in order to attract more drivers…When the price of fuel goes down, [the Firm] receives a lower fuel surcharge so really the shipper gets the savings. If there are fuel economy savings, that goes to the driver.*"
Reinvest in firm	"*Money is reinvested, but standard operations are not changed. There is either more or less money re-invested [in the firm.]*" "*[Low fuel price] frees up money for maintenance and upgrades to equipment.*" "*When fuel savings occur, that savings is directed towards protecting the business during economic lows. Money is hoarded in the operational account, it's not splurged.*"

4.2. Use of fuel savings—indirect rebound effect

This section focuses on the potential for indirect rebound effects triggered by the pass-through of fuel savings or price increases to customers. Pass-throughs could be done by changing freight rates or using a fuel surcharge, which has become a common practice in the trucking sector and may distort how we think about the impact of fuel prices and fuel efficiency on fleet operations (Winebrake et al., 2015a, b). To understand these impacts, we asked the firms questions related to the following:

- What do you do with cost savings associated with lower fuel prices or vehicle efficiency improvements?
- How does your firm set its freight rates and what is the role of fuel costs in those rates?
- Does your firm use fuel surcharges, and if so, what is the structure of those fuel surcharges?

Regarding what firms did with the savings from lower fuel prices or vehicle efficiency improvements, firms expressed interest in reinvesting in their company; retaining savings as profit; passing savings onto customers or others; and increasing driver pay. Table 5 shows that fuel cost savings can be allocated in a variety of ways and may be hard to track in many cases. (As one company noted, "*Savings is savings, there is no special file*", indicating that money saved on fuel expenditures could be used in any number of ways.)

At least two firms – the owner operators – questioned whether fuel efficiency improvements actually lead to *any* savings, with one firm stating, "*With recent changes in aerodynamics, aero-devices, automatic transmissions, engine programming, [the firm] has seen a "renaissance" in fuel economy. We had to pay dearly for those savings so we do not have extra money because of those savings*." Another firm agreed, providing an example from their fleet related to the purchase of a relatively newer truck v. an older truck, "*Most of the new technology is unproven for the long run. An older truck that was driven for 10 years, including the rebuilding of the engine and transmission replaced, cost roughly $94,000 in repairs over that period…The 2009 truck [modern aerodynamics and lower emissions]…owned for 7 years, cost just under $114,000 in maintenance, not including repairs under warranty (nor a rebuilt engine or replaced transmission)*".[5]

The indirect rebound effect is typically associated with the assumption that fuel savings are passed along to shippers and customers in the

[5] Recognizing that these quotes are from small, owner-operators may help regulators understand the different types of approaches that may be needed for educating firms on the pros/cons of fuel saving technologies and policies.

form of lower rates, thereby stimulating greater shipping demand. However, as Table 5 makes clear, the pass-through of fuel cost savings directly to shippers is not necessarily the norm, and fuel price savings are not necessarily handled the same way that fuel economy savings are handled. There are a number of factors that go into setting rates, including competitive market pressure and the role of other costs (e.g., employee salaries, office supplies, etc.). As one respondent stated concisely, "*Rates are only as good as what the market will stand*." That sentiment applies to markets developed through long-term contracts, brokers, or spot-markets.

Overall, our findings indicate that fuel savings may be reinvested or allocated in a number of ways, and no clear patterns or trends emerged from our interviews to imply that there is a preferred approach to handling fuel savings across firms. In fact, even the same firm may handle savings differently at different times based on other factors affecting their business (e.g., competition, cash flow needs, labor issues, etc.). Several of the responses—i.e. increasing driver pay, reducing prices of goods sold in retail stores, and passing savings onto shareholders—may result in (what we are here calling) economy-wide effects, as these changes will free up income to spend on goods and services throughout the economy, thereby increasing energy consumption or embedded energy in the goods and services consumed. This effect (often termed indirect rebound effects elsewhere), can be nonzero—for instance one study estimated indirect rebound effects for the household sector at 5–8% (Thomas & Azevedo, 2013). Likewise, reinvestments in trucking firms may increase energy use through consumption of goods or services; alternatively, if these investments improve the quality of service or output of service, indirect rebound effects may occur in the form of increased consumption of HDV transportation services, as indirect producer-side rebound effects (Santarius, 2015).

In order to more fully understand the potential for indirect rebound effects, we need to understand the role of fuel surcharges on firm behavior and service delivery pricing. Fuel surcharges have become an increasingly common practice in the trucking sector, and they play an important role in passing fuel price changes onto customers.

The majority of the firms we interviewed had fuel surcharges, which are charges added to freight (or other service) bills to capture changes in fuel prices. One might expect that as fuel efficiency improves, a trucking firm would lower its fuel surcharge to its customers, thereby lowering its effective rate. However, fuel surcharges may be seen as an opportunity to profit if a firm improves the efficiency of its vehicle fleet. For instance, the representative from one company said, "[I]*f we can improve on fuel economy, we win in regards to the fuel surcharge*".[6] Another firm noted that "*you don't use fuel economy, it's all about price*", indicating that the actual fuel economy of vehicles is not reflected in the fuel surcharge, and fuel economy improvements would not necessarily translate into changes in charges to the shipper. One firm interviewed uses a "base" of 5.5–6.0 mpg in their fuel surcharge calculations per guidelines provided by the U.S. Department of Energy. Even though this firm stated that they do not intend to "make additional money off our customers," if their vehicles achieve efficiencies greater than 6 mpg, the firm would profit on the fuel surcharge.[7] This sentiment has been borne out in industry reports, where fleets with the highest efficiency are shown to have the highest profits, while least efficient fleets are shown to have the lowest profits (DAT Solutions, 2013). Table 6 shows four different fuel surcharge approaches, with descriptive quotes for each.

Table 6
Four fuel surcharge structures with illustrative quotes for each.

Structure of fuel surcharge	Illustrative quote(s)
Based on DOE fuel prices	"*There is a baseline fuel costs are compared to, and when they rise or fall [based on DOE EIA weekly fuel prices], the surcharge will increase or decrease*." "*Fuel surcharges based on the weekly index provided by the DoE, which are adjusted on a weekly basis. The surcharge goes up/down based on this information. We don't use the surcharge as a way to make money off the customers, only as a way to recoup expenses… use a baseline of 5.5–6 MPG, which is in the DoE guidelines*." "*You don't use fuel economy, it's all about price, and based on the Department of Energy's national average that comes out every week on Monday. The surcharge is on a cost per gallon and because we charge by the [truckload], the surcharge is the difference between the baseline and the actual cost per gallon, and how many brackets there are between the two determine the extra costs per mile*."
Negotiated individually from base rate	"*They are negotiated individually with the customers from the base rate on up. As freight levels go up and down, it becomes part of the landed cost of fright. No one is wedded to the exact number, as they had been in years past. (The firm) charge by the mile so if we can improve on fuel economy we win in regards to fuel surcharge*."
Brackets	"*Fuel price is pegged with shippers at a certain number, such as $1.20, and then we have "brackets"…so every time the cost of fuel goes up, you add 1 penny to the rate. If it comes down, you take away a penny. This allows us to recover about 85% of additional fuel costs*."
Lagged and dynamically indexed	"*They are dynamically indexed. The surcharge typically lags…weeks behind whatever the price of fuel is on the market. If fuel prices go up, the surcharge goes up, and if prices go down typically the price goes down as well*."

4.3. Capital costs of vehicles

A third part of our interviews focused on vehicle purchase decisions and how vehicle capital costs potentially affect freight rates or other pass-through costs that could stimulate indirect rebound effects. As more efficient vehicle technologies often have higher capital costs, it is uncertain if firms pass along these costs to customers, and potentially offset the fuel savings benefits that could go to customers in the form of lower freight rates or fuel surcharges (see previous section).

Through our interviews we found that some firms passed along all capital costs – less the residual value expected on the secondary market – to their customers in the form of increased freight rates; that is, capital costs are embedded in their freight rates (along with a mix of many other factors). Therefore, customers do absorb some of the capital cost increases associated with more efficient vehicles. As an example, when asked if increased capital costs are passed onto customers, one firm responded, "*Not in a direct ratio, but it gets figured into the base rate*".

However, the entire incremental capital cost for a more efficient vehicle does not appear to be completely absorbed by the first owner of the vehicle. Some of the incremental cost is passed onto the second owner. As one firm responded, "*Automated transmission, improved fuel economy, the cost of that technology is reflected in the residual value. Secondary market value reflects the original value. So, a truck that originally cost $100k may cost $35k on the secondary market, while a vehicle that originally cost $110k would cost $38k on the secondary market*." Additionally, prices of efficient vehicles are higher on the secondary market when fuel prices are higher.

This situation is also true for leases, where capital costs are passed on to the lessee. One firm, which leases trucks to other trucking/freight companies, stated that lessees are charged a rate which accounts for increased capital cost of the vehicle, but also accounts for the residual value that the firm expects to get when selling the truck on the secondary market after the lease term.

[6] In two cases interviewees who do not use fuel surcharges stated that fuel costs are passed on entirely to customers. One respondent in particular noted that his firm does not work with fuel surcharges, and they bill the actual cost to move the freight. Another respondent noted that they do not have fuel surcharges, but "we have where fuel is completely pass-through".

[7] Pre-interview conversations with trucking industry experts brought this concept to light, stating that "Currently companies have low margins of about 3–10%. Note that with a more efficient vehicle, you can use the surcharge (which has the 6 mpg denominator) to make more money."

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Table 7 shows two main results of increased capital costs, as reported by firms in interviews, along with illustrative quotes by respondents. In sum, the assumption that higher capital costs for more efficient vehicles are passed along to customers – thereby offsetting some of the downward freight rate pressures from more efficient vehicles – seems to be valid. However, firms recognize the secondary market for these vehicles and so may not integrate the full incremental capital cost into their rates, knowing that they will have some return on their capital in that secondary market. Further, the extent to which the residual value is passed on may be a function of fuel prices. This may have important implications for future analyses of indirect rebound effects in terms of incorporating effects of increased capital costs into fuel cost savings estimates.

4.4. The role of drivers and driver behavior

A final aspect of our interviews focused on firm behavior with respect to the role of drivers, and driver behavior as a mechanism affecting fuel consumption. In theory, more efficient vehicles and lower transportation costs may disincentivize drivers from performing as efficiently as possible (see Section 4.1 regarding the direct rebound effect); and driving behavior can have an important influence on fuel consumption (Walnum & Simonsen, 2015; Stichter, 2012). But the response of drivers to fuel price stimuli is really a function of whether drivers are directly affected by efficient operations, and whether any incentives or opportunities exist for drivers to operate less efficiently. Said another way, what role and stake do drivers have in the overall performance of their vehicle?

The answer to this question is complicated due to issues such as vehicle ownership, driver compensation models, profit-sharing, and other external factors (e.g., federal regulations that affect driving patterns). For example, regarding driver compensation, firms in our sample suggested that driver behavior is related to how a driver was paid (by the mile, by the hour, by the trip, or a hybrid of these). For drivers paid by the mile (typically TL and LTL while on the road), firms recognized that speed may increase in theory; however, firms indicated that they use speed limiters to minimize this, and that they monitor behavior closely and provide incentives for drivers to operate efficiently. As one respondent stated, "*Our drivers, like most in the truckload sector, which accounts for about 78% of all U.S. freight, are paid by the mile. They also receive incentive pay when they perform well. For example, a driver who hits the fuel economy goal will get a retroactive bonus based on the miles operated over the period. This would be in addition to their base pay. Incentive pay is in place for several areas including fuel economy, safety, customer service, etc*." These incentives may offset any personal economic gains a driver would see due to driving faster.[8]

For drivers paid by the hour (typically LTL in service center or local delivery), speed is not a factor. Even truckload (TL) payment schedules are moving into hybrid formats with drivers now paid a base amount with a bonus per mile if they perform well, with fuel economy being one area of performance.

Lastly, almost all firms incorporated driver training as part of their operations, and several had intensive driver monitoring programs that provide their firms with feedback on driver behavior, which has become a best practice for the sector (Walnum & Simonsen, 2015; Stichter, 2012; Dubey & Gunasekaran, 2015). Firms also used telematics to plan routes, minimize costs, and track driver operations, and drivers can be called if they deviate from pre-planned routes that are designed to be as efficient as possible – again, no matter what the price of fuel or the fuel efficiency of the vehicle. The general theme was to provide drivers as much guidance, training, information, and direction as possible to maximize efficiency. As one respondent stated, "*The biggest trend right now is making it easier for the driver to get good fuel economy. The biggest contributor to that is the automatic transmission that uses smart controls and takes decision making away from the driver*."

Our interviews imply that firms take management of their drivers seriously and work to implement fuel saving operations and encourage good driving behavior whenever possible. The fact that drivers may be driving more fuel efficient vehicles does not seem to affect this sentiment. As suggested in Section 4.1, the incentive for increased speed and less efficient operations with lower fuel costs applies at the level of the trucking firm—where firms compete with other firms not only on price but on quality of service, which includes speed of delivery. Decision-makers noted that lower fuel costs have in some cases led to less stringent controls and speed limits on speed limiters, and have led to less emphasis on maximum efficiency in loading, and driver performance, etc. Our interviews suggest that drivers work within the constraints and incentive structures established by upper-level management in the firm. Therefore, we expect direct rebound effects from driver decision-making to be negligible.

Table 8 shows approaches in which firms control or incentivize driver behavior, including efficient operation.

5. Conclusion and policy implications

This paper presents the results of in-depth interviews with eight trucking firms of different types. Our goal was to better understand the way firms think about and react to fuel prices and vehicle efficiency, which is an important area of study given new federal regulations that mandate cleaner, more efficient vehicles for the US trucking sector. These regulations have the potential to create both direct and indirect rebound effects, and the interviews attempted to better understand the size of these potential effects from the perspective of trucking firms.

We find little evidence from our interviews of direct rebound effects with respect to vehicle miles traveled in response to improved efficiency. Firms, for the most part, operate to minimize costs while meeting service expectations no matter how efficient their vehicles are. Adding extra miles simply doesn't make sense for a firm operating in a competitive environment. In contrast to the light-duty (passenger) vehicle market, the HDV driver does not derive additional utility from traveling more miles. These results help validate recent quantitative, empirical work that shows negligible fuel price elasticity with respect to VMT.

However, our interviews do suggest the potential for direct rebound effects in the HDV sector in other respects. Respondents indicate that in seeking to better serve the customer, reduced fuel costs may induce increased energy use per mile or per ton-mile, resulting from increased travel speed or other operational inefficiencies such as less emphasis on driver performance or maximally efficient loading—which in turn can lead indirectly to increased VMT.

As for indirect and economy-wide rebound effects, we find mixed results that are a function of the particular firm and how it manages any savings resulting from improved vehicle efficiency. For example,

Table 7
Distribution of vehicle capital costs with typical quotes from interviewed firms.

Vehicle capital costs	Illustrative quote(s)
Passed onto customers in rates	"[Vehicle capital costs are] *not* [passed on] *in a direct ratio, but it gets figured into the base rate*".
Passed onto secondary market	"*…improved fuel economy, the cost of that technology is reflected in the residual value. Secondary market value reflects the original value. So, a truck that originally cost $100 k may cost $35 k on the secondary market, while a vehicle that originally cost $110 k would cost $38 k on the secondary market*." "*When fuel prices are high, yes [the secondary market reflects the higher capital costs of high efficiency trucks]. When they're down…no, [the higher capitals costs are not reflected in the secondary market]*."

[8] An exception is whether speed is needed in order to meet service conditions that may be at risk under new federal constraints on the number of hours a driver may drive each day. This has also been identified in other research (K. Levy, personal communication, 14 April 2016).

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Table 8
Driver behavior and decision-making as it relates to fuel consumption, and illustrative quotes.

Approaches to control or incentivize driver behavior	Illustrative quote(s)
Incentives to encourage efficient operation	"*They also receive incentive pay when they perform well. For example, a driver who hits the fuel economy goal will get a retroactive bonus based on the miles operated over the period. This would be in addition to their base pay. Incentive pay is in place for several areas including fuel economy, safety, customer service,* etc."
Automated controls	"*The biggest trend right now is making it easier for the driver to get good fuel economy. The biggest contributor to that is the automatic transmission that uses smart controls and takes decision making away from the driver.*"

for publicly traded firms, some of these savings go to shareholders; for retailers with their own transportation operations, savings can go to end customers who are purchasing the retail product; for a small trucking firm, savings may go to increase driver pay or take-home pay; and for all firms, some savings will be set aside to meet the anticipated increase in maintenance costs for the new vehicles and technologies. In any event, the interview responses indicate that not all of the savings are shared with customers through reduced freight or service rates, suggesting that increased demand for trucking in response to lower freight costs may not occur. We again note that firms recognize the potential for lower fuel costs to lead to increased speed of service, directly through higher speed limits, but also indirectly through reduced emphasis on efficient loading. In seeking to understand the potential for indirect and economy-wide effects, future research may seek to explore and incorporate into future analyses: a) how fuel price and fuel economy influence speed and other operational efficiencies, and b) demand elasticities for HDV services (in terms of VMT or ton-miles) based on speed of service versus price.

Fuel surcharges make evaluating the indirect rebound effect even more complicated. The structure of fuel surcharges indicates that while fuel *price* changes are always incorporated and passed onto customers, actual fuel *efficiency* of the fleet in MPG may not always trigger such pass-throughs. Therefore, while fuel price changes may be associated with more or less demand for trucking, changes in fuel economy may not have the same effect. This structure implies that firms may profit when their fleet meets an efficiency level that is better than that used in federal DOE surcharge calculations. Firms in this position may not be passing these savings along to customers, but may be taking these additional revenues as profit. As many firms use the DOE MPG index baseline in their fuel surcharge calculations—as opposed to the actual fleet MPG—the effect of efficiency improvements on fuel surcharges may depend more upon whether or not the DOE modifies the MPG baseline in response to new efficiency regulations, versus the actual efficiencies of the fleets using the DOE index and MPG baseline. This in turn will have implications for whether or not rebound effects would more likely be indirect through increased demand by freight customers, or economy-wide rebound through spending of profits throughout the economy.

A key result from our work that warrants future examination is the potential difference in responses of HDV firms to changes in fuel prices versus changes in vehicle fuel economy. Fuel prices have often been used as a proxy for fuel economy changes in transportation rebound effect research, as fuel prices and fuel economy together determine cost per mile. However, responses to fuel prices and fuel economy may differ, as has been shown in research in the light-duty vehicle market (Greene, 2012). Several of the interviewee comments suggest this to be the case for the HDV sector as well. For instance, our preliminary findings included: a) fuel price savings are passed onto customers, while fuel economy savings are allocated to driver pay; b) lower fuel prices can result in reduced emphasis on efficient loading or driver performance, while improved fuel economy does not induce such changes; and c) fuel prices are reflected in fuel surcharges, while fuel economy improvements may not be. Additionally, it was noted that increased capital costs are incorporated into rates, suggesting that while fuel price changes are passed onto the customer entirely, cost savings from fuel economy improvements are offset to a potentially large degree by the increased cost of the vehicle to the trucking firm—in both the primary and secondary market. Each of these distinctions has potentially important implications in terms of the extent to which the rebound effect occurs, and/or the way in which it will manifest—direct, indirect or economy-wide effects. Our findings—albeit preliminary—suggest that rebound effects in the HDV sector may manifest more in the form of indirect or economy-wide effects. Future research may explore further a) how firms' responses to fuel economy improvements differ from responses to fuel prices, changes in particular; and, how these responses may contribute to HDV VMT and energy use, both by HDVs and economy-wide.

In terms of policy implications, our results indicate that the energy savings and emissions reduction impacts of new policies aimed at improving the efficiency of HDVs are not likely to be diminished by immediate direct rebound effects in the form of increased VMT. Indirect demand effects are less certain and other factors (such as global economic growth) will have much more influence on energy consumption and emissions than freight rate effects. The percentage of fuel savings that are passed along to customers can range anywhere from 0 to 100%, depending on a variety of factors; although current empirical work indicates these values are low or not statistically significant (Winebrake et al., 2015a, b). Therefore, any analysis that incorporates an indirect rebound effect by adjusting freight rates by an amount equal to fuel savings would be highly conservative.

Further research, both qualitative and quantitative, is needed in this important area. As HDVs continue to gain an increasing share of energy use and emissions from the transportation sector, further understanding of the direct and indirect rebound effects of all types is required to facilitate appropriate decision-making by firms and policy-makers alike.

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Appendix A. Sample semi-structured interview questions

About your firm. Tell us a little bit about your firm and trucking operations: size of fleet, type of operations (e.g. private or for-hire; TL, LTL or parcel, etc.), quantity/weight transported annually, vehicle miles traveled annually, etc. Who owns the trucks and equipment used by your firm (e.g. leased or owned)?

Response to fuel prices. How has your firm responded (or how is your firm responding) to decreases in fuel prices, in terms of changes to behavior, operations, investments, etc.? How has your firm responded to increases in fuel prices? Is there a certain threshold that triggers certain changes? Do you use fuel surcharges? If so, how are they structured?

Response to fuel economy. If fuel prices were constant, but fuel economy of your vehicles improved, would your firm's behaviors change in a similar way to a decrease in fuel prices?

Response to capital cost increases. When the capital cost of vehicles/equipment increases (or has increased in the past) due to emissions standards or other, how has your firm responded? If vehicles cost more upfront, but they have operational savings (for instance more efficient vehicles have fuel savings), do you incorporate these savings into the purchase decision, or are other factors more important? What is the trade cycle for your vehicles?

Use of fuel savings. When fuel savings occur, do you dedicate the savings in a certain way? For example, do you direct these savings to customers (reduce prices or freight/delivery rates)? Shareholders? Capital investment? Who pays for fuel in your firm?

Cost evaluation and rates. How often would you say your firm's costs and revenues are formally evaluated (i.e. how often are changes in expenditures and revenues formally incorporated into changing customer rates, operations, investment decisions, etc.)? What are the factors/variables that are incorporated/considered in calculating or establishing freight rates? When operational costs change, how does that factor into freight or customer rates?

Competitive advantage. How does your firm choose to position itself against the competition? Which strengths/services/attributes does your firm focus on providing to customers? For instance, how does being the lowest cost firm compare in importance to being the safest or most reliable, or "greenest", etc.? Do these objectives affect your transportation decisions?

On-the-ground operations. Looking to the on-the-ground operations, who makes routing decisions (e.g. the company/backroom operations; the driver; routing software)? What are the primary factors considered in these decisions?

Driving behavior. Are drivers currently given any directions (or incentives) to minimize fuel use or maximize operational efficiency? Does your firm have in place any technical/computer controls to limit speed or idling? If so, when were these implemented/installed? Have you made any changes in terms of their usage since first acquiring them? How are drivers paid (e.g. by the hour; by the mile; other)?

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