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Dry Port-Seaport System Development: Application of the Product Life Cycle Theory

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ABSTRACT

Even with the growing number of studies on the dry port concept, we find a very little number of researches made on the progress or the development of dry port-seaport system. The objective of our paper is to collect and make a general overview of existent models in development of this system. The principle aim is to give more explanations about this system in order to be aware of its development and its impact in multimodal transport. Then, we develop a model of dry port-seaport system via the product life cycle theory in order to realize its growth, its relations and its potential tendency. Finally, we present examples from different regions using developed model. Our proposition helps to understand more the development of the system and to forecast its future behavior and impact. We can investigate more in decline phase in order to propose solutions rising system performance or creating a novel infrastructure.

İç Liman-Liman Sistem Geliştirme: Ürün Yaşam Döngüsü Uygulaması

Anahtar Sözcükler :

İç Liman

Liman

Multimodal Taşımacılık

Ürün Yaşam Döngüsü Teorisi

Tedarik Zinciri Yönetimi

ÖZ

Dry port kavramı ile ilgili yapılan çalışmaların sayısındaki artışa karşın, çok az çalışmada dry port-seaportların ilerleme ve geliştirilmesi konusu incelenmiştir. Bu çalışmanın amacı, bu sistemin geliştirilmesi açısından var olan modelleri ele alarak genel bir analiz yapmaktır. Birincil öncelikli olarak, söz konusu sistemin gelişimi hakkında fikir sahibi olabilmek adına açıklamalar yapılacak, multimodal taşımacılık üzerindeki etkisine değinilecektir. Sonrasında, ürün yaşam çevrim kuramı çerçevesinde bir model geliştirilerek, büyümesi, ilişkileri, potansiyel eğilimleri incelenecektir. Son olarak ise, farklı bölgelerde geliştirilen modelin kullanıldığı örnekler sunulmuştur. Çalışmada sunulan önerme, sistemin geliştirilmesini ve gelecekteki davranış ve etkilerini daha fazla kavramaya yönelik yardım sağlayacaktır. Sistem performansı ya da yeni altyapı kuruluşundan kaynaklanan problemlere çözümler önerme açısından sistemin düşüş noktalarında daha fazla araştırma yapılması önerilmektedir.

1. Introduction

Today, lack of space and growing congestion on seaport is one of the main problems facing the seaports performance. Congestion presents a risk, as traffic augments rapidly than estimated affirmed Barnard (2007). Thereby, an error in risk management can cost the dry port-seaport system too much (Bentaleb et al. 2015c). Seaport growth and, specifically, the dry port concept have been associated to the product life cycle theory (Cullinane and Wilmsmeier, 2011).. In their paper, where seaport developed and attains the maturity phase, the area necessary for storage space and other seaport services decrease, much investments in the maturity phase of the seaport expansion focus on the rationalization of seaport activities. Considering dry port, as node in multimodal transport, it has been created to mitigate the increasing congestion (Roso et al., 2009). For this, dry port developments have had additional consideration from researchers and academics all over the world. Bentaleb et al. (2015a) presented researches used dry port concept via a systematic review to give an idea about the quantity and quality of this studies. So, much research has deal with the concept of dry port as a solution to support seaport operations. Moreover, one of the outcomes of enhanced supply chain management is facilities designed particularly for multimodal organization (Prozzi et al., 2002). With the rapid growth of container flows and the development of multimodal transport (Mabrouki et al., 2013), seaports are in front of infrastructures problems associated with storage area and rising congestion. As consequence, it is quite normal to interest on seaport evolution which becomes more attractive (Mabrouki et al., 2014). Seaport performance is linked to the dry port performance and with a large vision is linked to the dry port-seaport system (Bentaleb et al., 2015b).

However, even with the quantity of studies relative to the dry port concept, limited quantity of studies has been developed on the evolution models of the dry port-seaport system. Based on the systematic review concerning dry port concept in the scientific literature made by Bentaleb et al. (2015a), the first model considering the progress sense of dry ports was presented by Wilmsmeier et al. (2011). They explain the directional development of the dry port. Their model was based on the Taaffe et al. (1963) model. Taaffe et al. (1963) modeled the transport development and improving accessibility access through internal expansion of the transport network. And recently in 2014, Bask et al. (2014) developed Wilmsmeier et al. (2011) model, taking into account the temporal factor. For that reason, the aim of this paper is to give an added value to more considering; understanding and explaining dry port-seaport system development. So, we propose a model by adopting the product life cycle theory on dry port-seaport system in order to examine its behavior from conception to departure or the creation of a new concept.

This paper is structured as follows. First, literature review on the dry port-seaport system development models in Section 2. Section 3 we present a product life cycle theory application on dry port-seaport system in order to understand the dry port-seaport system development and behavior. Finally, conclusion is presented in Section 4.

2. Overview of research on the development models of the dry port-seaport system

Based on the systematic review concerning dry port concept of Bentaleb et al. (2015a), the first model analyzing the development sense of the dry port was presented by Wilmsmeier et al. (2011). Their model considered the spatial evolution of transport infrastructure. They studied the direction of development of a dry port and tactics for collaboration of seaports and dry ports. Authors presented two concepts for the directional development. "Inside-Out" the development is from the dry port part. In contrast, "Outside In" the development is from the seaport's part (Figure 1). In the Inside-Out model, the integration in sense of possession can be determined by authorities, inland transport companies or logistics service provider.

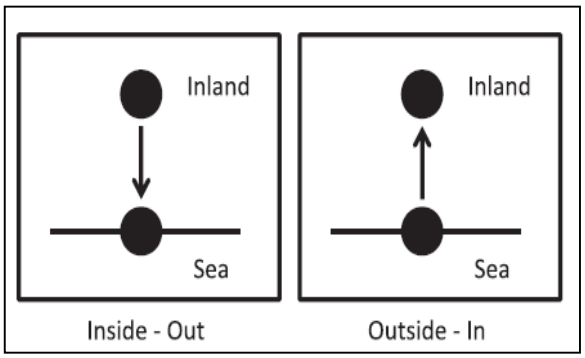

Figure 1. Dry port-seaport system development, model of Wilmsmeier et al. (2011)

The Outside-In integration is determined by the sea part via ocean carriers, seaport authorities or operators in seaport. Wilmsmeier et al. (2011) used three case studies to demonstrate the different development process. Wilmsmeier et al. (2011) was based on the Taaffe et al. (1963) model, who presented the explanation of an ideal-typical sequence of transport development and improving accessibility through internal expansion of the transportation networks (Figure 2). In Figure 2, the big circles symbolize seaports and dry ports, as the smaller circles symbolize less important nodes. The grey ways symbolize high priority corridors. According to Wilmsmeier et al. (2011), Taaffe et al. (1963) doesn't take into account the sense of development. Wilmsmeier et al. (2011) treat the missing directional focus in the model of Taaffe et al. (1963), and present the focus on directional development of the dry port.

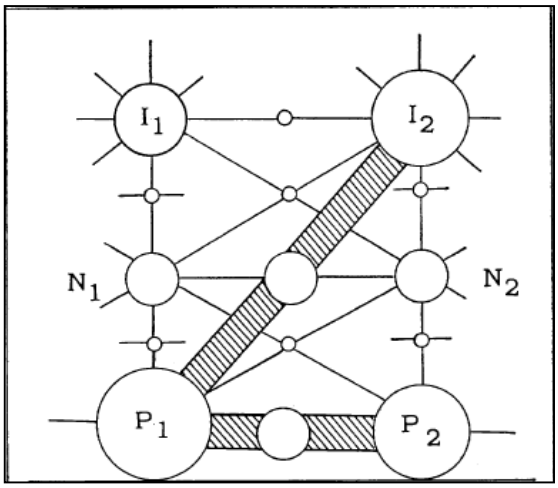

Figure 2. Dry port-seaport system development, Taaffe et al. (1963) model.

- P1; P2: Port concentration;
- N1; N2: Transport Nodes;
- I1; I2: Internal expansion.

Later, Bask et al. (2014) proposed a model for dry port-seaport dyads development in three phases: (1) Pre-phase, (2) Start-up phase and (3) Growth phase (Figure 3).

(1) The pre-phase is the state with the existing actors and some basics conditions for the creation of dry port in the multimodal transport system. At this level, the essentials questions are: the realization of a dry port is essential? Is there a current infrastructure or has he made strategies that could support the development of dry port? And at this step comes the role of governance. The efficient action and coordination of governance are wanted to allow investments in ultimate sites to construct a high-quality road and rail network, according to Bergqvist and Wilmsmeier, (2009). (2) The start-up phase is the opening which is the establishment of the idea and the first step in implementation of the plans of dry port. At this stage the involved actors discuss the execution process. (3) The Growth phase is the dry port development in an operational direction, for example the introduction of a diversity of added value activities and the rise relations between the involving actors and the development of infrastructures (Bask et al., 2014). In conclusion, Bask et al. (2014) developed the Wilmsmeier et al. (2011) model which has taken into account the spatial component by adding a temporal component.

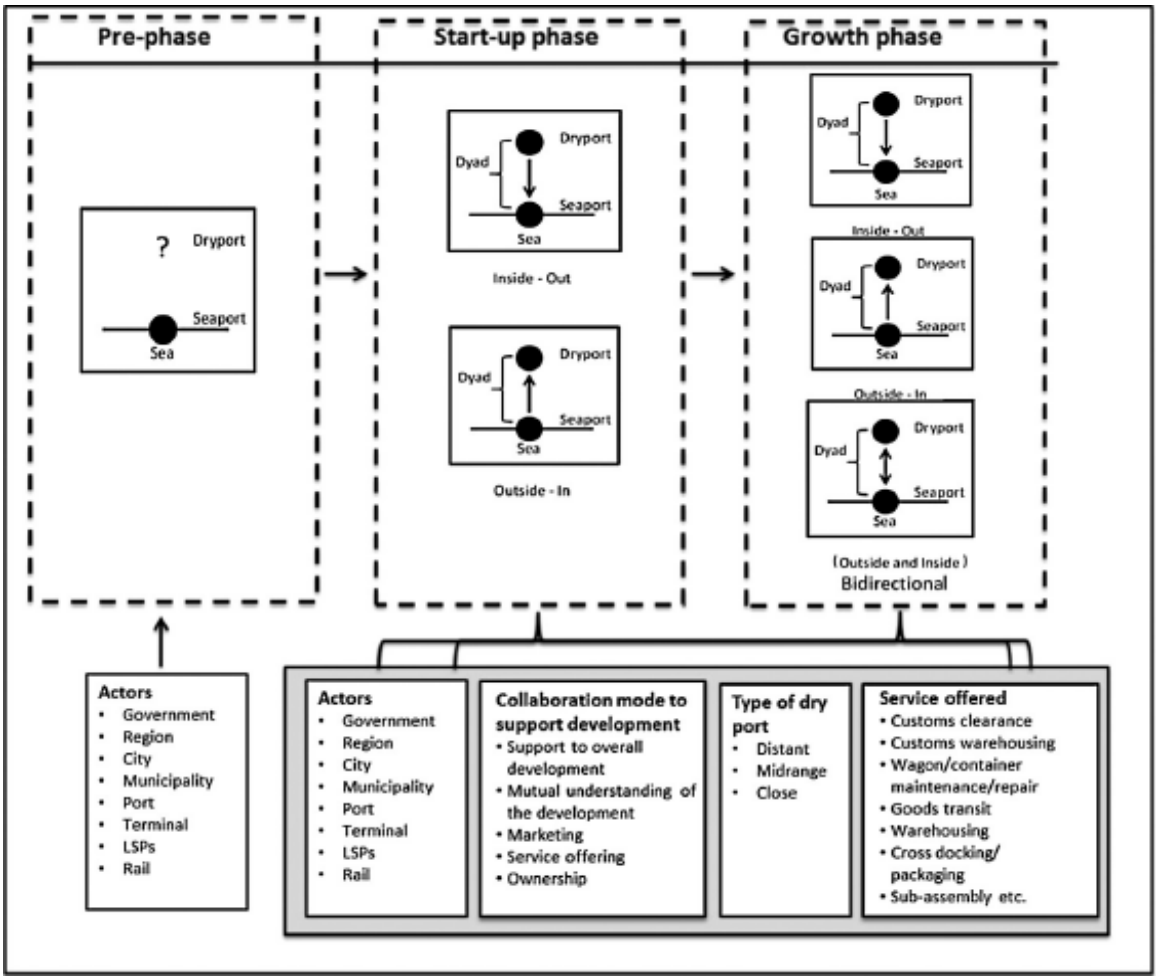

Figure 3. Dry port-seaport system development, model of Bask et al., 2014

We summarize below the main models in the dry port-seaport system concept development (Table 1).

Table 1. Assessment of measurement model

Authors	Layout	Contribution	Adopted vision
Taaffe et al. (1963)		Illustrate the transport development and improving accessibility through internal expansion of the transport network.	Priority vision.
Wilmsmeier et al. (2011)		Describe the sense of development of the dry in relation to seaport.	Spatial vision.
Bask et al. (2014)		Develop Wilmsmeier et al. (2011) model, taking into account the temporal component.	Temporal vision.

In our approach, we will apply the product life cycle theory to the concept of dry port-seaport system to understand more this system through a description of their development over the space and time with a micro economic vision.

3. Methodology

3.1. The product life cycle theory application ndings and discussions

This part primarily initiates the most important fundamentals of the product life cycle theory and how the concepts relay to the dry port-seaport situation. The theory is very well famous in marketing. We will apply the product life cycle theory to the dry port-seaport system with the aim to understand the system development and behavior. The progress of the system is examined in micro-economic perception by adopting the product life cycle theory. This theory describes the behavior of a product or service from design to obsolescence and it has been used since the 1970s (Ryan and Riggs 1996). This theory supposes that every product or service has common phases. The product or the service is under transformations in product plan, production circumstances and market environments. In general, the life of a product or a service has five phases based on the product life cycle theory. The typical model of a service or product is modeled by an arc composed by five different phases: Development; Introduction; Growth; Maturity and Decline (Figure 4).

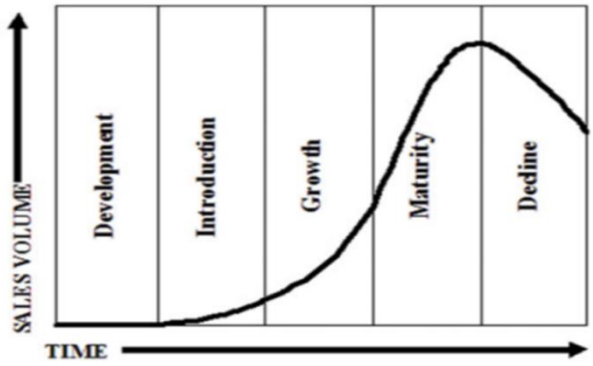

Figure 4. The product life cycle (Kotler and Armstrong).

3.2. The dry port-seaport system development: product life cycle theory application

In multimodal transport sector, the progress of dry port and accordingly the development of dry port-seaport system can be considered comparable to a product or service it may be supposed as having a life cycle with the same stages (figure 5). Applying the Vernon (1966) theory of product life cycle to the dry port-seaport situation involves a description of its special phases as follows:

3.2.1. Phase 1: Development

The recognition of dry port in the transportation structure, in this stage, the questions are: the creation of dry ports is necessary? Is there an actual infrastructure or has he made tactics that could maintain the development of dry ports? The first critical activity for the managers of a dry port is to collect an implementation plan. The plan should define the targets and goals of the dry port over the short, intermediate, and long term. The dry ports provide in this step of the system progress cycle limited services. In addition and during this stage, the geographic reach of the dry port is usually restricted to the adjacent city.

3.2.2. Phase 2: Introduction

The introduction of a dry port position in the transport system with some services permits the connection of direct trade with other non closest regions. Activities are elementary and not regular as being cargo based. The geographic reach of the dry port during this phase of development is classically limited to the adjacent city.

3.2.3. Phase 3: Growth phase

In this phase international trade increases. In most recently developed dry ports services will also certainly raise from the preliminary growth and introduction phases. Also, in this stage, economies level will increase with a speeding up rate of development. Standardization and process innovation are addressed and implemented, at the same time as principal equipment gains in significance more than person resources. The deserved regions of the dry port increases, determined by land infrastructure progress and dry port related services and the needed dry port space for storage increases. From its beginning, the aptitude of the dry port considerably augments in reaction to an ever more speedily increasing require. So in this phase, dry port develops in operational direction, for example the development of a diversity of services with added value.

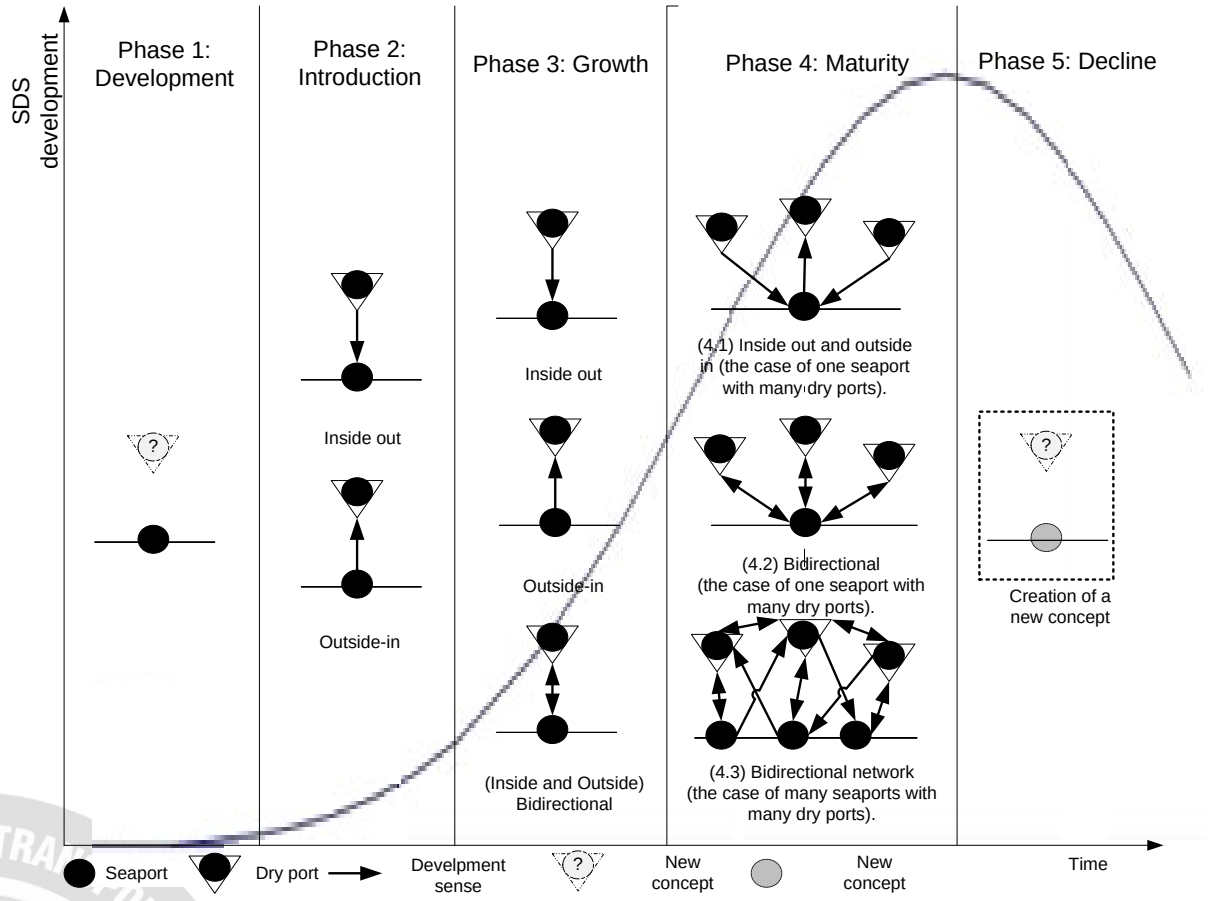

Figure 5. The product life cycle theory applied to dry port-seaport system development.

3.2.4. Phase 4: Maturity phase

Dry Port activity rises at a slower rate, competition in the market augments. As the number of dry ports augments, by promoting greater private sector contribution, dry port will move to the conception of a market organization. The external competition increases simultaneously and proportionate with larger maturity. Also during this phase, the dry port container storage space and other dry port services augment more and sometimes become a physical constraint on further development, or probably an important compound from other services. In result, the point of investment in the maturity phase of the dry port growth is the optimization of dry port activities. This phase presents the development with a large range of challenges. With a dry port becoming saturated, it can be very difficult for him to continue in the same level of service contemplated, much less continue to try to increase it. During this phase, new dry ports are being built to cope with the congestion and varied service ranges offered and subsequently create competition. This phase includes three sub-phases, namely:

- **Sub-phase (4.1)**, Inside out and outside in (the case of one seaport with many dry ports): this sub-phase of the maturity phase represents a spatial development of one seaport with several dry ports.
- **Sub-phase (4.2)**, Bidirectional development (the case of one seaport with many dry ports): this sub-phase represents the operational development direction of one seaport with many dry ports, such as the development of a variety of added value services.
- **Sub-phase (4.3)**, Bidirectional network (the case of many seaports with many dry ports): this sub-phase represents the operational development direction of many seaports with many dry ports.

3.2.5. Phase 5: Decline phase

This happens formerly when we arrive to the point of the limitations in feasible rationalization or improvement process in general is achieved.

Dry port operations decrease. Since, no additional extension of the dry port operations or no further effectiveness increases are potential, we are face to a fixed supply of dry port capacity. Market is falling and sales volume decrease. At this phase, we can announce the decline of this system and may be a new concept will be created and it could be a line of future research.

Through this application of product life cycle theory, we could understand the dry port-seaport as a whole. Then imagine a decline phase that could be a new opportunity of research to create a new concept or replace the current system with another in order to a enhanced understanding of the dry port-seaport system behavior and multimodal development.

3.3. Internationals experiences

In the following sections, the five phase's life cycle product theory developments are discussed for the different dry port-seaport systems cases of different region all over the world (Table 2).

We are based in some literature references in order to collect examples of the dry port-seaport system (SCAG, 2006; Hämäläinen, 2008; Timukhina et al., 2007; Roso et al., 2006; Roso, 2009; Seijas, 2009; Bentaleb et al., 2015a; Bentaleb et al., 2015b; Andersson and Roso (2016)

Bask et al., 2014; Benabbou et al., 2012; Beresford et al., 2012; Black et al., 2013; Caballini and Gattorna, 2009; Cezar-Gabriel and Sebastian, 2012; Chang and Notteboom, 2012; Chang et al., 2015; Chang-zheng, 2011; Chen and Wang, 2012; Cronje et al., 2009; Crainic et al., 2013; Crainic et al., 2015; Do et al., 2011; Dungore and Joshi, 2014; Fang et al., 2012; Fechner, 2012; Feng et al., 2013; Fengshan, 2013; Flämig and Hesse, 2011; Frost, 2010; Gancheva, 2012; Garnwa et al., 2009; González-Sánchez et al., 2015; Hämäläinen, 2008; Haralambide and Gujar, 2012; Haralambides and Gujar, 2011; Henttu, 2010; Henttu and Hilmola, 2011; Henttu et al., 2011; Huseynli and Hamidov, 2014; Iannone, 2013; Jeevan et al., 2015; Jing-wen, 2013; Juan, 2010; Ka, 2011; Korovyakovsky and Panova, 2011; Lattila et al., 2013; Li and Jiang, 2014; Li et al., 2011; Li et al., 2013; Li et al., 2015; Lovrić et al., 2013; Lv and Li, 2009; Makkhongkaew et al., 2015; Mingjian, 2011; Mlinaric et al., 2011; Monios and Wilmsmeier, 2012; Myagmarsure and Deng, 2015; Ng and Gujar, 2008; Ng and Gujar, 2009; Ng et al., 2013; Núñez et al., 2014; Onwuegbuchunam and Ekwenna, 2008; Padilha and Ng, 2012; Peng, 2010; Qiu et al., 2015; Qiu et al., 2014; Wilson, 2010). The selection of 10 dry port-seaport system cases was done using as selection criteria the information availability from publications, reports and public web information.

Table 2. Applying the product life cycle theory in different dry port-seaport system cases from different geographical region.

Continent	Country	Dry port-seaport	Dry port type	Development and Introduction phases	Growth Phase	Maturity phase	Decline phase
America	USA	Virginia dry port and Virginia seaport	Midrange dry port	The concept of the dry port Virginia (Virginia Inland Port: VIP) was first explored in the early of 1980. It is located 355 km from Virginia seaport. The dry port Virginia began operations in 1989 with initial annual volume of 8000-9000 containers. The seaport is located west of Washington DC, the services operate between the dry port and seaport five days a week .	The dry port Virginia provides road and rail interface for the transport of containers from the seaport of Virginia (Wilson, 2010). The annual production volume of VIP is around 20000 containers each year in 1999 and it was close to that level until 2001.	The dry port has significant rail infrastructure on site, consisting of 5.4 km rail (Wilson, 2010). In 2006, the ratio of the volume in logistics recorded in 14000 movements in 2003, 28000 in 2004, 35000 in 2005.	Not reached
Europe	Finland	Kouvola	Close dry port	Kouvola dry port is located 50 km from HaminaKotka seaport. It started	In 2004, 125,000 TEUs were discharged into the dry port Kouvola. The dry port Kouvola offers	The type of logistics services in Kouvola has augmented at a rapid rhythm in recent years.	Not reached

				in 1875. The dry port Kouvola began operating in 1920. The development of the concept of logistics Kouvola began in the early 2000s, 15 years later and the rail link to the seaport was built HaminaKotka .	services such as, storage, customs clearance, warehousing and several types of added value services. The dry port Kouvola is the largest in Finland in terms of rail logistics and the railroad.	Today there are 200 logistics operators and transport services in the region.	
	Sweden	**Eskilstuna dry port,**	Midrange dry port	The dry port Eskilstuna is founded in 2000 as a conventional multimodal dry port. It is situated 380 km from the Gothenburg seaport. It is a new dry port as it began operating in March 2004.	The dry port Eskilstuna manages daily trains from seaport Gothenburg containers. It manages around 20000 TEUs / year in 2006. Services available are: transfer between road and rail, storage, Depot, customs clearance and other added value services.	Not reached	Not reached
	Sweden	**Hallsberg dry port, Göteborg**	Midrange dry port	The dry port Hallsberg, is situated 260 km from the seaport Gothenburg. It took 20 years from the first idea to be ready.	Hallsberg dry port is located on an important railway junction, near the seaport of Gothenburg and Helsingborg. The services offered are: transfer between road and rail, storage, customs clearance, warehousing, shipping and other added value services. The annual production volume is around 60,000 TEUs annually.	It has a long time as a dry port and provides varieties of added value services.	Not reached
	Belgium	**Mouscron dry port, Antwerp**	Midrange dry port	Mouscron dry port is located a few hundred meters from the French border. Mouscron dry port is located 170 km from Antwerp seaport.	In 2005, the site has increased by 5 hectares. The services offered are: transshipment of containers, added value logistics services. In addition, a customs service is available. The capacity in 2004 is about 25000 containers and in 2008 the traffic around 23000 containers.	In 2010, the dry port has a capacity of 100000 containers.	Not reached
	Spain	**Madrid dry port, Bilbao seaport**	Midrange dry port	The Madrid dry port is a multimodal port in Coslada containers. The dry port of Madrid is located 400 km from the seaport Bilbao. A provisional authorization has been issued by the customs authorities in 2000; final approval was issued	In 2005, the volume is about 45,000 TEUs. In 2007, the dry port of Madrid has authorized a new private company called CONTINENTAL RAIL, 100% owned by the Spanish construction group ACS to handle the transportation of dry port in container Madrid.	In 2008, the volume is about 61000 TEUs. The physical characteristics of dry port are: Total area: 140000 m2; Storage area: 16000 m2; In 2009: Extension area of about 25,000 m2.	Not reached

				in 2003 for the dry port.			
Africa	**Morocco**	**Casablanca dry port,**	Close dry port	The dry port of Casablanca is the first dry port linked to Morocco which opened in 2008. It is located 6 km from the seaport of Casablanca.	In 2010 the capacity under Customs is over 50000 TEUs / year. Currently, the area is 8 Ha; storage capacity: 3900 TEUs and capacity is 120,000 TEUs under Customs / year.	Not reached	Not reached
	Tanzania	**Isaka dry port, Dar es**	Distant dry port	The dry port Isaka is located in the Shinyanga region of Africa. It functions as an inland port serving the seaport of Dar es Salaam. It is located 982 km from the seaport.	The Isaka dry port is one of the key links in Rwanda. In 2003 he achieved a volume of 1043 TEUs. The dry port storage capacity is 7,000 tons. It has two railway tracks with a capacity of 22 cars.	Not reached	Not reached
Asia	**Saudi Arabia**	**Riyad dry port, Dammam**	Distant dry port	Riyadh dry port started operations for the first time in 1982. It is located in the capital of Saudi Arabia. The dry port has handled in 2003, more than 250000 TEUs. It is located 400 km from the seaport of Dammam.	In 2013, the dry port handled 26000 containers. It is the only dry port in Saudi Arabia. In 2014, the dry port handled 30749 TEU.	Not reached	Not reached
Australia	**Sydney**	**Enfield dry port, Sydney**	Close dry port	In September 2007 the seaport of Sydney has received planning approval to develop a multimodal logistics center in Enfield. It is located 18 km from the seaport of Sydney. The total capacity is 60000 units.	Enfield dry port is built on a site of 60 hectares, with 12 hectares intermodal facility. The total capacity of 300000 units in 2009.	Not reached	Not reached

The major of the system examples currently locate themselves having confidently developed from the growth to maturity phases of the product life cycle theory. In agreement with the product life cycle theory hence, an important percentage of these cases not reach decline phase yet.

The expected development of dry ports is important to both the public and private sector. Characterization of the various phases of the development can provide the basis for developing strategies by managers to facilitate dry ports or to mitigate potential freight transportation system impacts.

4. Conclusion

The consideration of dry ports to improve trade corridor performance and develop the efficiency of global supply chains is starting to appear in the transportation area. This study has an added value to a better understanding of dry port-seaport system concept through a detailed description of its evolution stages in the literature. We presented previous research on development models of this system. Then we analyzed the system from micro-economic perspective. A product life cycle theory application was proposed for dry port-seaport system development in order to study its development and behavior. For future research, we could focus on the decline phase of our model in order to imagine a new concept of development for this system, its evolution in the future and the new behavior that will appear for the dry port-seaport system.

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