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Modeling fuel saving investments and fleet management in the trucking industry: The impact of shipment performance on GHG emissions

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ABSTRACT

Much has been written about the potential of new technologies to reduce the greenhouse gas (GHG) emissions of trucking, but much less on the determinants of these investments. The Trucking Sector Trip Segmentation Model (TSTS) predicts how firms make these investments in the context of operating heterogeneous truck fleets to service the spatially dispersed demand of shippers. This analysis suggests that improving the performance of trucking (speeding up shipments) could significantly reduce GHG emissions: investments in these technologies are incentivized by fuel savings accruing sooner. This effect could be large in the US as trucking firms often discount the future heavily.

1. Introduction

Governments in the US are intervening to reduce the greenhouse gas (GHG) emissions of the trucking sector because they have grown quickly in recent years and now account for 7% of net US emissions (EPA, 2013). For the most part, these interventions have used regulations to improve the technology of trucks to make them more fuel efficient. These Fuel Saving Technologies (FST) have included deflectors on cabs and trailers that reduce aerodynamic drag, tires that have lower rolling resistance, and more fuel efficient powertrains, along with many other off-the-shelf technologies (see Appendix for a comprehensive list). So far, the main interventions at the federal level have been the EPA's SmartWay program that certifies FSTs and encourages trucking firms to voluntarily invest in them (highlighting their cost-effectiveness), and the recently introduced fuel efficiency standard that will mandate manufactures to design and sell more fuel efficient trucks starting in 2016. Sub-national interventions have been led by California with its recent regulation requiring all heavy-duty trucks that operate within the state to be equipped with certain FSTs by 2014 (with some exceptions and a phase-in period).

While these interventions represent the first steps in tackling this pressing sustainability issue, they consist of blunt instruments that were designed without thoroughly considering the incentives and constraints of the sector, partially because of the lack of adequate analysis tools available. For policy makers to design smarter interventions that harness market forces to incentivize improvements in fuel efficiency, they require models of the trucking sector that capture: (i) the key factors influencing how trucking firms invest in FSTs, (ii) the key incentives and constraints that trucking firms face in managing and utilizing their vehicle fleets, (iii) the latent demand responses of shippers, and (iv) the environmental impacts from

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all relevant sources, not just from tailpipes. Thinking about the trucking sector in this comprehensive way is necessary to evaluate the effectiveness and efficiency of interventions, and avoid unintended consequences.

As detailed in the background section, many studies have focused on each of these four areas individually, but few have examined the interactions between them. One of these studies was Guerrero et al. (2013), which introduced the Trucking Sector Optimization Model (TSO) as a tool for predicting short-run responses in all of these four areas. This framework proved useful in describing how truck fleets and their emissions evolve through time in response to different types of governmental interventions. However, it made several assumptions in representing areas (i) and (ii) that limited the range sector responses that could be modeled, making it impossible to evaluate several other interventions that could be potentially very beneficial. This paper introduces an improved model that removes some of these limitations by providing a more realistic and detailed representation of how FST investments are made in the context of managing truck fleets.

Studying these interactions provides insights about features of the trucking sector that have been under analyzed so far and that are generally not considered when designing sector policies. One of these is that historically firms have invested in FSTs at much lower rates than would seem cost optimal. By analyzing the average costs of the sector, Guerrero et al. (2013) found that it is currently optimal for firms to invest more than $40,000 in off-the-shelf FSTs in order to achieve fuel economy improvements of more than 40%. These large investments, which would represent around 30–35% of the average price of a new heavy-duty truck (CARB, 2008a), are rationalized by the fact that around a third of trucking costs come from fuel purchases (Fender and Pierce, 2011).

There exists ample evidence that these large investments in FSTs are generally not taking place in the US, even though there are no publically available surveys for quantifying the magnitude of this shortfall. Indeed, many studies have found that the trucking sector could significantly reduce both costs and fuel combustion by investing more vigorously in FSTs (Frey and Po-Yao, 2007; TIAX, 2008; National Research Council, 2010). In fact, the fuel economy of heavy-duty trucks has not changed significantly over the last 20 years (Davis and Diegel, 2007; CARB, 2011), even after significant fluctuations in fuel prices and increases in the availability of FSTs.[1] This inaction by the private sector has been the primary driving force behind the recent regulations to increase the use of FSTs. While these efforts have been relatively successful so far (long-haul trucks in California look very differently than a couple years ago, with widespread use of side-skirts and other deflectors), they fall significantly short of achieving the reductions in fuel consumption and emissions that are possible and economical.

Other industries have also been observed to have similar "efficiency gaps" (see Gillingham et al., 2009 for a review of this literature). Jaffe and Stavins (1994) explained that these can be caused by various market and non-market failures that create barriers to investments in technologies that improve energy efficiency. Some recent research has found that many of these failures have a strong influence on the European and US trucking sectors (Aarnink et al., 2012; Vernon and Meier, 2012), causing them to operate less efficiently. Even though these are important issues, this paper does not study their nature directly; this will be a topic of future research. Instead, the model of the sector described in this paper captures the influence of some of these barriers, albeit in a simple way, to better characterize how FST investments are made. Jaffe and Stavins (1994) suggested that one way of doing this is through higher than *normal* discount rates, essentially capturing the higher uncertainty that firms face about the future when making these long-term investments. This was the approach adopted in this paper.

In addition to being influenced by market and non-market failures, FST investments are also affected by how vehicle fleets are managed. This includes decisions about how many trucks to purchase, how to utilize them throughout their service-lives, and when to retire them. To clarify, in this paper "truck utilization" refer to the types of services provided throughout the live of a truck (long-haul, dray, etc.), not the size of the shipments relative to the capacity of the vehicles. Truck utilization decisions are important because they determine the timing of costs and revenues in the lifecycle of trucks, impacting how they are valued in the present. Therefore, truck utilization has a direct influence on how firms make tradeoffs across time and select optimal operational strategies, especially with regards to making FST investments. This relationship is stronger the higher that trucking firms discount the future, which from the proceeding discussion can be assumed to be quite high.[2]

For example, slowing down the rate at which trucks make deliveries (by increasing driver rest requirements, for example) would lead vehicle utilization to be spread throughout time, causing variable costs to be discounted more heavily relative to capital costs. This would incentive trucking firms to invest less in FSTs, because future fuel savings would be *worth* less to them at the time of making these investments. Similarly, if a firm's discount rate increased because of new information or additional uncertainties, it would be incentivized to operate their trucks more intensely when newer, when the benefits are more certain, and retire them at a later odometer because maintenance costs (which are increasing) are discounted more heavily.

These interactions between FST investments and the management of truck fleets have not been studied previously in the literature, even though they are likely central to how the industry operates. As detailed in the following section, studies of

[1] For example, from 1988 to 1995 the average fuel economy was 5.8 mpg while from 2000 to 2005 it was 5.6 mpg (Davis and Diegel, 2007). This simple snapshot could be overlooking the effect of changes in truck loads or congestion, but nonetheless it indicates that the sector has not substantially prioritized fuel efficiency in the past.

[2] It is often said in the industry that an investment must payoff within 1–2 years for it to be viable, reflecting high levels of discounting.