Transportation Research Part A 77 (2015) 154–166

Contents lists available at ScienceDirect

Transportation Research Part A

journal homepage: www.elsevier.com/locate/tra

Heavy-duty trucking and the energy efficiency paradox: Evidence from focus groups and interviews

Heather Klemick*, Elizabeth Kopits, Ann Wolverton, Keith Sargent

National Center for Environmental Economics, Environmental Protection Agency, 1200 Pennsylvania Ave. NW (1809T), Washington, DC 20460, United States

ARTICLE INFO

Article history:
Received 8 September 2014
Received in revised form 5 February 2015
Accepted 5 April 2015
Available online 16 May 2015

Keywords:
Energy efficiency paradox
Technology investment decisions
Heavy duty trucking

ABSTRACT

Theory suggests that profit maximizing firms have an incentive to incorporate cost-effective technologies into their products. However, simple net present value calculations comparing upfront costs of fuel-saving technologies to future savings suggest this is not always the case. This puzzle is commonly referred to as the "energy efficiency paradox." A growing number of empirical studies examine why households may under-invest in energy efficiency. Fewer studies examine similar undervaluation by businesses. We explore investment decisions within the heavy-duty trucking sector for fuel-saving technologies via focus groups and interviews to gain insight into what factors might explain apparent underinvestment in fuel-saving technologies. We find some evidence that market failures related to lack of information about technology performance and network externalities contribute to slow adoption of some technologies. However, information about new technologies for tractors seems to generate limited spillovers. There is also some evidence of split incentives between owners and drivers, though companies have invested in a variety of technologies and approaches in an attempt to address these effects. Other factors important in trucking investment decisions that are not classic market failures include tradeoffs between fuel economy and other valued truck attributes, as well as uncertainty and risk associated with new technologies if decision-makers are loss averse.

1. Introduction[1]

In 2011, the Environmental Protection Agency (EPA) and Department of Transportation (DOT) introduced the first-ever regulations of fuel economy for medium- and heavy-duty trucks. They projected that not only would the regulations improve local air quality and reduce greenhouse gas (GHG) emissions, but they would also save the trucking industry \$50 billion in private fuel costs – a figure far exceeding the \$8 billion estimated cost of new technologies (EPA, 2011).[2] While 2011 was a time of historically high fuel prices, with diesel hovering near \$4 per gallon, high prices were hardly an aberration; on-highway diesel averaged well over \$2 per gallon since 2005 (EIA, 2012). The elevated price of fuel years prior to the

* Corresponding author at: National Center for Environmental Economics, US Environmental Protection Agency, Washington, DC 20460, United States.
E-mail address: klemick.heather@epa.gov (H. Klemick).

[1] The views expressed in this paper are those of the authors and do not necessarily reflect the views or policies of the U.S. Environmental Protection Agency.

[2] The analysis for the EPA-DOT medium- and heavy-duty truck standards observed that, "savings in fuel costs are *by themselves* sufficient to pay for the technologies over periods of time considerably shorter than vehicles' expected lifetimes" (U.S. EPA, 2011). Similarly, NESCCAF et al. (2009) claims that fuel consumption from heavy-duty tractor-trailers could be reduced substantially "while providing net savings for the owner based on lifetime fuel savings [that pay] for the incremental vehicle, operation, and maintenance costs."

http://dx.doi.org/10.1016/j.tra.2015.04.004
0965-8564/Published by Elsevier Ltd.

regulation begs the question: Why are trucking companies not already adopting fuel-saving technologies absent the mandate for improved fuel economy?

The "energy efficiency paradox" describes the observation that households and firms often fail to adopt technologies and behaviors that experts estimate would save them money over the long term by reducing energy costs (Jaffe and Stavins, 1994).[3] While the initial investment in a more efficient technology is typically more expensive than the alternative, net present value (NPV) calculations accounting for upfront costs and projected future energy savings often find that such investments pay off well within the lifetime of the product.

Researchers have posed a variety of hypotheses to explain the slow diffusion of energy-saving technologies. They include classic market failures such as imperfect information about new technology and related "learning-by-using" externalities; liquidity constraints limiting upfront investments; network externalities that occur when the net benefits of a new technology depend on widespread adoption by other users; and principal-agent or split-incentive problems, in which energy costs are borne by a "principal" but investment decisions are made by a separate "agent" (Jaffe et al., 2005; Gillingham et al., 2009; Levinson and Niemann, 2004).

Research focusing on households has also highlighted behavioral anomalies – situations in which consumers appear to behave contrary to their own financial interests – as an explanation for the energy efficiency paradox. With respect to light-duty vehicle purchase decisions, Turrentine and Kurani (2007) argue that unquantifiable symbolic meanings and values can play a role in consumer behavior; for example, some drivers may view resource conservation or thrift as important or view rising prices as evidence of conspiracy. With the potential exception of loss aversion (discussed below), these situations are expected to be less relevant in explaining firm behavior because businesses that neglect to adopt profit-enhancing technologies would lose out in a competitive marketplace (Shogren and Taylor, 2008).

Market failures aside, some researchers have also pointed to factors not accounted for in typical NPV calculations that could decrease savings from adopting energy-saving technologies (Jaffe et al., 2005; Huntington, 2011). These include ancillary costs of technology adoption, such as lower quality or higher maintenance costs (Jaffe et al., 2005; Broydo Vestel, 2009); significant heterogeneity in energy use that could make adoption less beneficial for those that use less energy (Hausman and Joskow, 1982); and actual energy savings under real-world conditions that fall short of engineering estimates (Metcalf and Hassett, 1999). Uncertainty about future energy savings or other aspects of technology performance could also be important if decision-makers exhibit risk aversion or loss aversion, which has been shown to be potentially important in the light-duty vehicle market (Sutherland, 1991; Greene, 2011; Greene et al., 2013).[4] When these factors play a role, low adoption of energy-saving technologies may not reflect market failures, but rather a larger set of factors or different preferences than typically appear in NPV calculations.

Market failures and other factors excluded from NPV calculations are often labeled "market barriers" that limit investment in energy-saving technologies (Jaffe et al., 2005). Because these explanations have different policy implications we distinguish between them. From an economic perspective, market failures (including environmental externalities)[5] can help justify market-based instruments, information programs, and technology standards that encourage socially optimal levels of technology adoption. However, if other factors that do not represent market failures contribute to slow adoption, regulations may yield social costs for users that partially offset fuel-savings. Various explanations for slow adoption of energy-saving technologies are not mutually exclusive; some or all could play a role for any particular technology. Anderson and Newell (2004) found that manufacturing plants rejected audit recommendations with energy savings that outweigh upfront costs for a mix of reasons such as high initial costs, cash flow issues, bureaucracy, lack of staff for implementation, process or equipment change requirements, risk of a problem with equipment, and inconvenience.

There is little empirical literature exploring evidence of an energy efficiency paradox in the heavy-duty trucking industry. Vernon and Meier (2012) focused on the potential for split incentives between a firm and its drivers: When the company pays the fuel costs, the effectiveness of fuel-saving technologies may be undermined by driver behavior. The authors used available industry data to estimate that drivers do not pay the cost of fuel or receive fuel-saving bonuses from their company for almost 70% of the miles driven. Based on interviews and surveys of mostly owner–operators, Roeth et al. (2013) identified lack of credible information about real-world fuel savings; payback uncertainty; capital constraints; reliability of new technology; and unavailability from preferred suppliers as possible barriers to the adoption of fuel-saving technologies. Based on available industry data and interviews with experts, the Carbon War Room (2012) posited limited access to capital for long-haul owner–operators combined with high upfront costs, split incentives between truck owners and those that pay for fuel, and lack of awareness about new technologies as barriers to adoption.

[3] Case studies of particular industries and technologies have noted evidence of the energy efficiency paradox mainly with regard to appliances, buildings, and industrial processes (e.g., DeCanio and Watkins, 1998; de Almeida, 1998; Harris et al., 2000; Thollander and Ottoson, 2008; Ryghaug and Sorensen, 2009). Multi-industry econometric analyses, though rarer, have also found some support for the energy efficiency paradox in businesses (Kounetas and Tsekouras, 2008; Schleich and Gruber, 2008).

[4] The literature varies in the extent to which behavioral anomalies such as loss aversion are considered market failures (Shogren and Taylor, 2008). Some use a distinct category referred to as behavioral failures to distinguish these from classic market failures (e.g., Gillingham et al., 2009). We follow this convention and do not classify loss aversion as a market failure, though we acknowledge that loss averse behavior is inconsistent with the predictions of classical economic theory based on perfectly rational representative consumers with complete information, and it is possible that policies targeting behavioral failures could result in welfare improvements.

[5] Unpriced negative externalities associated with energy production such as pollution undoubtedly play a role in suboptimal adoption of energy-saving technologies, but since the benefits of reducing pollution largely do not accrue to the user, this issue is orthogonal to the energy efficiency paradox.