

Jahn, Carlos; Schlingmeier, Johannes

Conference Paper

Cooperation in Empty Container Logistics

Provided in Cooperation with:

Hamburg University of Technology (TUHH), Institute of Business Logistics and General Management

Suggested Citation: Jahn, Carlos; Schlingmeier, Johannes (2014) : Cooperation in Empty Container Logistics, In: Blecker, Thorsten Kersten, Wolfgang Ringle, Christian M. 978-3-7375-0341-9 (Ed.): Innovative Methods in Logistics and Supply Chain Management: Current Issues and Emerging Practices. Proceedings of the Hamburg International Conference of Logistics (HICL), Vol. 18, epubli GmbH, Berlin, pp. 499-514

This Version is available at:

<https://hdl.handle.net/10419/209245>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



<https://creativecommons.org/licenses/by-sa/4.0/>

Cooperation in Empty Container Logistics

Carlos Jahn and Johannes Schlingmeier

Abstract

Seaborne container transport volumes have doubled between 2001 and 2011 from 59 to 118 million TEU. The demand for container transport also induces demand for empty container repositionings, as not all import locations have an equally large demand for export of containerized cargo. As a result, empty containers have to be transported from equipment surplus- to deficit-locations. Around 25% of all transported containers are empty, resulting in costs of USD 33 billion in 2011. Since overcapacity in the industry has put margins under pressure and empty transports are often not paid for by the shipper, limiting those expenses is crucial for carriers.

While technology-, pricing- and operations research-related approaches have been implemented widely, cooperative strategies have received little attention in practice. The literature attributes this to the fact that the benefits of such a strategy have not been proven yet.

Based on the network-model, we believe, that an interchange of equipment between carriers in surplus- and deficit-locations will reduce the required number of empty moves. The paper constitutes the first empirical analysis of the potential of equipment interchange and will reveal that between 5-10% of moves can be avoided. The analysis is conducted as a case study and based on actual container moves collected from nine global container carriers. By proving the benefits of equipment interchange, we hope to contribute to further cooperation among carriers.

Keywords: empty container logistics, cooperation, equipment interchange, imbalances

1. Introduction

Worldwide container transports at sea have doubled between 2001 and 2011 from 59 to 118 million TEU (Drewry Maritime Research, 2012; Global Insight, 2011). To conduct containerized transports, shippers require empty equipment, which – if not available – needs to be repositioned to the export location (Di Francesco, Crainic and Zuddas, 2009, p.758). These repositionings help to absorb the transport imbalances by moving empty equipment from surplus to deficit regions (Moon, Do Ngoc and Konings, 2013, p.107). However, the amount of empty repositionings is significant: Every fifth seaborne container and 40% of all equipment transported over land are empty (Konings et al., 2001, p.334, Karmelic, Dundovic and Kolanovic, 2012, p.223). Already in 2005, 82 million containers were loaded and unloaded empty in ports (Vojdani and Lootz, 2011, p.2). The cost arising from empty logistics for carriers alone amounted to USD 33 billion in 2011 (Notteboom and Rodrigue, 2008, p.167; Vojdani and Lootz, 2011, p.2). This equals 7-10% of operating expenses for carriers. Hence, empty container logistics requires significant efforts from carriers and deserves their attention. Because of carriers' currently low earnings, their overall profitability is dependent on the efficiency of their empty logistics (Flämig, Wolff and Herz, 2011, p.5; Olivo, Zuddas, Di Francesco and Manca, 2005, p.367; Feng and Chang, 2008, p.470; Lam, Lee and Tang, 2007, p.265; Song and Carter, 2009, p.292)

This efficiency can be reached in multiple ways. Levers to reduce costs for the carrier in empty container transportation include logistics, technology, pricing and management/organization. These levers can be classified in those that reduce the number of required empty transports and those that reduce the cost per empty transport by raising the transport efficiency (e.g. by improving the network design). The approaches are internal or external (cooperative).

While logistical, technological and pricing levers have received significant attention and are widely implemented, managerial and organizational levers – and especially cooperative ones – are barely relevant in practice, although

receiving significant theoretical coverage. Several reasons have been identified, why equipment interchange or even pooling is difficult to implement. One – and according to literature the most important – is that if carriers have similar imbalances, then exchanging equipment will not reduce the number of required empty repositionings (Lun, Lai and Cheng, 2010, p.161). Braekers, Janssens and Caris (2011, p. 697) state, that "Future research could identify cost-saving opportunities from cooperation among carriers". The following chapters aim to answer this question and by achieving this to remove one of the most prominent roadblocks to cooperation in empty container logistics.

2. Problem description

2.1 Root causes for empty container logistics

Empty equipment is the prerequisite for the transport of containerized cargo. If no empty equipment is available, the shipper cannot fill a container and hence the transport cannot be conducted. Therefore, empty containers have to be transported to an export location, if supply is insufficient. There are four major root causes for empty container logistics: structural trade imbalances, seasonal demand for transportation, equipment type imbalances and the large number of equipment owners (Song and Dong, 2011, p.92; Olivo et al., 2005, p.4).

Global and regional trade imbalances are the biggest reason for the transport of empty containers. If a region has more containerized exports than imports, automatically this region has an under-balance of containers (Boile, Theofanis and Mittal, 2004, p.3; Hüttmann, 2013, p.31; Pawlik, 1999, p.119; Bandeira, Becker and Borenstein, 2009, p.383). This phenomenon leads to global imbalances. On top of the region-wide imbalance, each trade, i.e. the transport between two regions, can be unbalanced which may require empty repositionings even in overall balanced regions (Brito and Konings, 2011, p.1; Diaz, Talley and Tulpule, 2011, p.218).

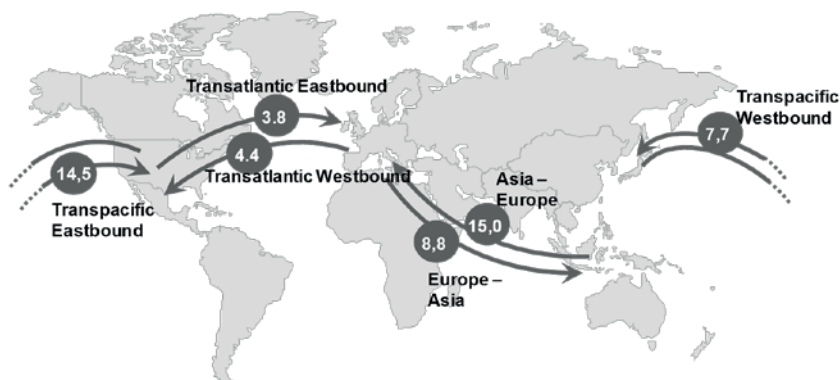


Fig. 1: Container flows 2012 in million TEU (Drewry Maritime Research, 2012)

The most prominent examples of global imbalances are the transpacific trade and the trade between Europe and Far East Asia. In both cases, the export surplus of Far East Asia causes the imbalance. The Transpacific trade connects North America with the Far East. While, in 2012, 14.5 million TEU were shipped eastbound, only 7.7 million TEU were shipped in the opposite direction, leaving a trade imbalance (and hence demand for empty repositionings) of 6.8 million TEU. A similar imbalance can be found on the trade between Europe and Far East. On top, empty repositionings also occur intra-regionally (Braekers, Janssens and Caris, 2011, p.681). While urban areas are usually net-importers of cargo, hence have an empty-container surplus, industrial centers are often net-exporters of cargo, requiring additional empty containers to be repositioned. Weight differences between the regions' export cargoes also add to trade imbalances (Konings, 2005, p.224; Olivo et al., 2005, p.204; Hüttmann, 2013, p.35).

A trade that is balanced over the course of a year can still show temporary imbalances. These imbalances arise from seasonal cargo flows ("temporal imbalances"). Such flows are typically caused by seasonal products (fruits and vegetables) or special events, such as the Chinese New Year. Trades with a large share of seasonal transports are between Northern Africa and Europe and between Latin America and Europe (Lei and Church, 2011, p.754; Braekers,

Janssens and Caris, 2011, p.681; Olivo et al., 2005, p.204; Hüttmann, 2013, p.35; Konings, 2005, p.224; Karmelic, Dundovic and Kolanovic, 2012, p.223).

Beyond overall trade-surpluses or -deficits, cargo requirements can cause "operational imbalances" (Song and Dong, 2011, p.92). Certain cargo requires the use of special equipment, for example, perishable cargo needs to be transported in a reefer container. Light cargo on the other hand is preferably transported in 40-foot-containers, instead of 20-foot-containers to save cargo handling expenses (Song and Carter, 2009, p.294). If one export location requires the use of a certain equipment type which cannot be used for the next export of the previously receiving location, then this equipment needs to be repositioned empty – even on a trade which may otherwise be balanced.

Since containers are owned by different actors, these actors' trade structures can also add to the imbalances. While regional, temporal and operational imbalances can be classified as structural, "company specific imbalances" arise from the specific customer mix and trade structure of each company. Since in principle, each owner only uses its own equipment, empty transports are regularly required even in an overall balanced location. As company-specific imbalances are not structurally caused, they can be avoided to some extent. This paper investigates the potential to reduce empty repositionings caused by company-specific imbalances (Shintani, Konings and Imai, 2010, p.762).

2.2 Effects of empty container logistics

As every form of imbalances requires the repositioning of empty containers, the dimensions of empty logistics are significant, making it an integral part of every carrier's planning. About 22% of all containers transported at sea and about 40% of all inland moves are empty (Mongelluzzo, 2004, p.10; Shintani, Konings and Imai, 2010, p.750; Crainic, Gendreau and Dejax, 1993, p.104). This results in company, environmental and societal effects.

For carriers, the costs of empty repositionings are significant. In 2011 the direct costs of the empty container logistics for carriers summed up to USD 33 bn. These direct costs include transportation and terminal cost and the cost for

maintenance and repair of the container. On top of these direct costs, empty repositioning also causes indirect costs such as higher investments in a larger equipment fleet and increased administrative efforts. Empty container logistics also have significant effects on other actors, such as leasing companies, shippers, terminal and depot operators (Lun, Lai and Cheng, 2010, p.151). But also society and the environment are affected by empty container logistics – mainly because empty transports increase overall traffic. Additional traffic increases both emissions and the utilization of infrastructure which adds to an already high utilization of infrastructure bottlenecks (Flämig, Wolff and Herz, 2011, p.49). Last but not least, unnecessary transports also lead to waste of non-renewable fuel (Hüttmann, 2013, p.52).

3. Research gap

The topic of empty container logistics has received significant attention by literature. Current summaries can be found in Hüttmann (2013) and Brito, Konings (2011). Earlier works reach back to the 1970s – the early years of containerized cargo shipping (White, 1972; Ermolev, Krivets and Petukhov, 1976; Pezier, Cresswell and Davenport, 1979). But attention has not ceded since. Especially the cost and efforts of empty repositioning have been discussed widely (Olivo, Di Francesco and Devoto, 2003; Notteboom and Rodrigue, 2008). Most publications have in common that they do not only describe the effects of empty container logistics but also offer potential solutions. As shown earlier, these strategies can be grouped in internal (optimizing) and external (cooperative) strategies. Also, they can be grouped in strategies to avoid empty container transports and to efficiently conduct empty transports (figure 2).

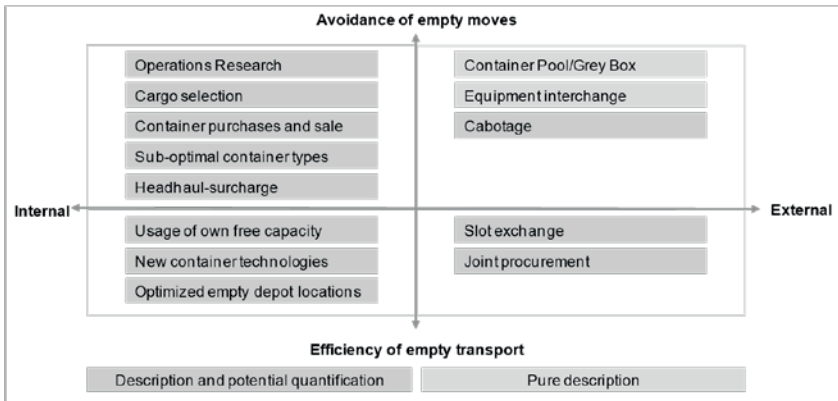


Fig. 2: Status of research on carriers' empty container strategies

Extensive descriptions and potential quantifications have been made for internal strategies and for cooperative strategies to efficiently conduct empty container transports (Song and Carter, 2009, p.292). However, little quantitative research has been conducted on cooperative strategies to avoid empty transports. Dang, Yun and Kopfer (2012, p.708) comment on the status of research as follows: "[...] little research has been reported on the coordinated optimization of empty container positioning [...]". Several authors have described the logic of reducing the number of required empty transports through equipment interchange. Boile (2006, p.65f.) calculates a theoretical potential. Song, Carter (2009, p.301f.) establish a mathematical model using a fictive imbalance-breakdown to individual carriers. Neither of the authors conducts a detailed qualitative assessment based on actual data.

Even less empirical research has been conducted on a container-pool or grey-box-pool. The concept is to move the ownership of equipment from the individual carrier to a new 3rd party company. Theoretical discussion of this strategy has started in the early 2000s (Hanh, 2003; Lopez, 2003, p.350). Mongeluzzo (2004) describes the advantages of equipment pooling, however sees significant problems in realizing such form of cooperation. Other authors discussing equipment pooling in container shipping are Notteboom, Rodrigue (2008), Ferulli

(2010) and Hüttmann (2013). Song, Carter (2009) have also assessed the potential of equipment pools – however based on fictive data and on an aggregated trade level. Braekers et al. (2011, p.697) summarize the lack of quantitative research on the potential of equipment interchange: "Future research could identify cost-saving opportunities from cooperation among carriers [...] Technological developments [...] seem to be interesting options to facilitate and/or reduce the costs of empty container management. However, so far, there has been little research on the potential savings of these technologies. Finally, most research takes the perspective of a single ocean carrier or transportation company."

4. Research methodology

Based on the network-model, we believe, that the interchange of equipment between carriers in can reduce the required number of empty moves (Weber, 2008, p.63; Delfmann et al., 2010, p.45; Vahrenkamp, Kotzab and Siepermann, 2012, p.10; Klaus, Krieger and Krupp, 2012, p.445; Doborjginidze, 2005, p.21). This paper will assess the impact of container interchange between carriers on the total number of empty moves required in the system trough a case study. In order to close the research gap - the lack of a quantitative potential analysis - actual empty container transport data was collected. Eleven global container carriers were approached to submit their empty container transports in 2012. Of those, nine carriers actually participated and provided detailed data on their empty moves. These nine carriers constitute ~46% of the global container carrier fleet – making this is very well usable sample (Alphaliner, 2013). The sample includes carriers from all relevant global shipping regions.

Each empty container move was recorded including information on the month, the origin and destination locations, the equipment size-type and the carrier's name. In total, ~35 million empty container moves were provided for this study. Only dry containers were investigated, as the different reefer systems make an interchange more complex than for dry equipment.

If one carrier has a surplus of empties (i.e. more equipment than he needs to transport the export cargo), he could in theory provide this equipment to a carrier who has a shortage of containers. In such a case, an exchange of equipment would make sense from a system's point of view; however individual carriers may still chose not to provide containers for competitive reasons or to optimize individually. If on the other hand both company's containers were owned by a third party, the exchange of containers would not be the choice of an individual carrier but one that takes into account overall system optimization. Analysis of the destination of the equipment has been excluded, as this would only be relevant to assess the potential of equipment interchange between carriers who still own their equipment. Those carriers would need to know the destination where they would receive back their equipment as this would be the origin for any future shipments. If however all equipment is owned by one entity, this company would need to serve all shipments anyways – regardless of the equipment's origin.

Each empty export or import that can be avoided is called a match. For a match as defined in this analysis, three conditions need to be met. First, the import and export from a certain location need to be from two different companies. Second, the containers need to be of the same equipment type and size. Third, both import and export need to happen in the same month of the year 2012. If those conditions are met, a match is possible and will be counted for the analysis. The results of the empirical analysis are described in the next chapter.

5. Case study results

In total, ~35 million moves in 308 geographic clusters across all regions were analyzed. It was assessed in detail whether the individual carriers' empty container flows had opposing directions in the same month of the year 2012. By applying the rules for a successful match outlined above, globally over two million empty moves could have been avoided in 2012 by exchanging equipment

between liners – based on the sample covering ~45% of the total market. This equals six percent of total empty moves.

Equipment can be exchanged in all regions. Only 95 analyzed clusters did not have any matching potential. Of these, only one carrier was active in 45 clusters, making any cooperation impossible. Hence, only 50 clusters show equal imbalances for all carriers. Europe and North America have the largest relative matching potential with 13% of empty moves each - significantly higher than in the third major region of containerized activity – North East Asia (2%). Most other regions show a similar share of avoidable empty transports between three and seven percent.

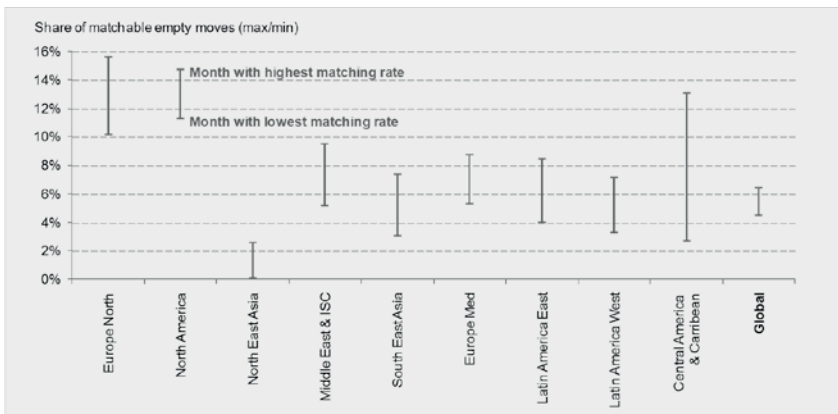


Fig. 3: Range of monthly shares of avoidable empty moves per region

During the course of the year, the share of empty moves that can be matched varies by region. Figure 3 shows the maximum and minimum monthly matching rate per region and globally. In North America, this quota for example varies from 11-15%. In Central America and the Caribbean, the quota varies between 3-13%. Matching quotas however are fairly stable between equipment types. In most regions, the share of matchable transports does not vary significantly between 20-ft, 40-ft und 40-ft High Cube equipment.

6. Discussion

This research quantifies the impact of pooling container equipment on the number of required empty container transports. It was shown, that cooperation between carriers – or a joint equipment-owning unit can have a positive effect on the number of required moves. This can be attributed to the fact, that carriers have different equipment imbalances, i.e. the equipment imbalances are partially company-specific. This means that six percent of imbalances are company-specific, which in turn quantifies the predominant perception in literature: Lun et al. (2010) and Theofanis, Boile (2008) among others assume that the majority of imbalances are similar between carriers (Theofanis and Boile, 2008, p.59; Lun, Lai and Cheng, 2010, p.161). This research proves this but on the other hand shows that a significant share is company specific - hence avoidable. This study also provides an answer to Braekers, Janssens and Caris' (2011, p.697) request to identify the cost-saving opportunities from equipment interchange, closing this research gap.

The results of this study also support the research on cooperation in empty container logistic by removing the fundamental argument against the solutions offered (e.g. equipment interchange, container pooling, etc.) – that all carriers have similar imbalances. The same holds for cooperative solutions in practice. By proving the potential, this research may help in leveling one the major roadblocks to cooperation in empty container logistics.

7. Conclusion

While this paper has shown transport- and cost-saving potential from exchanging equipment in empty container logistics, the study was conducted ex-post. I.e. all empty moves were foreseeable. Therefore, one should call this potential a theoretical potential as likely only a share could be realized in practice, as not all equipment surpluses and deficits are foreseeable to the extent necessary to exchange equipment.

On the other hand, this research offers a good indication as it shows what the absolute maximum benefit of an equipment pool would be and what any equipment pool could be measured against. Future research should compare the theoretical potential of an ex-post analysis with actually realized potential in other industries (e.g. pallet pools, airfreight containers). This paper also deliberately ignores behavioral aspects of equipment interchange. A company may for example not be willing to share its equipment for competitive reasons.

In order to increase the practical relevance of the shown result, future research should also investigate the drivers of the cooperation potential. As was seen, the share of avoidable empty moves significantly varies between regions, equipment types and over time. Hence, the value of an equipment pool could be increased if it was clear what drove the potential, i.e. what factors influence, whether an equipment interchange is promising.

References

- Alphaliner, 2013. Monthly Monitor June 2013.
- Bandeira, D.L., Becker, J.L. and Borenstein, D., 2009. A DSS for integrated distribution of empty and full containers. *Decision Support Systems*, 47(4), pp.383–397.
- Boile, M., Theofanis, S. and Mittal, N., 2004. Empty intermodal containers—a global issue. *Proceedings of the 2004 Transportation*.
- Braekers, K., Janssens, G.K. and Caris, A., 2011. Challenges in Managing Empty Container Movements at Multiple Planning Levels. *Transport Reviews*, 31(6), pp.681–708.
- Brito, M. De and Konings, R., 2011. Container management strategies to deal with the East-West flows imbalance. In: *Nectar Cluster Meeting on Freight Delft*, pp.1–14.
- Crainic, T., Gendreau, M. and Dejax, P., 1993. Dynamic and stochastic models for the allocation of empty containers. *Operations Research*, 41(1), pp.102–126.
- Delfmann, W., Danglmaier, W., Günthner, W., Klaus, P., Overmeyer, L., Rothengatter, W., Weber, J. and Zentes, J., 2010. *Positionspapier zum Grundverständnis der Logistik als wissenschaftliche Disziplin*. Bremen, pp.1–9.
- Diaz, R., Talley, W. and Tulpule, M., 2011. Forecasting Empty Container Volumes. *The Asian Journal of Shipping and Logistics*, 27(2), pp.217–236.
- Doborjginidze, G., 2005. *Analyse der Entwicklung intermodaler Logistik-Netzwerke in mittel- und osteuropäischen Ländern*. Köln: Kölner Wissenschaftsverlag, p.176.
- Drewry Maritime Research, 2012. *Container Market Review and Forecaster Q2 2012*. London.
- Ermolev, Y.M., Krivets, T.A. and Petukhov, V.S., 1976. Planning of shipping empty seaborne containers. *Cybernetics*, 12(4), pp.644–646.
- Feng, C.-M. and Chang, C.-H., 2008. Empty container repositioning planning for intra-Asia liner shipping. *Maritime Policy & Management*, 35(5), pp.469–489.
- Flämig, H., Wolff, J. and Herz, N., 2011. A hotspot for empty flows. *Baltic Transport Journal*, (4), pp.48–49.
- Di Francesco, M., Crainic, T.G. and Zuddas, P., 2009. The effect of multi-scenario policies on empty container repositioning. *Transportation Research Part E: Logistics and Transportation Review*, 45(5), pp.758–770.
- Global Insight, I., 2011. *Trade and Transportation Report*. New York.
- Hanh, L.D., 2003. *The Logistics of Empty Cargo Containers in the Southern California Region: Are Current International Logistics Practices a Barrier to Rationalizing the Regional Movement of Empty Containers*. pp.1–40.
- Hüttmann, B.K., 2013. *Empty Container Logistics in the Maritime Economy - Evidence from the North Range*. 1st ed. Hamburg: Verlag Dr. Kovac, p.410.

- Karmelic, J., Dundovic, C. and Kolanovic, I., 2012. Empty Container Logistics. *PROMET-Traffic&Transportation*, 24(3), pp.223–230.
- Klaus, P., Krieger, W. and Krupp, M., 2012. *Gabler Lexikon Logistik: Management Logistischer Netzwerke und Flüsse*. 5th ed. Wiesbaden: Gabler Verlag.
- Konings, R., 2005. Foldable Containers to Reduce the Costs of Empty Transport? A Cost–Benefit Analysis from a Chain and Multi-Actor Perspective. *Maritime Economics & Logistics*, 7(3), pp.223–249.
- Konings, R., Thijs, R., Organisation, S., Studies, M., Planning, T. and Section, T.E., 2001. Foldable Containers : a New Perspective on Reducing Container-Repositioning Costs Technological, logistic and economic issues. *European Journal of Transport and Infrastructure Research*, 1(4), pp.333 – 352.
- Lam, S.-W., Lee, L.-H. and Tang, L.-C., 2007. An approximate dynamic programming approach for the empty container allocation problem. *Transportation Research Part C: Emerging Technologies*, 15(4), pp.265–277.
- Lei, T.L. and Church, R.L., 2011. Locating short-term empty-container storage facilities to support port operations: A user optimal approach. *Transportation Research Part E: Logistics and Transportation Review*, 47(5), pp.738–754.
- Lopez, E., 2003. How do ocean carriers organize the empty containers reposition activity in the USA? *Maritime Policy & Management*, pp.339–355.
- Lun, Y.H. V., Lai, K.-H. and Cheng, T.C.E., 2010. Managing Empty Containers. In: *Shipping and Logistics Management*. pp.151–164.
- Mongelluzzo, B., 2004. Thinking inside the box. *Journal of Commerce*, 5(2), pp.10–12.
- Moon, I., Do Ngoc, A.-D. and Konings, R., 2013. Foldable and standard containers in empty container repositioning. *Transportation Research Part E: Logistics and Transportation Review*, 49(1), pp.107–124.
- Notteboom, T. and Rodrigue, J.-P., 2008. Containerisation, Box Logistics and Global Supply Chains: The Integration of Ports and Liner Shipping Networks. *Maritime Economics & Logistics*, 10(1-2), pp.152–174.
- Olivo, A., Di Francesco, M. and Devoto, R., 2003. Intermodal freight transportation. The problem of empty containers in transportation service production. *Transporti Europei*, 9, pp.49–53.
- Olivo, A., Zuddas, P., Di Francesco, M. and Manca, A., 2005. An operational model for empty container mgmt. *Maritime Economics* 7(3), pp.199–222.
- Pawlik, T., 1999. *Seeverkehrswirtschaft: Internationale Containerlinienschiffahrt - eine Betriebswirtschaftliche Einführung*. Wiesbaden: Gabler Verlag, p.178.
- Pezier, J.P., Cresswell, D.C. and Davenport, S.J., 1979. The Economic Risks of Intermodal Containerisation by 1988. *The Geneva Papers on Risk and Insurance-Issues and Practice*, 4(3), pp.6–55.

- Shintani, K., Konings, R. and Imai, A., 2010. The impact of foldable containers on container fleet management costs in hinterland transport. *Transportation Research Part E: Logistics and Transportation Review*, 46(5), pp.750–763.
- Song, D.-P. and Carter, J., 2009. Empty container repositioning in liner shipping. *Maritime Policy & Management*, 36(4), pp.291–307.
- Song, D.-P. and Dong, J.-X., 2011. Effectiveness of an empty container repositioning policy with flexible destination ports. *Transport Policy*, 18(1), pp.92–101.
- Theofanis, S. and Boile, M., 2008. Empty marine container logistics: facts, issues and management strategies. *GeoJournal*, 74(1), pp.51–65.
- Vahrenkamp, R., Kotzab, H. and Siepermann, C., 2012. *Logistik - Management und Strategien*. 7th ed. München: Oldenbourg Verlag.
- Vojdani, P.N. and Lootz, D.F., 2011. Modellierung und Bewertung der maritimen Leercontainerlogistik unter Berücksichtigung des Container- Poolings. *Logistics Journal: Proceedings*, 7(1), pp.1–14.
- Weber, J., 2008. Überlegungen zu einer theoretischen Fundierung der Logistik in der Betriebswirtschaftslehre. In: *Beiträge zu einer Theorie der Logistik*. Berlin: Springer-Verlag.
- White, W.W., 1972. Dynamic transshipment networks: An algorithm and its application to the distribution of empty containers. *Networks*, 2(3), pp.211–236.

