



Slow steaming and a new dawn for wind propulsion: A multi-level analysis of two low carbon shipping transitions

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ABSTRACT

The key enabler of international trade, shipping is heavily reliant on fossil fuels and responsible for approximately 2% of global carbon emissions. For the sector to reduce its emissions in line with climate change objectives, a wholesale transition is required from the current carbon intensive shipping system to one with a lower climatic impact. Drawing on the multi-level perspective from the socio-technical transitions literature, this paper focuses on two technological developments which could reduce the emissions from shipping – slow steaming and wind propulsion. Outlining the landscape changes which may hinder or support the incorporation of each of these innovations into the broader shipping regime the paper shows how slow steaming has been accommodated within this regime, in response to high oil prices and the economic downturn. In the longer term it concludes that additional policy measures may be required to ensure slow steaming persists should landscape pressures reduce. Oil prices, and the environmental agenda, are driving the development of wind propulsion, but more needs to be done to support those companies which seek to demonstrate and commercialise modern incarnations of the original pioneers of the seas.

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1. Introduction

Shipping has shaped modern economies. Historically, seaborne imports of raw materials drove the industrial revolution and shipping opened up new markets to manufacturers [1]; technological innovations on the seas and on land, coupled with infrastructure development, regulations and new organisations underpinned the global system we see today [2]. From a common ancestry, distinct maritime sectors evolved where cargo specific vessels require different port infrastructure and operate under different business models.

Compared to other parts of the global economy, the shipping industry is subject to little regulatory pressure to reduce its carbon emissions. Under the UNFCCC framework, nations have committed to keeping global mean temperatures to within 2 °C of pre-industrial levels by 2100. Shipping is regulated via the International Maritime Organisation (IMO) which in principle accepts that the shipping industry “will make its fair and proportionate contribution” to the levels of mitigation deemed necessary to reduce the likelihood of a global mean temperature rise commensurate with averting dangerous climate change [3] and has introduced two policies to this end, the Energy Efficiency Design Index (EEDI) applicable to new ships and the use of Ship Energy Efficiency

Management Plans (SEEMP) for the existing fleet [4]. A comparison of the impact of these policies with projections of future shipping demand, however, suggests they will have little impact on absolute emissions, which are projected to grow with increasing demand for shipping services [3,5].

Against this backdrop of increasing CO₂ emissions and little evidence of meaningful mitigation policies, the High Seas project has explored how UK shipping may make radical reductions in emissions commensurate with stabilisation within 2 °C of pre-industrial levels by 2100. The project has considered the apportionment of emissions [6], the potential for technological innovation [7] and has developed scenarios articulating pathways for UK shipping emissions in-line with the 2 °C target [8]. Shipping is blessed with a large number of technologies with the potential to reduce emissions (see for example [10]), yet as the High Seas scenarios highlight, emission reduction pathways are framed not only by technology and changing operational practices, but also by the quantity and origin of goods transported. The scale of the challenge, given projected growth in demand for shipping, is such that incremental improvements in technology are inadequate, but instead a wholesale transition to a new socio-technical system is required, necessitating changes to multiple linked elements including technology, infrastructure, business practices and culture across different scales and including diverse actors.

Much of the work focusing on reducing emissions from shipping has assessed emission abatement potential and the cost

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effectiveness of technical and operational measures. Marginal Abatement Curve (MAC) modelling suggests that cost effective measures have the potential to reduce CO₂ emissions from the sector by between 33% by 2030 [9], 27% [10] and 25% [11], depending on the assumptions made about fuel price and discount rate [12]; the cost effectiveness of more expensive measures would be increased by the EEDI and SEEMP [9]. Clearly, however, given that many cost effective measures have yet to be widely taken up there are many barriers to adoption, which have been the subject of industry studies (e.g. [12,13]) and an increasing academic literature (e.g. [14–16]). Contractual arrangements in shipping are highly complex, and in some forms fuel costs are paid by a shipper and not a vessel owner, reducing the incentive for owners to invest in energy efficiency measures [16]. Many companies do not measure and manage fuel use; systems may not be available to record actual consumption, as opposed to fuel bunkered [12] and companies may not have the resources to analyse data that is collected [13,17]. When fuel prices were low, energy efficiency was not a high priority for ship owners or operators [12], with a lack of clear responsibility for delivering energy efficiency as a consequence [17]. Communication between shore and ship is a key barrier to implementation of many operational measures including voyage management, fuel measurement and reducing delays in ports [12,14,17]. Ship owners may be hesitant to invest in new technology in the absence of clear, independent data on vessel performance, and ship yards reluctant to include novel technologies on new build vessels [12,18].

Reducing emissions from shipping, therefore, requires us to look for action beyond ship owners and operators, to encompass a host of actors working across national borders: ports; ship yards, their engineers and designers; banks and finance companies; shipping regulators. Changes are required to multiple linked elements, not technology in isolation, but also infrastructure, business practices and culture across different scales, from vessels to the wider system in which they operate. This paper answers a call to move beyond economic assessments [19] and consider this wider socio-technical system in all its complexity.

Taking up this challenge, the goal of this paper is to explore the transition from an unsustainable system, to a more sustainable one, focusing on two promising areas of innovation – slow steaming and wind propulsion. An analytical framework developed by transition researchers for the study of radical socio-technical innovation, the multi-level perspective approach, is adopted [2,20–22]. The aim is to explore progress and the trends within shipping (the regime level) and the exogenous landscape level which may support or hinder these developments. In Section 2, the paper briefly introduces the MLP, using it to frame an overview of the shipping system to make the case for the usefulness of the approach; Section 3 describes the methodology. In Section 4, the MLP is used to analyse two elements of a new, low carbon shipping system, slow steaming and wind propulsion, whilst Section 5 concludes by considering the implications of this work for the reduction of emissions from the shipping sector.

2. Theoretical framing: transitions and the multi-level perspective

Conceptualising shipping as a socio-technical system highlights that the shipping sector is made up of elements such as technology, infrastructures, policy, consumer practices, markets and cultural meanings, aligned and maintained by a diverse set of actors including engineers, policy makers, industry and consumers. Existing socio-technical systems are characterised by stability, lock-in and path dependence [23], which leads to incremental change to the system [20] as radical changes have to fight against incumbent

technologies and ways of doing to become widely adopted. If the shipping sector is to make the significant reductions in emissions required by climate change mitigation, incremental change is not enough, instead a transition from the current fossil fuelled system to a new, low carbon socio-technical system is required. To analyse and understand the interactions and interplays which shape such transitions, researchers have developed the multi-level perspective (MLP) [2,21,22].

The MLP has been applied to the historical analyses of transitions across many sectors, transport included, such as sailing ships [2]; land transport [24]; cargo handling [25] and aviation [26]. These studies shed light on processes of technological transitions and highlight that a technology transition is not solely about the technology, but instead innovation is supported by changes across multiple dimensions such as institutions, culture, infrastructures, markets and user practices. In essence technology transitions are multi scalar, with changes having to be manifest across these dimensions from the micro-scale, within firms, to the meso and macro, within specific sectors through to the wider economy and nation state.

The MLP identifies three levels within a socio-technical system: niches, the regime and the landscape (see for example [2,22]). Radical innovations emerge at the micro-level within the protected space of a technological *niche*, where these innovations can benefit from macro-level *landscape* changes to durably change the incumbent meso-level *regime*. This framework is illustrated with reference to shipping, in Sections 2.1–2.3.

2.1. Landscape influences and the shipping system

The landscape is the external context which bounds the interactions of the actors within the socio-technical system [2]. The sociotechnical landscape influences development within the shipping regime through diverse factors such as oil price, economic growth, demographics, cultural values, politics, policy and the environment. Walsh et al. [27] provide a historical overview of drivers of growth in trade and show that diverse landscape changes have shaped shipping. Macro-level trends may stabilise the regime, acting as a barrier to change, or conversely destabilise it, providing an opportunity for regime change [20].

An enabler of international trade, transporting some 80% of global trade by volume in 2013 [28], shipping has enjoyed a long period of growth, increasing at around 4% per year since the 1990s [29]. Despite the challenges presented by the global recession, with downturns in EU economies impacting on major exporting countries, shipped trade continues to grow, albeit at a slower pace supported by increasing South South trade and growing demand in Asia and Africa, [28,29]. Projections of future trade show continued growth across shipping as a whole and are likely to exert a stabilising pressure upon shipping, reinforcing the existing regime. That said, growth may not be consistent across all parts of the regime, thus, whilst container shipping is likely to grow over the coming decades [5] if there is a widespread decarbonisation of energy systems to meet climate change objectives, this may impact considerably on demand for the shipping of fossil fuels [5,30].

Regulation within shipping has been driven in response to landscape changes, and vessel design and operation has changed as a consequence. Public and political concern over oil spills from tankers, for example, has prompted maritime safety legislation including the IMO's MARPOL 73/78 regulation following the Torrey Canyon accident in 1967 [31] and the US Oil Pollution Act of 1990 following the running aground of the Exxon Valdez in 1989 [32]. Emerging landscape pressures, therefore, could drive change towards more sustainable practices and transform the shipping regime. In recent years, environmental issues, most notably climate change and sulphur emissions, have placed pressure on the sector

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