Energy Policy 84 (2015) 44–57

Contents lists available at ScienceDirect

Energy Policy

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

Barriers to energy efficiency in shipping: A triangulated approach to investigate the principal agent problem

Nishatabbas Rehmatulla*, Tristan Smith

UCL Energy Institute, Central House, 14 Upper Woburn Place, London WC1H 0NN, UK

HIGHLIGHTS

- We provide the first analysis of the principal agent problem in shipping.
- We develop a framework that incorporates methodological triangulation.
- Our results show the extent to which this barrier is observed and perceived.
- The presence of the barrier has implications on the policy most suited to shipping.

ARTICLE INFO

Article history:
Received 21 January 2015
Received in revised form
16 March 2015
Accepted 20 April 2015

Keywords:
Principal agent
Market failures
Barriers
Shipping
Transportation

ABSTRACT

Energy efficiency is a key policy strategy to meet some of the challenges being faced today and to plan for a sustainable future. Numerous empirical studies in various sectors suggest that there are cost-effective measures that are available but not always implemented due to existence of barriers to energy efficiency. Several cost-effective energy efficient options (technologies for new and existing ships and operations) have also been identified for improving energy efficiency of ships. This paper is one of the first to empirically investigate barriers to energy efficiency in the shipping industry using a novel framework and multidisciplinary methods to gauge implementation of cost-effective measures, perception on barriers and observations of barriers. It draws on findings of a survey conducted of shipping companies, content analysis of shipping contracts and analysis of energy efficiency data. Initial results from these methods suggest the existence of the principal agent problem and other market failures and barriers that have also been suggested in other sectors and industries. Given this finding, policies to improve implementation of energy efficiency in shipping need to be carefully considered to improve their efficacy and avoid unintended consequences.

1. Introduction

1.1. Background

Shipping is a derived demand, i.e. it exists in response to demand for the transport of freight. Transportation, and particularly shipping, thus plays a critical role in the global economy and as such is one of the key enablers of globalisation. The shipping industry supplies a safe, reliable and cheap form of transport connecting the world's consumers with the world's raw materials and skilled, low-cost labour markets. Given the high correlation between the historic relationship of global Gross Domestic Product (GDP) and shipping activity (measured in tonne miles, i.e. payload by distance) as shown in Fig. 1, the global GDP can be used to some extent estimate the demand for future shipping activity, although currently this relationship is showing signs of decoupling. At an annual GDP growth rate of around three to four per cent, it is estimated that shipping's activity will increase by around 200–300% by 2050 (Buhaug et al., 2009; Smith et al., 2014).

This continued growth rate brings with it several challenges which may question the sustainability of the shipping industry; one of them being climate change. Energy efficiency (i.e. increasing productivity using the same amount of energy) is one of the strategies to address the issues of climate change (UNEP, 2011) and other strategies include using renewable energy sources (e.g. solar, wind), using fuels with lower carbon content (e.g. liquid natural gas and biofuels) and using emission reduction technologies (e.g. through chemical conversion, capture and storage). Currently, the global transport sector emissions represent around 13% of global CO_2 emissions, of which total shipping CO_2 emissions (from international and domestic shipping) accounted for over 3% (around

---

* Corresponding author.
E-mail address: n.rehmatulla@ucl.ac.uk (N. Rehmatulla).

http://dx.doi.org/10.1016/j.enpol.2015.04.019

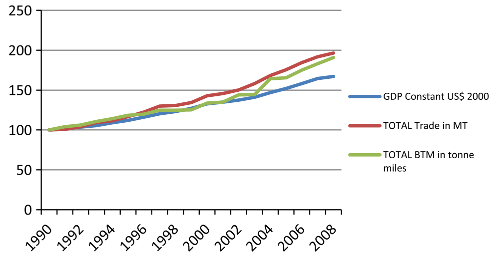

Fig. 1. Historic relationship between shipping activity and GDP Data from UNCTAD (1997–2008) and Clarksons (2010).

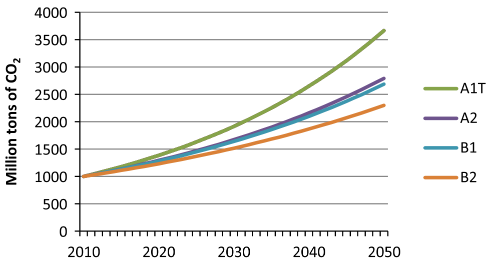

Fig. 2. International shipping emissions based on IPCC SRES Scenarios. *Source*: Buhaug et al. (2009).

1 Gt) of global CO_2 emissions in 2007. This contribution to emissions in comparison to the cargo transported, makes shipping the most energy efficient form of transport compared to air, road and rail (Buhaug et al., 2009). However, given the aforementioned growth rate, it is estimated that shipping's CO_2 emissions will grow by one and half to three times under the business-as-usual scenario (compared to emissions in 2007) by 2050 as shown in Fig. 2. Hence there is an even greater need for improving energy efficiency of the ships. The industry has adopted 'first of its kind' international regulation in its efforts to mitigate CO_2 emissions, the energy efficiency design index (EEDI), a command and control, design based standard that is tightened every five years from 2015 to 2030, but its impact is estimated to be only around 25% reduction in CO_2 emissions on business as usual by 2050 (Bazari and Longva, 2011).

Currently, fuel costs in shipping generally account for between 50% and70% of a ship's operating costs, which is set to increase as Heavy Fuel Oil (HFO)[1] costs increase, creating further incentives towards energy efficiency in shipping. More than fifty measures (Eide et al., 2009; Buhaug et al., 2009; Wang et al., 2010) have been identified that could result in efficiency gains and they are generally grouped as technical measures (some applicable to new and some to existing ships) and operational measures. These measures along with their abatement potentials have also been presented in several shipping specific marginal abatement cost curves[2] (MACC's) (Buhaug et al., 2009; Faber et al., 2011; Eide et al., 2009; Wang et al., 2010) that commonly feature measures, especially operational measures, that are cost-effective. A cost-effective measure is one that is economically efficient (yields a positive Net Present Value) and energy efficient (Sweeney, 1993; Golove and Eto, 1996). Yet, the implementation of these cost-effective measures has not been empirically examined in shipping and this paper attempts to gauge this with a view to understanding the barriers that may be inhibiting the uptake of such measures.

1.2. Barriers to energy efficiency

The barriers to energy efficiency debate has gained momentum since the 1980's with the first bibliographical account of barriers to energy efficiency by followed by empirical research by Blumstein et al. (1980), which is then followed by a host of literature, see for example Fisher and Rothkopf (1989), Hirst and Brown (1990), Howarth and Andersson (1993), Sanstad and Howarth (1994), Jaffe and Stavins (1994), Howarth and Andersson (1993) Howarth et al. (2000), Thollander and Palm (2013). Several studies across a wide range of sectors and regions have empirically shown that cost-effective energy efficiency measures are not always implemented despite the substantial abatement potential, see for example Velthuijsen (1993), Gillissen and Opschoor (1994), Harris et al. (2000) Sorrel et al. (2004), Zilahy (2004), Rohdin et al. (2007), Shi et al. (2008), Sardianou (2008), Thollander and Ottosson (2008), Schleich (2009), Hasanbeigi et al. (2009), Trianni et al. (2012). A common conclusion of these studies, mainly based on respondent perceptions (measured through surveys), has been the identification of a range of barriers that result in a sub-optimal level of uptake. They define barriers as postulated mechanisms that inhibit investment in technologies which are both energy efficient and economically efficient (Sorrel et al., 2004). The difference between the actual or observed lower levels of implementation of cost-effective measures and the higher level that would appear to be cost-effective from the consumers or firms point of view based on techno-economic analysis (Brown, 2001; Golove and Eto, 1996) is referred to as the 'energy efficiency gap' (Jaffe and Stavins, 1994). Some of the energy efficiency gap can be explained by rational behaviour to market barriers that may not be captured by the techno-economic analysis. If these can be accurately modelled, then the remaining energy efficiency gap can be explained by market failures, behavioural and organisational barriers as shown in Fig. 3. The magnitude of the energy efficiency gap will also be dependent on the extent to which models address take-up of measures and the way implementation is measured.

According to Brown (2001) market barriers are obstacles that are not based on market failures but nonetheless contribute to the slow diffusion and adoption of energy efficient measures. They can

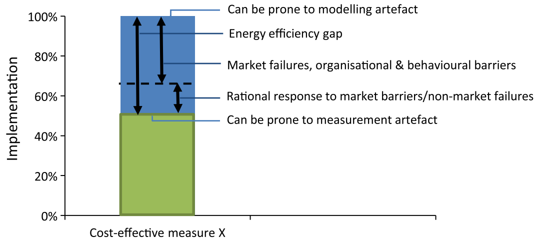

Fig. 3. Explaining the energy efficiency gap.

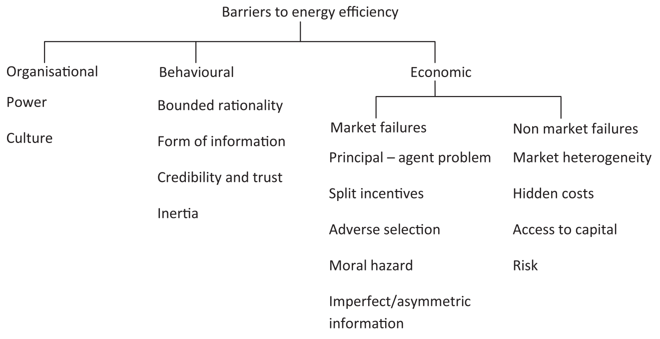

Fig. 4. Classification of barriers.

---

[1] A type of residual fuel oil that is the predominant type of fuel used in ships.

[2] A common method to calculating the techno-economic potential of CO_2 reducing measures and the order in which they may be adopted.