Port and dry port life cycles: aligning systems complexity

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PORT AND DRY PORT LIFE CYCLES

Aligning systems complexity

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Abstract
The aim of this chapter is to revisit in the context of more recent work in the field the work of Cullinane and Wilmsmeier (2011) on the contribution of the dry port concept to the extension of the port life cycle. This extension relied on the use of vertically integrated corridors between the port and the dry port to move containers quickly and smoothly from the port to the hinterland for processing and stripping. This chapter brings another layer to this conceptualisation by adding the inland context, applying the intermodal terminal life cycle of Monios and Bergqvist (2016), in order to discuss synchronicities between the port and inland terminal (or dry port) life cycle. Both seaport and dry port in the hinterland have their own institutional governance structures, national and local policy and planning regimes and internal investment strategies regarding infrastructure capacity limits, and these change over time according to the different life cycles. Yet the demand for improved quality of port hinterland access to facilitate trade means that the two nodes must increasingly work together, which is already demonstrated in increasingly integrated ownership and operational models. However, for port hinterland transport to function smoothly, it is essential to understand both potential synergies and conflicts between various stages of the port and dry port life cycles.

Keywords: seaport, dry port, inland terminal, intermodal terminal, product life cycle (PLC), intermodal terminal life cycle (ITLC) maritime, governance, intermodal

1. Introduction

The aim of this chapter is to revisit in the context of more recent work in the field the work of Cullinane and Wilmsmeier (2011) on the contribution of the dry port concept to the extension of the port life cycle. In their chapter, the authors showed how dry ports can be used to increase port capacity by shifting containers inland for processing. Fierce port competition in the years leading up to the global economic crisis in 2008 saw ports using dry ports as tools of port competition, using freight facilities in the hinterland not simply for transporting containers inland but also for customs clearance, processing and administration activities (Notteboom and Rodrigue, 2005; Roso et al., 2009; Monios and Wilmsmeier, 2013). The onset of recession and dip in freight demand relieved the immediate challenge on port capacity, as did many port expansions that were completed in this period that had been initiated before 2008. Yet processes and models of port-hinterland integration continue to diversify due to several influences and challenges.

The trend towards using dry ports to enlarge the hinterland of the seaport is not new (van Klink and van den Berg, 1998), neither is the integration of logistics services within the transport chain (Notteboom and Winkelmans, 2001). The discussion on port regionalisation of Notteboom and Rodrigue (2005) identified that the hinterland was the new battleground and source of cost savings for large ports in a range that had already achieved similar cost savings and operational efficiencies at the quayside. Graham (1998: 135) wrote that "the land-side is characterized by relatively low investment, high operating expenses, little scale incentive to collective operation and a considerable level of unremunerated activity requiring cross payment out of sea freight," and this remains the case today.

The early port development literature from the 1960s was focused more on spatial development than actor-centric approaches, due in part to the historical industry structure. More recently, the complexity of the port's interactions with hinterlands and forelands (Notteboom and Rodrigue, 2005; Monios and Wilmsmeier, 2013) and their institutional relationships (Ng and Pallis, 2010; Jacobs and Notteboom, 2011; Notteboom et al., 2013; Wilmsmeier et al., 2014) have been essential aspects of analysis for understanding the port's development path.

The five stages of the traditional product life cycle (PLC) are development, introduction, growth, maturity and decline. The adapted PLC applied to ports by Charlier (1992) was based on five stages: growth, maturity, ageing, obsolescence and restructuring. The development and introduction stages are missing because most port sites have been in operation for long time periods, in some cases many hundred years. In the two decades since this model was applied, the development of entirely new ports is more familiar (e.g. China); nevertheless, from a strategic perspective, the interest is on how an ageing port reacts to changes in the market, changes in

technology and changes in port competition. Therefore, rather than a simple decline phase, the model focuses on obsolescence (Charlier, 2013). For example, a location may be obsolete due either to the introduction of a competitor port, new structures of world trade meaning that the location is no longer closest or cheapest to sources of demand, or changes in technology meaning that the port berths are no longer deep enough to accommodate larger vessels or the cranes are no longer able to handle containers fast enough to avoid congestion. In contrast to the traditional PLC model, the port life cycle includes a restructuring phase. Ports can restructure in various ways, such as deepening and lengthening berths and adding more and larger cranes to accommodate larger vessels, they can expand the size of the terminal if space permits, they can improve processes to achieve faster transit through the gate or faster processing of containers.

Cullinane and Wilmsmeier (2011) also applied the PLC to ports, and, following Schaetzl (1996), argued that this restructuring could take place by "location splitting" as a means to extend the port life cycle when limitations in feasible rationalisation, investment and access are reached. Such creation of a subsidiary in the hinterland provides a potential solution that avoids an inevitable decline, caused either by the emerging inappropriateness of the actual port location (e.g. once-central urban ports) or an increasingly competitive environment. One question that arises is whether location splitting as proposed by these authors can be induced by landside-driven factors as well. This means that terminals in the hinterland are not developed only as a result of port strategies but by cities seeking economic development opportunities or by real estate developers establishing logistics platforms (see section 3 for discussion of the Wilmsmeier et al., 2011 "directional development" model that contrasts port-driven vs inland-driven models of developing terminals or dry ports in the hinterland).

Cullinane and Wilmsmeier (2011) found a connection between the port's need to expand to serve growing trade and the increasing vertical integration in the logistics sector. The dry port concept (see next section), in which the inland freight facility is viewed as highly integrated with the port, suggests that vertically integrated corridors between the port and the inland location could improve port efficiency by moving containers quickly and smoothly to the hinterland for processing and stripping, including other functions such as customs (Beresford and Dubey 1991). The achievement of such a smooth functioning port-hinterland system may help to postpone the decline in the port's life cycle that may come about due to reaching the limits of infrastructural capacity within the port itself.

2. Definitions of dry ports and inland terminals

Terminology for describing inland freight handling nodes in the hinterland of seaports has become quite confusing in recent years. An early term was Inland Clearance Depot (ICD), which focuses on the ability to provide customs clearance at an inland location rather than at the port. Similarly, the term "dry port" has often been used interchangeably with ICD (Beresford and Dubey 1991; Garnwa et al. 2009) for the same reason – as the goods were legally entering the country at the inland location, it acted as the seaport yet it was not on the water hence "dry port". As such facilities have grown and are often linked to facilities providing logistics activities where freight is stored or processed, the "dry port" term has more recently been used to describe a kind of integrated logistics facility (Roso et al. 2009), thus sharing similarities with terms such as "freight village" or "logistics platform" (see also "Güterverkehrszentrum" (GVZ) in Germany, Logistics Activities Zone (ZAL) in Spain or interporti in Italy).

Discussions can also focus on the operational link between the seaport and the inland site, such as a high capacity link (rail or barge) and a high level of operational integration in the management (Veenstra et al. 2012). Other terms include inland terminal, intermodal terminal and inland port. Rodrigue et al. (2010) related the multiplicity of terms to the variety of geographical settings, functions, regulatory settings and the related range of relevant actors, and proposed that the key distinction is between transport functions (e.g. transloading between modes, satellite overspill terminals or load centres) and supply chain functions (e.g. storage, processing, value-added). Yet some of these terms (e.g. inland port, dry port, and several of the logistics terms such as freight village) are used to describe a large site containing both transport and logistics functions. Sometimes a small intermodal road-rail terminal with one rail service per day to/from a port is referred to as a dry port, whereas other times a large logistics platform with several large warehouses and a high capacity road-rail terminal with several services a day to a port is also called a dry port. Other times the former is called an intermodal terminal or inland terminal and the latter a freight village or logistics platform (cf. discussion in Monios, 2015). A key distinction is that "dry port" is only used in a maritime context (for obvious reasons), thus intermodal terminals not handling cargo from a port would have no reason to use such a term, but they may then start handling maritime flows and introduce customs clearance facilities hence becoming eligible to use such a term. For consistency with the Cullinane and Wilmsmeier (2011) chapter that we are discussing, we primarily use the term dry port, but for the most part this can be considered interchangeable with inland terminal or intermodal terminal, which is the term used in some of the other papers used in our conceptual discussion.

3. Directional development

Wilmsmeier et al. (2011) utilised insights from industrial organisation to examine how different institutional frameworks reveal nuances in the different kinds of integration between seaports and inland terminals or dry ports. They introduced a conceptual approach (directional model) to dry port development contrasting Inside-Out development strategies (land-driven e.g. developed by rail operators or public bodies) with those that are pursued Outside-In (sea-driven e.g. developed by port authorities or port terminal operators). While not all site development strategies can be classified solely as one or the other, this broad conceptual distinction highlights conflicting strategies and the importance of port investment if a dry port development is to lead to a successful business, handling port container shuttles for one or more seaports, thus assisting the seaport(s) in developing their hinterlands (Monios and Wilmsmeier, 2012).

This classification is particularly important because it highlights the challenges of port-hinterland integration and the potential conflicts between different actors. Monios and Wilmsmeier (2012, 2013) showed that the assumed levels of integration in intermodal corridors is in many cases at odds with the reality. Their analysis identified several difficulties arising from the nature of intermodal transport that challenge successful implementation of hinterland integration strategies. It is not only that differences can be observed between those developed by ports (Outside-In) and those developed by inland actors (Inside-Out), but that, while rail remains a marginal business, the industry remains fragmented, large shippers refuse consolidation and fragile government subsidy remains the basis of many flows, dry ports cannot become instruments of hinterland capture and control for ports. The integration processes predicted by the port regionalisation concept (cf. Notteboom and Rodrigue, 2005; Monios and Wilmsmeier, 2013) cannot happen until the inland logistics system becomes more integrated, and there is insufficient evidence as yet that inland transport is consolidated to the extent that maritime transport (e.g. global shipping lines and port terminal operators) has become over recent years. Moreover, in many cases the complexity of institutional design and the conflict of interest and collective action problems continue to constrain integration between maritime and inland transport systems. For example, precisely how an inland freight facility can be integrated with a port (either by activities or more formally through ownership) and how it can extend the port's life cycle by taking on some formerly port-based activities, depends on the specific actions it undertakes and the institutional relationships between the various organisations (e.g. whether the port authority or port terminal operator owns the dry port, whether they own or have any integration with the rail shuttles or with the logistics platform and its activities).

In recent years, some authors have engaged with the directional model and attempted to develop it further, from a binary model covering only the development phase into a matrix with two or more phases and two or more options at each phase. Bask et al. (2014) proposed that, while the development phase can be either Inside-Out or Outside-In, the growth phase could also be bi-directional, involving a high level of equal collaboration between the port and the dry port. Similarly, Raimbault et al. (2015) also took up the directional model, suggesting that only two directions is too simple and both directions can be at play simultaneously in a relational perspective. Their empirical analysis found that dry port development and integration (or not) with seaports is "as much a part of the wider structural changes as the actual retreat of transport activity from waterfront locations." One way to revise the directional model on the basis of this recent work could be to transform it from a binary model (Inside-Out vs Outside-In) covering only the development phase into a 3x3 matrix, including three phases (development, growth, maturity) and three model types (Inside-Out, Outside-In, bi-directional) at each phase. Yet, this would be rather simplistic and would not capture the complexity of institutional and operational relationships underpinning successful intermodal hinterland corridors linking seaport(s) with dry port(s). Crucially, it also would not account for the later period of the life cycle, where the dry port (and the port) face decline due to several influences, often infrastructural lacks but also changes in the market structure. The next section will explore these in more detail by turning to the intermodal terminal life cycle.

4. Intermodal terminal life cycle

The intermodal terminal life cycle (ITLC) was developed by Monios and Bergqvist (2016) and is presented in Table 1. While this model was developed for intermodal (primarily road-rail) terminals without explicitly considering their relations with seaports, it can be adapted for use here. The ITLC takes account both of the original product life cycle model as well as previous applications to seaports (Charlier, 1992) and inland ports (Leitner and Harrison, 2001). The Monios and Bergqvist (2016) model is based on the concerns raised in the literature regarding the difficulty distinguishing between PLC phases with certainty as well as identifying and measuring the main influences. Therefore, their adapted model is not based on unit sales like the number of containers transported. A model could be constructed based on related traffic figures over time, but the purpose of this model is to guide strategy, which relates to another criticism of the generic PLC model's inability to differentiate clearly between phases. Consequently, the life cycle in this model is divided into observable phases of development and operation rather than on, e.g. container throughput.

If maturity for an intermodal terminal can be defined, as for ports, as "when it cannot provide more space to the customer due to saturation or to impediments that stop further expansion" (Charlier, 2013: 599-600), then this is the trigger to enter the fourth phase, defined by Monios and Bergqvist (2016) as "extension strategy". This term is necessarily broad, because it may include different strategies of restructuring physically (e.g. terminal expansion), operationally (e.g. redesign of the site, different traffic sources and rail operators using the terminal) and institutionally (e.g. new business model, new ownership, integration between terminal and other actors like rail operators or seaport terminal operators). The point of "maturity", then, is not a phase but a trigger for restructuring, which, if successful, will lead to another period of operations until the next challenge arises.

The extension strategy phase is based on the restructuring phase from the port life cycle by Charlier (1992). Transport infrastructure can be upgraded and service portfolios developed to meet changes in the market; on the other hand, the infrastructure will also need to be maintained or simply monitored for long periods of time. Where a regular product or service on the market will simply be withdrawn and cease to be manufactured/offered due to absence of demand, transport infrastructure cannot be removed so easily. Public sector bodies will need to decide what to do with such infrastructure and consider whether it should be retained in the public stock or the land redeveloped for another purpose.

Table 1. Main features of each phase of the intermodal terminal life cycle

	Planning, funding & development	**Finding an operator**	**Operations & governance**	**Long-term or extension strategy**
Link to original PLC phase	Development	Introduction	Growth and maturity	Decline (+ potential restructuring, cf. Charlier, 1992; Cullinane and Wilmsmeier, 2011)
Length	3-10 years	1-2 years	>10years	>15years
Main stakeholders	-Public infrastructure stakeholders (e.g. rail authorities, planners, etc.) -Large shippers -Real estate developers -Terminal operator -Rail operators -Ports	-Public infrastructure owner -Terminal owner (if different to the above) -Terminal operator	-Public infrastructure owner -Terminal owner (if different to the above) -Terminal operator -Rail operators	-Public infrastructure owner -Other public stakeholders (e.g. rail authorities, planners, etc.) -Terminal operator
Main activities undertaken	-Planning -Design -Funding sought -Tendering of construction -Construction	-Designing business & ownership model -Tendering for operator -Designing concession agreement -Contract development	-Continuous improvements -Responding to changes in technology & demand	-Renewed terminal concession -Potential changes in business & ownership model -Potential expansion -Ensuring long-term strategy and control -Potential sale & redevelopment of site for new purpose

Source: adapted from Monios and Bergqvist (2016)

Drawing on the ITLC, the directional model for dry port development via-à-vis seaports can be expanded, including a fourth phase as well as adding a fourth type (inland only with no port involvement) to produce a 4x4 matrix (Table 2).

Table 2: 4x4 dry port development matrix based on the ITLC (Monios and Bergqvist, 2016) and the directional model (Wilmsmeier et al., 2011)

Phase	**Development**	**Introduction**	**Operation**	**Extension strategy**
Direction	Inside-Out	Inside-Out	Inside-Out	Inside-Out
	Outside-In	Outside-In	Outside-In	Outside-In
	Bi-directional	Bi-directional	Bi-directional	Bi-directional
	Inland only	Inland only	Inland only	Inland only

One advantage of drawing on the ITLC is to address concerns raised by Raimbault et al. (2015) that, in addition to the direction of development and the identification of the key public and private

actors involved, greater focus is needed on power relations between actors regarding strategic alignment of interests. Furthermore, a dry port facility may be developed under certain assumptions about its business model and traffic sources, with particular expectations of the role it would likely play in the port's ongoing strategic development (e.g. will the port guarantee traffic levels or not, will the port and dry port collaborate in organising rail shuttles or will it be left to the decision of rail operators). But over the years of its operational life the conditions may change and with that the role of the dry port. The dry port may be sold or re-concessioned, it may gain or lose the business of various rail operators (who ultimately are the ones hauling the traffic and using the terminal) or it may require maintenance or upgrades and become involved in contractual disputes over who should fund these investments.

Research shows that much of the time the port actor is a peripheral player in these ongoing day-to-day operational difficulties, even if they maintain a high percentage of ownership in the dry port (Monios and Bergqvist, 2016). Such operational problems may cause, e.g. trains to be delayed or have to wait in sidings, or containers not to be available on time. These problems endanger the high levels of throughout and integration required by a large seaport handling large numbers of container drops and relying on a smooth hinterland transport system. This challenge is exacerbated by the increasing size of container vessels now dropping thousands of containers in a single call. Can a seaport fully rely on their inland connections to such a high degree? Building on these concerns, the next question is what this expanded model (see Table 2) means for seaports. How does it enhance or constrain their location splitting options?

5. Relevance of life cycles to port and terminal planning

Despite an increasing volume of containers being transported inland from ports by rail, the number of dry ports in vertically integrated arrangements producing operationally and institutionally linked seaport-dry port intermodal corridors have not eventuated to the degree forecast a decade ago. Therefore, in mind of the many challenges and strategy fragmentations observed in the governance of dry ports, particularly during the maturity stage in their own later years when they require investment, several questions arise:

- What does this mean for the port life cycle, or as implied above, for a potentially aligned port-hinterland system life cycle?
- Can ports still rely on inland facilities to relieve pressure on their own development?
- Should ports be more proactive in developing and operating dry ports in the hinterland?

- Should ports return to their more traditional focus of expanding their handling capacity in the port?
- How complex is the creation of an alignment of different development strategies and phases?

As shown in the previous section, the different elements of the transport system, whether infrastructure, services, or governance models have a certain economic lifetime (Schaetzl, 1996) that can be characterised by sets of common phases. In recognition of the system's complexity, a key issue is not only to understand the implications of life cycle development of each of the elements (seaports or dry ports), but also the alignment or potential synchronisation of each of the life cycles.

Since many infrastructure and governance models in transport and economic geography research are generally long term in nature, alignment of different life cycles becomes a strategic issue. Thus, the assumption is that the life cycles run in parallel but are also interconnected. Cullinane and Wilmsmeier (2011) looked at how the dry port extends the port's life cycle, thus taking the Outside-In direction as a single perspective. The previous sections have shown that various combinations of directional development exist. The numerous models and facets of dry port development intrinsically change the complexity of aligning the individual life cycles. This complexity creates vagueness or lack of information for the planner who potentially cannot grasp or register the entirety of the development and its environment. The difficulty in aligning the seaport and dry port life cycles explains why the most successful seaport-inland links tend to be Outside-In developments, where the seaport actor has a better chance of controlling the system, or at least retaining a high level of operational information in order to synchronise their own planning (Wilmsmeier et al., 2015).

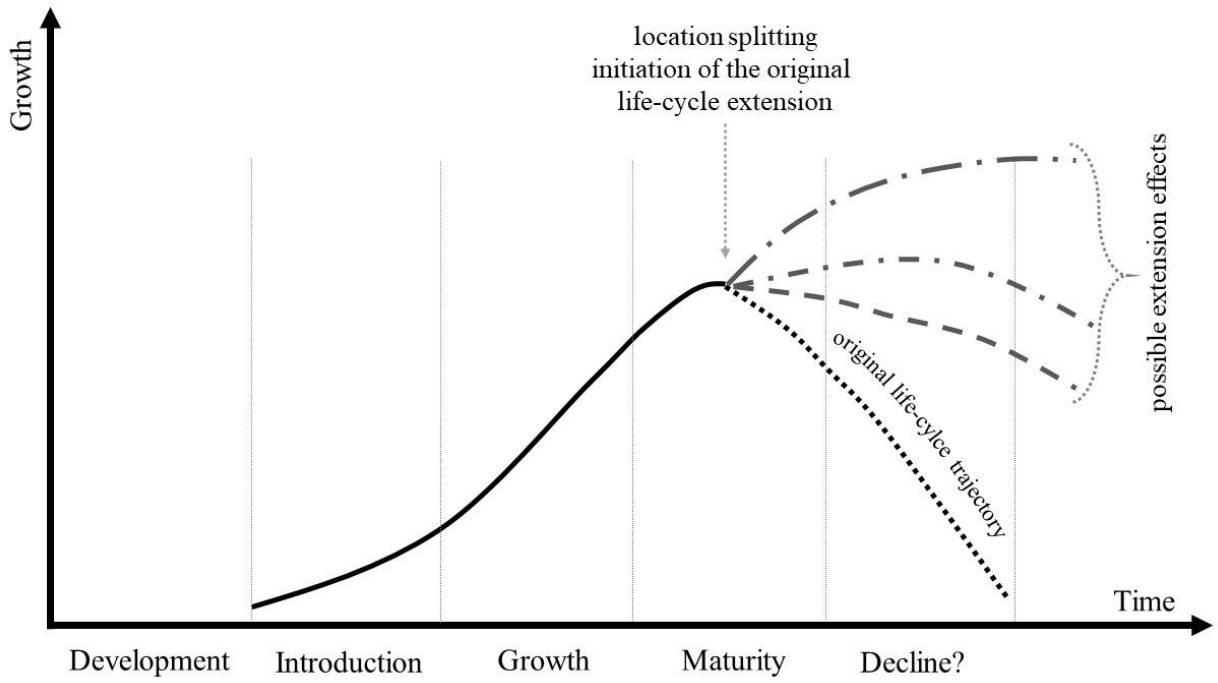
From an Outside-in directional perspective, a port authority or port terminal operator can trigger the expansion of the seaport either with the goal to extend the seaport's life cycle (e.g. Valparaiso, Chile) or to expand the port's hinterland (e.g. ECT, Rotterdam, Netherlands), via a strategy of location splitting. In these cases, the port authority or port terminal operator may decide to initiate a new dry port or enter a strategic alliance with already existing dry ports. From the port life cycle perspective the system is thus extended not only in its spatial reach and capacity volume, but also in a temporal, functional and governance perspective. Yet, many terminals in the hinterland of seaports have an Inside-Out orientation, thus, when considering the influence of the ITLC as discussed in the previous section, these terminals may be at any phase of their own

development and facing various challenges and future scenarios of which the port actors may be unaware.

The potential of life cycle extension from a port authority or port terminal operator perspective creates both challenges and opportunities. An understanding of the individual life cycles and their interaction increases the flexibility and development potential of the seaport terminal and its system capacity (i.e. container handling capacity). At the same time, the aligning and interconnection of different life cycles between seaport and dry port allows the expansion of the concept of the "terminal/port production system", offering additional benefits that reach beyond the pure scale increase of logistics activity. Yet they also raise many challenges due to the difficulty of the seaport actor(s) understanding or anticipating the changes taking place at the dry port potentially hundreds or thousands of miles away, even in a different country. Aligning the seaport's life cycle (which is known to the seaport strategist) with a variety of different and potentially unknown dry port life cycles is depicted graphically in

Figure 1.

Figure 1: Port life cycle expansion in the context of the dry port life cycle



Source: authors

According to the generic product life cycle theory, each life cycle phase needs to be considered, which will be taken from the seaport perspective. However, one key aspect of seaport strategy that is often overlooked in discussions of port-hinterland integration is the role of port governance. Some of the governance issues in dry port development and operation were raised in the ITLC of Monios and Bergqvist (2016), but an analysis of the strategic role of hinterland development in the port life cycle must also consider the evolution of seaport governance models and their impact on investment and expansion strategies.

Over the last decades, the "landlord" model of port governance (subject to regional and local differences), involving seaport terminal concessions, was introduced through port reforms around the world. In other words, the responsibilities for port services are shifted from a monopolistic public supplier, with human capital as the main factor of production, towards a private sector supplier. Changes in the environment and port operations (e.g. towards terminal automation) increased the capital intensity of developments; thus, capital investment to increase efficiency became a principal driver to implement this new governance model. In addition, the institutional responsibilities were in many cases devolved from a national to a local or regional scale (Wilmsmeier and Monios, 2016).

The growth stage mirrors the rapid expansion in international trade activity in which the new governance models allow the realisation of economies of scale by implementing standardisation and process innovation, and private capital investment for technological efficiency gains increasing their importance over human capital. Related governance models and growth prospects initiated an internationalization of private sector interests, which is also driven by the new capital requirements stemming from emerging needs for infra- and superstructure development and expansion as well as the introduction of new port related activities. In this context, the local and regional (public) institutions, e.g. port authorities, principally manage the fulfilment of the concession contracts and private sector obligations.

In the maturity phase, the main goals of the governance models relying more heavily on the engagement of private sector actors have been achieved by standardisation and technical efficiency and competition in the market increases. Given the demand growth in the previous phase, port authorities typically move towards increasing competition by stimulating new terminal development and by promoting greater private sector involvement. While port activity grows at slower rates, infrastructure approaches physical constraints for further expansion or to create competitive environments. In consequence, investment during the maturity stage focuses on the rationalisation of port services, particularly as land becomes a scarce commodity and commands premium prices or rents. This is paired with a new exposure of local authorities to private international and global operators and an increasing mismatch of power between the locally embedded authority and global players. Further, a certain urgency evolves to change the role of port authorities. During this phase, the local institutions and national authorities are experiencing a potential risk of losing control of the management and development direction of the port, particularly also in relation to port hinterland development. As market share is lost to competing ports with overlapping hinterlands the limitations of a devolved local governance model become apparent (Wilmsmeier and Monios, 2016).

The decline phase occurs once the point has been reached where the limitations in feasible governance have been reached and no further expansion of the port area or no other efficiency gains are possible at the local level and the supply of port capacity becomes fixed. This is the point where Cullinane and Wilmsmeier (2011) argued for dry ports being one way to expand the port's life cycle. However, if the governance model is not adjusted according to the changes in the (competitive) environment of a seaport it can become as obsolete as the infrastructure itself or may lead to stagnation of the future development path of the port.

During the transitional process by which a product moves from the development and introduction phases through the growth, maturity and decline phases of its life cycle, the conditions

for production and of the market will change (for terminal operators). Port governance is basically responsive (or reactive) to the demands of their customers (local and national economies). It is reasonable to assert, therefore, that the seaport governance life cycle is very much (functionally) dependent upon the evolution of its social and economic environment. This is a factor which is heavily influenced by the development of the respective seaport and the maritime industry in general.

The life cycle extension success of creating positive expansion effects depends on the alignment of the different life cycles. Existing approaches focus on volume effects, but structural and "production system" effects (e.g. diversification of services) are less considered. The connection of seaport and dry port life cycles can enhance the flexibility and the adaptability of the port-hinterland system, but requires new roles and activities of the port authority (van den Berg, et al., 2012; Baccelli et al, 2008) and the terminal operator, particularly in the area of planning. The architecture of the "integrated production system" increases in its complexity as infrastructure, economic dynamics, and governance in the hinterland are becoming more relevant. Accordingly, development decisions need to be based on an analysis of whether implementing a dry port is simply a protectionist measure that would prop up a failing seaport or whether it will be planned as a node of an integrated seaport hinterland system (as argued by Cullinane and Wilmsmeier, 2011).

In recognition that different elements (infrastructure, governance) of related port systems might have reached their maturity stage, the discussion on the "how" of the extension of the current system life cycle seems of high relevance. It might be argued that the currently needed transitions are decisive in the determination of extension of inevitable decline and require, more than ever, a holistic view, without losing the modularity of the system in sight. One reason for the continuing lack of full scale integration between seaports and dry ports is the specific isolated manner of planning and decision-making in the absence (or still only little developed) holistic view, including potentially a lack of understanding of the dynamics and interaction of the various system elements and their life cycles.

As the life cycles of the seaport-hinterland system elements might merge in different phases of each of the individual elements, different perspectives complicate planning issues (Monios and Bergqvist, 2016). These range from daily operational challenges in the rail network that may impair regular full shuttles to/from the port (Bergqvist and Monios, 2014) to contractual issues between rail stakeholders (e.g. dry port operators and rail operators using the dry port terminal)(Bergqvist and Monios, 2014) and institutional issues regarding port involvement in the dry port (Wilmsmeier et al., 2015). Thus, a detailed view on a proper understanding of planning

and integration issues is necessary to improve efficiency, quality and cost of the integration. The more detailed differentiation between Inside-Out and Outside-In directional development during different phases of the life cycle and the consideration of the governance cycle contributes to the understanding of the complex discussion regarding policies and planning supporting the development of dry ports, as the actors and their overall strategies and aims are potentially different and unaligned.

6. Conclusion and research agenda

The question thus is not only at which stage of the life cycle a port is at, but rather to understand the interaction of different cycles in order to proactively influence transitions between phases in a coordinated and effective manner. Port hinterland integration is a reality, but its success in creating positive externalities and reducing negative ones varies significantly across countries and regions. The discussion reveals the system complexity when including the hinterland and its elements (especially the dry port) in the port life cycle perspective, showing that the need for aligning different cycles becomes evident.

From a port authority point of view, various forms of integration with the hinterland are feasible and can offer new market opportunities and create new business areas, such as becoming a logistics cluster manager, deriving strategies to shift negative externalities away from the traditional port boundaries (e.g. modal shift to rail to reduce the environmental impact of truck transport – Gonzalez-Arregal et al., 2018) or even reducing these by increasing the overall efficiency of the system.

From the dry port operator point of view, seaport hinterland integration will allow for extending market reach and competitiveness. However, as the "terminal production system" expands, new complexities in the planning and management of capacity, information flows, and cargo flows emerge as well. Since the expansion is intrinsically linked to capacity and structural changes, the potential price for errors or dysfunctionalities in the system become greater. While regulation was not discussed in this chapter, ongoing issues of oligopoly in global shipping may also impact on port-hinterland integration, because eventually systems and not individual modes and locations will be competing. Thus market dominance at sea could potentially translate into the hinterland through vertically integrated transport chains. This is a consideration for future research because an inappropriate consideration of the changing competition regimes may lead to significant distortions in resources allocations "in an industry in which residual monopoly power or at least the risks of collusion between a few operators can be quite important." (Jara, et al, 2008,

1704). This argument applies to the seaport and dry port as well as the maritime and logistics industry.

The argument of this chapter is that such new challenges cannot be identified in the absence of an understanding of the port, shipping and logistics industry and the principles that move their operations. Understanding the system complexity in port hinterland development contributes to the formulation of realistic policy, planning and regulatory questions, a step towards the development of new theoretical approaches that are less mechanistic and instead flexible and organic in their nature.

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