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The waves of containerization: shifts in global maritime transportation

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ABSTRACT

This paper provides evidence of the cyclic behavior of containerization through an analysis of the phases of a Kondratieff wave (K-wave) of global container ports development. The container, like any technical innovation, has a functional (within transport chains) and geographical diffusion potential where a phase of maturity is eventually reached. Evidence from the global container port system suggests five main successive waves of containerization with a shift of the momentum from advanced economies to developing economies, but also within specific regions. These waves are illustrative of major macroeconomic, technological and sometimes political shifts within the global economy. They do not explain the causes, but simply the consequences in the distribution in container traffic and growth (or decline). Yet, they provide strong evidence that containerization has a cyclic behavior and that inflection points are eventually reached, marking the end of the diffusion of containerization in a specific port or port range. Future expectations about the growth of containerization thus need to be assessed within an economic cycle perspective instead of the rather linear perspectives.

1. Introduction: the spatial and functional diffusion of the container

1.1. Waves and container port development

After more than half a century since its introduction, the container continues its spatial and functional diffusion within global transport systems. Diffusion can be investigated at the level of the container shipping network in terms of growth in the intensity and connectivity of ports, but such an approach would require a substantial dataset to review all the shipping services. A simpler approach is to look at the geographical growth structure of individual container ports. Containerization has diffused to an extensive array of locations and supports a wide variety of supply chains, from retail goods, parts and commodities. Such diffusion is far from uniform, on par with the changes in the commercial geography of the global economy. This is particularly the case relative to the export-oriented strategies of Asian countries that have rebalanced a global trade system that used to revolve around the economic triad (North America, Europe, and Japan). In light of these economic and technological changes, economic cycles are offering a relevant perspective to investigate the spatiotemporal evolution of containerization. Furthermore, there are three other reasons to consider and understand waves when analyzing containerization. The first is that containerization waves are indicative of global changes in a broader economic environment. The second reason is that the waves of containerization raise the general question of the circular relationship between maritime transport and economic development. The third relates to forecasting future containerized traffic, an exercise that commonly considers growth processes in a linear fashion while the extent and rate of the growth is nonlinear; cycles are a relevant perspective to articulate this nonlinearity.

Waves (the term 'cycle' is used interchangeably) are amply covered in the business and economic literature but many of their aspects, such as duration and amplitude, are subject to debate. The duration of a wave is related to the process being looked at. One of the longest, the Kondratieff wave[1] (Kondratieff, 1935) (often referred to as a K-wave), usually imply a time frame of 45–60 years and try to depict technological diffusion within economic systems (Barnett, 1998). Kuznets waves (15–25 years; demographic changes), Juglar waves (7–11 years; major investments in fixed capital) and Kitchin cycles (3–5 years; manufacturing and inventory cycles) refer to events of shorter duration and have been evidenced (Korotayev and Tsirel, 2010). Changes are usually measured through growth rates of an economic activity, such as GDP, production, commodity prices or sales. A notable branch of investigation concerns product life cycles and the shifts in the geography of production as a product goes through distinct phases. These usually involve introduction (or adoption), growth (or acceleration), peak growth, maturity and eventual

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[1] Waves are usually named after the economist who first brought them forward.

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degeneration (e.g. Hayes and Wheelwright, 1979). There is also a seasonality in many commercial activities, particularly in retail, which can be considered a cycle occurring annually. Waves are also covered by the geographical literature on the spatial diffusion of innovations (e.g. Hägerstrand, 1966; Alves and Morrill, 1975; Rogers, 2003) with many processes following a diffusion process that can be contiguous or hierarchical.

The conceptual usage of waves within maritime and port studies is much more limited, but implicitly implied in port development models (e.g. Bird, 1963; Hayuth, 1981), in particular for the literature addressing the diffusion of containerization (e.g. Levinson, 2006; Notteboom and Rodrigue, 2009; Rodrigue et al., 1997). Yet, these approaches consider containerization as a whole and have not looked at what cycles imply at the individual port level and the fact that different ports have been part of different growth patterns and thus part of different economic cycles. While studies looking at the dynamics of individual port or port range are common, global investigations appear much less prevalent (e.g. Fremont, 2007; O'Connor, 2010; Ducruet and Zaidi, 2012). One reason that can be advocated for this shortcoming is that such an approach requires familiarity with global macroeconomic processes and international trade, areas where port studies have conventionally not placed much focus.

The wave approach can be applied to an individual container port, a port range, or to the whole global port system to better capture their temporal and spatial dynamics. The framework offered by Kondratieff waves (K-waves) appears suitable since its time frame matches the functional and spatial diffusion of containerization (45–60 years). Thus, it is argued that containerization is a K-wave process, which is obviously incomplete and characterized by different levels of maturity depending on the markets. It is also argued that within this K-wave, specific phases in container port development are taking place, such as introduction, acceleration, peak growth and maturity (Fig. 1). Yet, what these phases imply in the geographical diffusion of port containerization is not clear and needs to be identified. For an individual port, a K-wave represents the full realization of its hinterland (gateway) and foreland (hub) potential in light of geographical and site characteristics. For a port range, a K-wave relates to the setting and interrelations of its ports to service its commercial hinterland, implying a rank/size outcome in the port structure with a few major gateways dominating. Often, there are few major drivers (hinterland or foreland related) behind each wave, which explain the evolution of a set of ports. However, it should be noted that two very different ports (i.e. hub and gateway) can belong to a same wave, even if their drivers are different. What matters here is the shape of their trajectories over time, namely when they adopt, develop, and reach a stage of maturity.

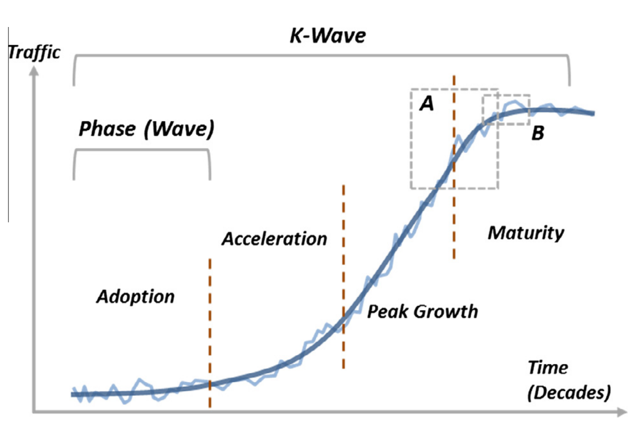

Fig. 1. The K-wave, phases of containerization.

A transition (also called medium wave) considers the changes taking place within a K-wave where the system is undertaking a shift from one phase to another; an inflection point taking place over a few years. For instance, during a transition a port may shift from peak growth to maturity due to changing market conditions, such as demand saturation in its hinterland. Transitions are therefore particularly useful at identifying the time frame and the conditions associated with this shift. Otherwise, there is no change in the growth conditions and patterns during the considered time frame and thus a port remains within its existing phase.

1.2. Methodology

The paper investigates economic cycles as components of the demand of containerized maritime transport over a K-wave, and this mainly at the global level. Within this temporal framework the paper tries to identify specific growth phases of the geographical diffusion of containerization that can be statistically evidenced. It will also look at recent transitions that can underline which segments of the container port system have achieved a phase of maturity.

Before analyzing the waves of containerization, the evolution of global container throughput and its concentration level is investigated. We apply the Gini coefficient, a widely used index that measures the deviation from a perfectly uniform distribution of container throughput between ports (Kuby and Reid, 1992; Notteboom, 1997, 2010).

The identification of phases (waves) within the K-wave will rely on cluster analysis where a large sample of container ports is categorized according to their growth pattern, namely its time frame and scale. Hierarchical Cluster Analysis (HCA) is a statistical method commonly used for finding relatively homogeneous clusters of observations based on their measured attributes. From a dataset, HCA finds groups (clusters) that minimize their endogenous dissimilarity according to a set number of groups. Initially it places each observation in a separate cluster and then combines the clusters sequentially, reducing the number of clusters at each step until only one cluster is left. When there are N cases, this involves $N - 1$ clustering steps. This hierarchical clustering process can be represented as a dendrogram where each step in the clustering process is illustrated by a join of the tree until only one branch is reached. It is for the analyst to decide on the relevant number of groups, but such a choice is made in light to have the minimum number of groups possible with an acceptable level of dissimilarity. The Ward clustering procedure takes into account the chi-square distances between the profiles and the associated observations (Everitt et al., 2001). This way it provides a decomposition of inertia with respect to the nodes of a dendrogram. The total dissimilarity of the dataset is reduced by a minimum at each successive level of merging the observations.

Cluster analysis has been used to identify the long waves of containerization between 1970 and 2010 in five-year increments. There are two reasons for using five year increments instead of annual data. The first and most important reason is that the approach on long waves focuses on long term trends of maritime transportation, rather than on short term traffic fluctuations (mainly linked to local specificities of ports, outside the scope of the study). Selecting five-year intervals is therefore an approach that captures long term trends while avoiding short term variations. The second reason is incomplete data over long time series covering a large number of ports. The HCA is particularly well adapted to the identification of long waves because it allows the distinction of homogeneous clusters of ports simultaneously based on the variation of their shares of global container throughput and on the shapes of their trajectories over time. A