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Revisiting history: Can shipping achieve a second socio-technical transition for carbon emissions reduction?

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ABSTRACT

This paper draws on socio-technical transitions theory to contextualise recent developments in the technological and operational eco-efficiency of ships, which may ameliorate but not resolve sustainability challenges in shipping. Taking an historical perspective, the paper argues that shipping is fundamentally a derived demand arising out of, but also enabling, the spatial separation of production and consumption that are integrated through global value chains. It is argued that the twin processes of innovation-enabled specialisation (into e.g. container ships; bulk carriers etc.) and increased scale both of ships and of shipping operations have embedded shipping into logistics systems of increasing complexity and reach. The objective of the paper is to demonstrate, using secondary data, the long-run trends in the growth of shipping carbon emissions for bulkers and tankers, as well as the impact of increased scale and vessel speed on such emissions. A fuel-based, top-down, methodology, based on fuel consumption estimates derived from secondary source industry data that are suitable for a macro-level analysis, is used to estimate global shipping carbon emissions. It is argued that technologies or operational innovations that reduce the environmental burdens of shipping, while useful, do not represent the socio-technical system 'regime' shift that international maritime logistics requires in order to contribute to improved sustainability. Rather, in the relative absence of strong governance mechanisms in the maritime field, it is underlying 'landscape' shifts in production and consumption that are likely to act to reduce the demand for shipping and hence to be more significant in the longer run.

1. Introduction

The purpose of this paper is to investigate whether technological and operational innovations in shipping will result in a substantial and swift reduction in carbon emissions, and herald the emergence of a new socio-technical regime in shipping. Rather than seeking to forecast outcomes, the paper considers historical change to date to argue that profound path dependency alongside further shipping volume growth is likely to overwhelm eco-efficiency measures.

There is a robust stream of scholarship on the ways in which technological innovations permeate economic and social life to become embedded as dynamic, self-reproducing structures, encompassing markets, products, regulatory frameworks, practices, and behaviours. Recent research in this area stems from pioneering studies on shipping, and the transition from

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sail to steam (Geels, 2002). Increasingly, those interested in socio-technical transitions are turning from historical studies to more policy-orientated endeavours to promote sustainability – and one area of interest is transport (Geels, 2005, 2012; Fallde and Eklund, 2015; Upham et al., 2015).

It is expected that when shipping is observed over time it will have become more embedded in global production systems as a result of, and by virtue of its contribution to, the spatial separation of supply and demand. It is further expected that the combination of path dependency and fragmented governance structures in shipping will have acted to reduce the scope for socio-technical developments at a 'niche' level, and the impact of eco-efficiency measures. Consequently, the working hypothesis underpinning this discussion is that, unlike other transport realms within which sustainable socio-technical transitions interventions may be achieved, the global shipping industry is far more likely to be immune to the usual prescriptions of this theoretical perspective.

In Section 2, socio-technical transitions theory is discussed and relevant literature in the transport realm, where the connection to climate change has long been recognised, is reviewed (Chapman, 2007). Section 3 summarises sustainability issues associated with shipping, with a focus on carbon emissions growth using bulk and oil tankers as illustrative examples. The argument presented in Section 4 is that the processes of innovation-enabled specialisation (into, for example, container ships; bulk carriers; oil tankers), standardisation, and operational innovations have underpinned economies of scale and embedded shipping into logistics systems of increasing complexity and reach. These developments have facilitated the creation of global value chains (Sturgeon et al., 2008; Coe and Yeung, 2015). Shipping, therefore, emerges both as a consequence of, and contributor to, the separation of production and consumption locations. Section 5 concludes that underlying shifts in production and consumption are likely to be more significant than carbon reduction measures which might reduce the environmental impact of shipping.

2. Theoretical background: socio-technical transitions and shipping

Socio-technical transitions theory (Geels, 2002) posits the notion of an embedded regime in a state of dynamic equilibrium for any given ensemble of technologies and related practices. The socio-technical transitions literature has a concern with how, why and to what effect innovations permeate through society. The theory adopts what is termed a multi-level perspective where the socio-technical space is divided into three distinct levels: niche, regime and landscape (see Fig. 1). At the heart of this socio-technical analysis is the 'regime' level centred on key technologies, around which accrete a dynamically-stable aggregation of economic structures, organisations, governmental regulations and laws, governance, social practices, behaviours and beliefs, which collectively act to allow the reproduction of the embedded regime. In turn, external or 'landscape' conditions in the form of resource availability, cultural norms and other factors provide a contextual framework within which the embedded regime may expand and develop. At the micro-level there may be 'niche' or grassroots innovations that ultimately grow to displace an embedded regime and hence power another wave of accumulation around a new set of technologies (Kemp et al., 1998; Hargreaves et al., 2013). Geels and Schot (2007) have further postulated a range of transition 'pathways' along which change may happen. As Turnheim et al. (2015) explain, the scope for different pathways crucially depends upon governance structures in place: where such structures are weak the available pathways and the pressure for change are more limited.

2.1. Regimes, landscapes and niche emergence and shipping

Transitions theory is a way of understanding the permeation of socio-technical change across time and space. The socio-technical transitions literature tends to focus on niche emergence, and regime displacement or stability in the face of new technologies, consumer attitudes and related market matters (Wells and Nieuwenhuis, 2012; Xenias and Whitmarsh, 2013), and hence generally has a sector or single regime focus – although some studies have sought to understand and explain inter-regime relations (Sutherland et al., 2015) in a manner that echoes nascent analyses of the food-water-energy nexus (Al-Ansari et al., 2015). Increasingly, interest in socio-technical transitions is concerned with the analysis or stimulation of structural shifts towards improved sustainability (Moss, 2009; Markard et al., 2012). While energy systems have been a core area of interest in this regard (Vasseur and Kemp, 2011; Von Bock et al., 2015), transport has also been considered (Nykvist and Whitmarsh, 2008; Whitmarsh, 2012; Geels, 2012). While in shipping the impact on adjacent 'regimes' is modest, the position of shipping within global production and consumption systems is crucial.

'Niches' are generally thought of as technological developments or spatially-constrained protected spaces within which experimentation takes place (Coenen et al., 2010). Again, the implications for such developments to impact the shipping socio-technical 'regime' are currently very limited. Sometimes, assumptions of the need for niche protection do not hold as Wells and Lin (2015) have demonstrated for the 'spontaneous emergence' of electric bicycles in China – but this exception may be hypothesised to arise in part because of the relatively low capital cost of the technology concerned, and the extremely modest infrastructure requirements. In personal transport modes, so-called 'early adopters' face modest costs and risks (Dill and Rose, 2012) though for larger vehicles such as cars other barriers emerge as a concern (Sovacool and Hirsh, 2009).

In contrast, technologies that require large capital investments and associated infrastructures, such as shipping, may be hypothesised to be 'strongly embedded' and thus have greater path dependency. This embedding is part of the process of 'regime' formation as described in the case of shipping by Geels (2002). That is to say, the emergence of key technologies

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