DECARBONISING THE DEEP-SEA CONTAINER SUPPLY CHAIN:THE POSSIBLE CONTRIBUTION OF PORT-CENTRIC LOGISTICS

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ABSTRACT

It has been claimed that one way of reducing carbon emissions from the deep-sea container supply chain is to locate distribution centres at ports, stuff / unstuff containers there and effectively rationalise hinterland transport. Research in the UK, where this form of port-centric logistics (PCL) is now quite well established, has examined the numerous ways in which it can affect carbon emissions. This paper reports the results of online and interview surveys of shippers on the likely uptake of PCL in the UK. It also summarises the results of spreadsheet modelling of the potential CO_2 savings from channelling containerised imports of retail supplies through port-based DCs as opposed to more centrally located facilities. The research has explored four other ways in which PCL can influence carbon emissions, including reductions in empty container movements, an acceleration of container turnarounds, freight modal shift within the hinterland and the accommodation of carbon-efficient slow-steaming within global logistics schedules. The tentative conclusion is that, on balance, PCL can yield a net carbon reduction, though it will require much wider adoption of the PCL paradigm for it to have much impact of the overall carbon footprint of UK logistics.

Keywords: Port-centric logistics, container supply chains, CO_2 emissions.

1. PORT CENTRIC LOGISTICS: THE CONCEPT AND THE REALITY

The re-orientation of logistics systems around ports has become a hot topic in recent years, particularly in the UK where the concept of 'Port-Centric Logistics' (PCL) has been heavily promoted by several ports. In their seminal paper on the subject, Mangan et al (2008) define PCL as 'the provision of distribution and other value-adding logistics services at a port'. As Majumdar (2012) points out, however, when defined in such general terms, 'there is nothing new about the concept of PCL – most port managers would say that ports have provided warehousing and lot-specific deliveries forever'. Monios and Wilmsmeir (2012, p. 217)) also acknowledge that 'being critical, one could say that the new term describes little other than the standard practice of providing warehousing services at ports'. With the growth of containerisation in the 1960s and 70s, though, the port became a transit point and much warehousing capacity migrated inland to more centrally located distribution centres (DCs). The distinguishing feature of PCL is that the containers are destuffed at the port and their contents stored and handled at a new generation of large DCs located there.

This apparently challenges two fundamental principles of logistics. It undermines one of the original purposes of the container which was to facilitate the movement of containers through the ports and provide secure, standardised, inter-modal transit between end points in the maritime supply chain (Levinson, 2008). It also places DCs in peripheral locations with semi-circular hinterlands, when basic economic geography suggests that they should be centrally located with respect to their market areas.

This may explain why, despite the hype, PCL has so far had limited impact on the spatial distribution of warehousing space in the UK. Garrett (2011) found that only 9% of the country's DCs with more than 9000 sqm of floorspace and only 4% of DCs with more than 50,000 sqm floorspace were in counties with deep-sea ports. Being in the same county does not mean that a warehouse is near enough to the port to qualify for the designation 'port-centric'. A more accurate measure of the impact of PCL on the UK logistics property market can be found in Jones LaSalle database of warehouses with over 100,000 square feet of floorspace opened between 1995 and 2011. Out of the 720 warehouses in the database, only six are located in the vicinity of container ports: Felixstowe (1), Southampton (1), Tilbury (1) and Teesport (2). The port most strongly promoting the PCL concept, Teesport, has no deep-sea container services, though its container feeder services have managed to lure DCs of the UK's two largest supermarket chains, Tesco and ASDA. The retailers that established DC's at or near ports have reconfigured their inbound supply chains in response to the huge surge in containerised imports since the late 1990s. The DCs handling these imported goods (sometimes called 'import centres') have gravitated to these gateway locations, removing the need to move containers inland, often eliminating a link in the inbound supply chain and exploiting lower cost land in the vicinity of the port. Relatively few retailers, however, have so far pursued this locational strategy.

It is argued, however, that the UK is on the eve of a major shift to PCL with the imminent opening of the new London Gateway container port in the Thames Estuary. This is being portrayed as a 'game-changer', a purpose-built maritime logistics hub combining a major container port and an adjoining 230 hectare distribution park, modelled on DP World's Jebel Ali port in Dubai (Ward, 2010). Located only 40 km east of central London its immediate hinterland is populous and high-earning. It is estimated to be 'closer to 63% of the UK market' than the UK's two largest container ports, Felixstowe and Southampton and will have better road and rail connections. Already several large retailers have indicated that they are planning to establish DCs at London Gateway, suggesting that the PCL trend is gathering momentum in the UK.

2. ENVIRONMENTAL IMPACT OF PCL

The promotional literature on PCL from ports and property companies claims that, in addition to conferring economic advantages on companies locating logistical facilities at the ports, it can yield environmental benefits (e.g. PD Ports, 2011). It is argued that these benefits mainly accrue from a reduction in the aggregate distance travelled by trucks. For example, the developers of London Gateway, DP World, claim that when fully developed it will remove 65 million truck-miles from UK roads annually (Ward, 2012). Individual companies with port-based DCs have also quantified the savings in vehicle-kms they have achieved (Table 1).

Table 1: Estimated Distance and CO_2 Savings from PCL

company	type	reduction in truck-kms (million)	annual reduction in CO_2 emissions (tonnes)
Tesco	retailer	35.2	31,000
ASDA	retailer	15.2	13,000
Sabic	chemical company	5-7	7-10,000
George	retailer	8.0	7,000
Taylors of Harrogate	tea / coffee merchants	2.6	2,000

Source: Van Marle (2011)

Sainsburys claim to have saved 140 road miles per TEU entering the UK through the use of a DC based at the port of Felixstowe (Mangan et al, 2008).. The non-food director of the supermarket chain ASDA claimed that the company's port-centric DC near Teesport would enable the company 'to dramatically reduce (its) impact on the environment' saving two million road miles a year, 'equivalent to four trips to the moon and back' (Anon, 2006). These reductions in the amount of hinterland transport translate into reductions in a range of externalities, including CO_2 emissions (Table 1). Given current concerns over climate change, it is the potential carbon savings are often highlighted by those advocating PCL. Few attempts have been made, however, to assess the magnitude of these carbon savings at either micro or macro levels. This paper builds on a preliminary analysis reported in a previous publication (McKinnon and Woolford, 2011) to try to assess the overall contribution that PCL can make to the decarbonisation of logistics operations in the UK. It does this in two ways:

1. It reports the findings from online questionnaire and interview surveys of shippers related to the PCL issue. This empirical data shed new light on shippers' perceptions of the benefits and costs of locating DCs at container ports and their likelihood of adopting a PCL model.

2. It extends and refines the earlier modelling by carbon footprinting a much broad range of inbound supply chains for containerised imports into the UK.

The paper focuses on the environmental benefits of PCL for inbound flows of maritime containers into the UK. Although PCL can be symmetrical and apply to trade flows in both directions, its application in the UK pertains mainly to inbound movements. This partly reflects Britain's huge imbalance in containerised trade. In 2011, almost exactly twice as mainly loaded containers entered the UK through its four main deep-sea container ports (Felixstowe, Southampton, London and Liverpool) as left it (Department for Transport, 2012). Most of the discussion of PCL has also related to the reconfiguration of inbound supply chains, predominantly for retail goods.

In the next two sections we outline the nature and results of the shipper surveys before going on to assess the various ways in PCL can help to decarbonise container supply chains.

3. SHIPPER SURVEYS

3.1 Online questionnaire survey

This survey was conducted in collaboration with the Global Shippers Forum (GSF), an organisation set up in 2011 to represent the interests of shippers in international transport negotiations (www.globalshippersforum.com). 125 of its member companies in the UK were sent an email invitation by the GSF to participate in the survey, 34 of whom completed the questionnaire (27%). 47% of these companies only imported containers, while another 44% moved containers in both directions. It is estimated that the companies responding to the survey were responsible for 430,000 inbound container movements annually. The majority of the respondents were retailers (53%), with manufacturers and wholesale distributors representing, respectively, 35% and 9% of the sample.

3.2 Interview survey

A sample of twenty large shippers was selected in three ways: (i) with the advice of the GSF (ii) on the basis of participation in earlier focus group meetings and (iii) through involvement in previous research projects related to shipping and / or logistics-related carbon emissions. Fifteen of the companies agreed to participate, comprising a diverse mix of manufacturers, retailers, distributors and a waste recycler, generating between 5000 and 400,000 container movements annually. All of the companies operate in the UK though were registered in several countries (eight in the UK, four in the US, two in Switzerland and one each in the Netherlands and China). All the interviews were semi-structured. Four were conducted face-to-face and the remainder on the telephone.

The main objective of these surveys was to assess the shipper's role in the decarbonisation of the deep-sea container supply chains. It was in this context that enquiries were made about the companies' use of, interest in and plans for PCL. In the next section, PCL-related data from the two surveys will be integrated in a discussion of the useage and applicability of the PCL concept.

4. COMPANY RESPONSES ON PCL

Twenty-three of the companies responding to the online survey provided data on the proportion of their inbound containers destuffed in different locations (Figure 1). This indicated that, on average, only 6% of the importers' containers were stripped in the vicinity of a port. By comparison, on average 48% travelled inland to a general DC for unloading and 37% to dedicated warehouse for imported goods. This confirms that, at present, only a relatively small proportion of containerised imports into the UK are channelled through port-based facilities.

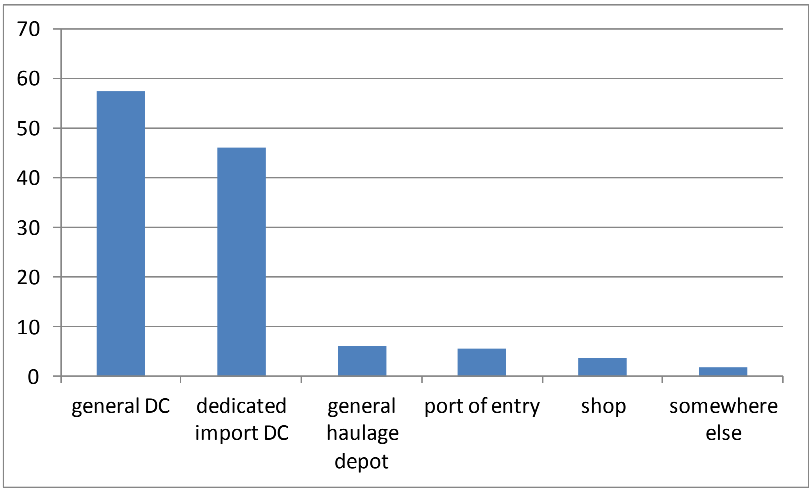

Figure 1: % of inbound deep-sea containers destuffed in different locations.

Only two of the interviewed companies currently operate port-based DCs in the UK, though two more have firm plans to establish one, in both cases at the new London Gateway port. Several of the companies are engaged in PCL in other countries (Netherlands, Belgium and the US) but do not consider it appropriate in the UK. The majority of the shippers interviewed, however, have neither experience of PCL or any plans to pursue this strategy in the foreseeable future. The interviews explored the reasons why these companies did not consider PCL to be suitable. These can be summarised as follows:

1. Britain's deep-sea container ports are in coastal locations and hence on the periphery of the UK market area. A port location is therefore going to be inherently less efficient in transport terms than a central one, within the so-called 'golden triangle'. If a DC stored and handled only deep-sea imported goods, a port-based location might be acceptable, especially if the additional costs associated with the off-centre location could be offset by other factors (to be discussed later). However,

companies mixing goods sourced from deep-sea markets with those supplied from elsewhere favoured more central DC locations.

2. By establishing a DC at a particular port the shipper would essentially commit itself to using the container shipping lines calling there. For companies currently using several carriers calling at different UK ports, this would represent a significant loss of flexibility. They also recognised the risk that a deep-sea operator they used regularly might switch ports leaving their port-centric DC with an inferior range of inbound services. Given the volatility of the deep-sea container market, companies were reluctant to link their short-term tendering for container services to a long term property investment. From a port perspective, PCL offers a means of 'anchoring' traffic and, by implication, shippers (Wilmsmeier and Monios, 2012), but carriers cannot be similarly bound to a port nor can the longer term competitiveness of their rates and service quality be guaranteed.
3. Related to this point was the argument that the annual volume of containers a shipper brings through an individual port is often not large enough to base a DC of cost-effective size there. This would entail moving from a flexible, multi-port, multiple carrier strategy with all the associated risks of concentrating all inbound flows through a single point. Also, the 'strong geographical specialisation of UK ports' which Wilmsmeier and Monios (2012: 124) observe, results in shippers using different ports for services on different deep-sea trade lanes. This promotes a spreading of container traffic between ports.
4. Imported supplies, particularly of retail goods, are generally packed tightly into containers, usually 'hand-balled' in the low-labour cost countries from which they are sourced. Palletising and transhipping these goods into articulated trucks significantly reduces the density of the load increasing the number of trips required to move the same quantity of goods. One UK retailer, for example, indicated that for some categories of product the ratio of articulated truck to 40ft container movements could be as high as 4 to 1. In the online survey, shippers were asked what proportion of the containers they imported were loaded to the weight or space limit. 83% of the importers estimated that 70% or more of their containers were completely filled. By comparison, a survey of the trucks used by 22 large non-food retailers in the UK in 2002 found that on average only 51% of the available vehicle-cube was actually utilized, and some of this cube would have been occupied by handling equipment. This confirms that the load of single 40 ft container is likely to be 'decanted' into two or more articulated trucks with box trailers.

The surveys found that, on average, shippers were making relatively little use of port-based DCs though a few major retailers are channelling a large proportion of their deep-sea imports through such premises and several others are planning to following their example. The main criticism of PCL, that it entails putting DCs in peripheral locations, is much less applicable to London Gateway as it is up-river rather than coastal and more centrally located within a hinterland of huge market potential. It remains to be seen however if it will be able to attract a sufficient range of deep-sea container services to allay the second and third of the shipper's concerns listed above.

5. WAYS IN WHICH PCL CAN REDUCE CARBON EMISSIONS.

There are five possible ways in which PCL can cut carbon emissions from the movement of inbound containers:

5.1. More direct movement of containerised imports from ports to final destinations.

This is potentially the main way in which PCL can cut carbon emissions. By stripping an inbound container at the port and storing and handing the imported goods at a port-based DC, a retailer can reduce the number of links in the supply chain and deliver the supplies more directly to shops. The co-location of the destuffing operation with other DC functions at or near the port effectively reduces the total distance the imported goods travel between the port of entry and the shop. It is difficult to generalise about the net distance saving, however, as this depends on the relative locations of the port, any inland container terminal used, the original inland DC and the final delivery point.

Earlier simulation modelling assessed the potential CO_2 savings from various inbound supply chain configurations (McKinnon and Woodford, 2011). This focused solely on distribution by road. One set of simulations used Felixstowe and Teesport as the ports of entry, Birmingham and Wakefield as the locations of inland container depots, Manchester as the original DC location and Stoke-on-Trent, Preston and Carlisle as the shop locations. The analysis was confined to two geographical corridors and underpinned by assumptions about the average loading of containers and road semi-trailers and the routing of deliveries. Overall, the modeling found that all the supply chain configurations yielded a net carbon saving, though this saving varied widely from 7% to 60% depending on the circuity of the conventional, non-PCL chain.

This modelling has been extended to cover a broader range of DC and shop locations and the three largest UK deep-sea container ports (Felixstowe, Southampton and Tilbury) (Table). As Tilbury is only 13km from the site of the new London Gateway port it serves as a usually surrogate for the new port-centric hub. The five DC locations chosen (Milton Keynes, Magna Park (near Lutterworth), Swindon, Wakefield and Warrington) are widely regarded as strategic locations for distribution within the UK and numerous large retail DCs are already clustered there. Eight shop locations were selected in major regional centres (London, Birmingham, Bristol, Nottingham, Leeds, Manchester, Nottingham and Glasgow). Allowance was made for the spending power of the populations in the economic planning regions within which these cities are the dominant retail centre (in this analysis the South East of England and East of England regions were combined). This made it possible to weight changes in CO_2 emissions resulting from PCL with respect to population and average disposable income. It was assumed that containerized imports arriving at one of the three ports would be channeled through one DC *en route* to each of the eight shops, located either at the port of arrival or at one of the five inland DC locations. All hinterland movements would be by road and no use would be made of inland container depots (ICDs) or other forms of dry port. It was also assumed that warehouse-related emissions would be the same regardless of whether the DC was at a port or an inland location.

The modelling employed the Containerised Cargo Carbon Calculator developed by Aecom as part of the EU Interreg IVB North Sea Region Programme (www.ccccalculator.com). This tool plots road, rail and sea routes between the main UK ports and inland locations which minimize transit times. In the case of road journeys a road network database is used and over-the-road transit times, distances and CO_2 emissions are calculated. It was assumed for the purposes of this analysis that the inbound containers would be 9ft high 40 ft long and carry an 11 tonne load. The 'enhanced' set of emission factors incorporated into the software tool were used as these are tailored to container transport. As discussed above, one of the critical parameters in the comparison of CO_2 emissions from PCL and 'centralised' logistics is the ratio of box van trailers to containers in hinterland transport. This ratio was varied by 0.25 intervals within the range 1 to 4 to assess its impact on the estimated differences in CO_2 emissions.

Figure 2 shows how, under the conditions of this analysis, the level of CO_2 emissions from PCL varies with the box-van : container ratio. The analysis initially took no account of the total disposable income of the populations in the surrounding regions ('without weighting' results). This established that if the box van : container ratio was less than two there would be a net CO2 reduction in using PCL, rising to a 27.5% saving if parity could be achieved in the amount of product carried by conventional lorry and container. When weighting factors were inserted into the spreadsheet to allow for regional variations in total disposable income the CO2 reductions from PCL significantly increased. The threshold box van: container ratio yielding a net CO2 saving rose from 2 to 3.25. At an average ratio of two, the CO2 savings increased from 1 to 15%.

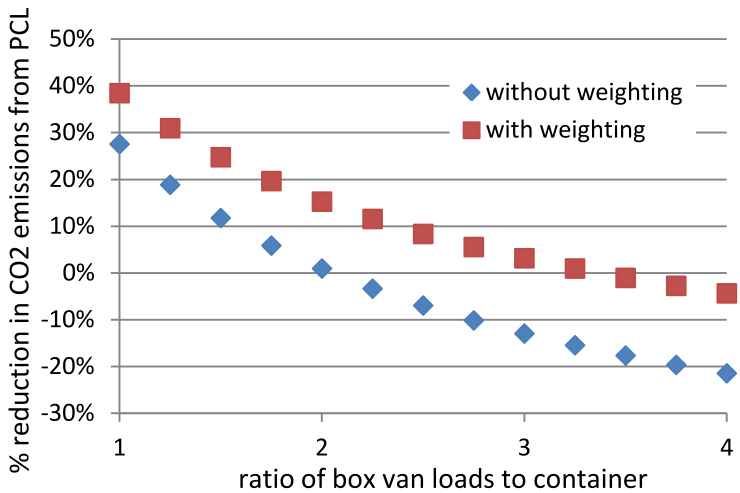

Figure 2: Total Reduction in CO_2 Emissions from Using PCL with Variable Box Van: Container Ratio

The analysis also showed how the level of CO_2 saving from PCL varies with the location of the deep-sea port (Table 2). Ignoring regional variations in total disposable income, the net changes in CO2 emissions would be very small, with reductions of 3% and 0.5% for Tilbury and Felixstowe and a 1% increase in emissions from PCL based at Southampton. Once account is taken of disposable income, however, the analysis suggests that PCL based at all three ports would offer significant CO_2 reductions with Tilbury the clear winner (-21%) and the other two ports yielding similar carbon savings (-12% / -13%). This lends support for claims that the new London Gateway port, only 13 kilometres from Tilbury, is likely to prove an environmentally-beneficial location at which to develop the PCL model.

Table 2: CO_2 Reductions from Routing Imported Goods Directly from DCs based at UK Deep-sea Ports

	unweighted	weighted by income
Felixstowe	-0.5%	-12.1%
Southampton	1.0%	-13.0%
Tilbury	-3.0%	-20.8%
total	-0.9%	-15.2%

5.2 Reducing the need for inland repositioning of empty containers

One of the essential elements of a PCL strategy is that container loading and unloading are confined to the port, eliminating the need for empty containers to be returned from an inland location to the port. An empty 40ft container weighs approximately 3.7 tonnes. Moving it by road from a centrally located DC in, say, Magna Park to Felixstowe would emit approximately 165 kg of CO_2. Minimising the hinterland movement of empty containers can therefore yield a significant direct carbon saving. By accelerating container turnaround times, it also increases the annual container trip rate thus reducing the total number of containers required to handle a fixed amount of world trade and their 'embodied carbon'. It is estimated that, on a life cycle basis, there are approximately 12 tonnes of embodied carbon in the average 40ft container (Hammond and Jones, 2008). The potential for using PCL to accelerate trip rates partly depends on the pattern of empty container repositioning across the hinterland. If empty containers have to be moved inland from the port to pick up export consignments, rather than be moved over a shorter distances from import destinations to be backloaded with exports, PCL may not result in any net reduction in vehicle-kms or emissions. As Monios and Wilmsmeier (2012) note, 'leaving import containers at ports reduces inland container availability for exporters' (p217).

5.3 Opportunity to raise maximum container weight above the maximum legal weight of a truck:

When a container is moved inland to a DC, its maximum load is constrained by the legal weight limit of the truck (44 tonnes in the UK). The heavy tare weight of the container effectively reduces the available weight-carrying capacity of the vehicle below the maximum weight that could be carried in a conventional box van trailer. It can also result in the container being under-loaded, in weight terms, onboard the deep-sea vessel, increasing transport costs and emissions. As inbound container loads are relatively light, however, the truck weight limit has relatively little impact on the carbon intensity of inbound container movements within the UK. The density of Britain's containerised imports is relatively low resulting in containers 'cubing out' long before they 'weigh out'. In 2011, the average loaded inbound container handled by the UK's deep-sea ports weighed 14.4 tonnes, well below the 25-26 tonnes than could be carried within the UK truck weight limit. In the online survey 45% of importers reported having no inbound containers subject to a weight constraint, while an additional 23% had less than 10% of the containers weight limited. Even in the case of the small proportion of imported containers with dense loads, PCL would not necessarily relax the weight constraint as container loading could still be restricted by truck weight limits applied in the foreign market.

5.4. Facilitating the adjustment of global supply chains to 'slow steaming'

There may also be a link between PCL and 'slow steaming', a practice that has become widespread since 2008 and helped to reduce the carbon intensity of container shipping. Although motivated primarily by a desire to cut costs, slow steaming has been a very effective carbon reduction measure, cutting emissions from deep-sea container vessels by around 11% over the period 2008-10 (Cariou, 2011). In theory PCL should partly compensate for the longer deep-sea transit times by compressing delivery times within port hinterlands thus making it easier for companies to accommodate slow-steaming within their global supply chains. Only three of the shippers interviewed confirmed that there was likely to be a positive association between PCL and slow steaming and none were able to elaborate on the nature and strength of this relationship. This is a topic that requires further investigation.

5.5 Facilitating modal shift to rail and waterborne services

Total carbon emissions from hinterland transport are very sensitive to the choice of transport mode. According to unpublished research undertaken for a major UK railfreight operator carbon emissions per TEU-km for rail are between a third and a quarter those of road. There is evidence of PCL assisting a modal shift to rail or water-borne services. For example, the supermarket chain ASDA has transferred the movement of imported clothing products from road to a coastal feeder service connecting an inbound deep-sea service to Felixstowe with its port-centric DC in Teesport (Brett, 2010). There are fewer examples of freight switching to lower carbon modes on journeys outbound from port-based DCs. The replacement of two shorter journey legs via an inland DC with one longer direct delivery to a retail outlet generally increases the length of haul, in theory allowing rail to exploit more effectively its comparative advantage in long distance movement (Monios and Wilmsmeier, 2012). The new London Gateway container port is predicting that 30% of its traffic will move by rail, much of it from its integral logistics park. On the other hand, it is possible to construct a much less favourable scenario for the impact of PCL on the freight modal split. Rail currently has a very small share of secondary distribution between DCs and retail outlets in the UK, while a major switch to PCL would shrink the market for hinterland container movements, of which rail currently holds a 24% share. Given these conflicting pressures, it is difficult to forecast the net effect of PCL on freight modal split within the hinterlands of the UK container ports.

6. CONCLUSION

The huge increase in the reliance of the UK retail sector on containerised imports has begun to skew the distribution of warehousing capacity towards the ports. Although the amount of DC development at major container ports has so far been relatively modest, the imminent opening of a major new, purpose-built port logistics complex on the outskirts of London may prove to be the ‘game-changer’ that the publicity material predicts. The results of two surveys of shippers summarised in this paper help to explain their reservations about locating DCs at ports, though the new London Gateway development should overcome some of the concerns – if it is able to attract a sufficient range of deep-sea container services.

The main focus of this paper, however, has not been the viability of the PCL concept. Against a background of growing interest in PCL and frequent claims by its proponents that it is environmentally-beneficial, the research reported in this paper has tried to assess in greater detail whether PCL offers a means of reducing the carbon intensity of the maritime supply chain. It has revisited five possible ways in which PCL can cut carbon emissions discussed in a previous paper and analysed the main one, reducing hinterland distances for containerised imports, in greater detail. This much more extensive carbon modelling confirms that there is likely to be a significant net CO_2 saving from PCL, though its magnitude is highly sensitive to the average number of box-van trailers that it takes to distribute the contents of a container.

More empirical research is required on the variations in this container : box-van trailer ratio across inbound retail supply chains to improve the calibration of the spreadsheet model. Quantification of the carbon savings from the other four potential decarbonisation effects of PCL will also need more industry data as none of the statistics currently in the public domain permit this analysis. The modelling reported in section 5.1 related solely to ports with deep-sea containers services and needs to be extended to other ports, such as Teesport and Grangemouth, which handle substantial flows of container feeder traffic. Future research could also investigate other forms of PCL, supplementing the current study of imported flows of retail supplies with the use of PCL by exporters and other categories of importers.

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