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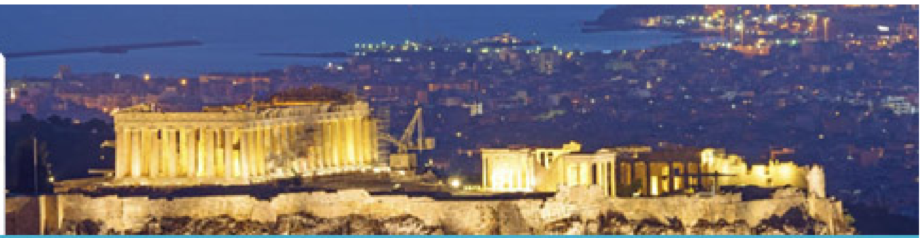

Les défis de développement pour les villes et les régions dans une Europe en mutation

# The dynamic of Container Ports Hierarchy

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## Référence à la session / reference to the session

## Résumé / Summary

How the relative ranking and hierarchy of container port traffics change? From an economic point of view, the fundamental driver is the pattern of trade but how fast are the ranking of ports changing and in which proportion. This paper purpose a new insight into port dynamics and trajectories based on rank-size (Zipf, 1949) model and Markov Chain. This is applied to a set of 222 containers ports from 2000 to 2015.

Distribution of traffic amongst container ports

The annual data on port container traffics in TEU from the period 2000-2015 are extracted from Containerization International Yearbook 2000-2015). The sample includes 222 container ports (Table 1) that represented 89% of world total TEU traffics in 2010. Traffics have been multiplied by 2.6 over the entire period (+165%), a growth mostly explained by changes from 2000 to 2005 (+65.8% against +30.8% in 2005-2010 and +22.1% in 2010-2015). The growth for the 65 ports located in Asia/Australasia/Mid East (29.3% of the sample) explains the general increase in traffics.

Table 1. Container port traffics growth rate (in %)*
# of ports 2000-2005 2005-2010 2010-2015

North/South America 40.5 46.3 9.2 22.1
Asia/Australasia/Mid East 29.3 81.2 41.5 23.5
Europe/Africa 30.2 47.8 20.2 17.0
Total 100 65.8 30.8 22.1
* Based on 222 ports
Source : Containerisation International Yearbook (2000-2015)

There are some large disparities across regions (Table 2). The mean TEU in 2000 ranges from 507 103 TEUs for ports located in North and South America to 1 753 922 TEUs for Asia/Australasian/Mid East Ports. From 2000 to 2015, the mean traffics were multiplied by 1.9, 3.2 and 2.1 in America, Asia and Europe/Africa, respectively. The average rank of Asian-ports decreases from 83 to 76 amongst the 222 ports. Finally, the three largest ports in 2000 were Hong Kong (18 m TEU, Singapore (17 m TEU) and Busan (7.5 m TEU) and in 2015, Shanghai (37 m TEU), Singapore (31 m TEU) and Shenzhen (24 m TEU). Rotterdam is the first non-Asian port in 2000 (6 .3 m TEU, #5) and in 2015 (12 m TEU, #11).

Table 2. Descriptive statistics 2000 and 2015

| | Mean Rank | Mean TEU | Std. TEU | Min TEU | Max TEU |
|---|---|---|---|---|---|
| North/South America | 130 | 507 103 | 839 958 | 21 718 | 4 879 429 |
| Asia/Australasia/Mid East | 83 | 1 753 922 | 3 241 775 | 20 232 | 18 100 000 |
| Europe/Africa | 114 | 728 064 | 1 133 199 | 29 147 | 6 280 000 |
| Total 2000 | 111.5 | 938 849 | 1 998 941 | 20 232 | 18 100 000 |
| North/South America | 133 | 989 141 | 1 477 322 | 26 500 | 8 160 457 |
| Asia/Australasia/Mid East | 76 | 5 554 979 | 7 878 112 | 45 000 | 36 500 000 |
| Europe/Africa | 117 | 1 513 569 | 2 317 788 | 39 726 | 12 200 000 |
| Total 2015 | 111.5 | 2 484 259 | 4 942 273 | 26 500 | 00 000 |

The analysis of port hierarchy is derived from the pioneer work of Zipf (1949) on the Rank-Size for the populations of cities. According to Zipf, the distribution of cities within a region follows a Pareto-law. Applied to ports, it means that when the coefficient of hierarchy is low (less than 1), the region is characterized by the important weight carried by larger ports. When the coefficient is high, traffic are distributed evenly amongst the various ports. The evolution in the degree of hierarchy in the Rank-Size relationship for the entire sample and by region is reported in Figure 1. The concave shape of the curves indicates that whatever the sample, the midsize ports have an important weight in the structure of the container port system.

To estimate the degree of hierarchy in Rank-Size distribution for a limited sample, we relied on the Gabaix and Ibragimov (2011) estimation of the Pareto-Zipf curve 〖(ln〗⁡(R)=α+βln⁡(S)) so that:
ln⁡(R-1/2)=α+β ln⁡(S)
With R is the rank of a given port, and S is the size in TEU of a given port. A decrease in the absolute value of the Pareto coefficient β, indicates a general trend towards more concentration within a port system.
Results reported in Table 3 stress a relatively low level of hierarchy over the four years under consideration (-0.59), meaning that if some ports are with some very high traffic, the majority are with limited traffic, close to the median. Furthermore, a general increase in concentration of ports over the years exists, meaning that the weight of largest ports gradually increase over the year. Furthermore, these general trends are similar when ports are aggregated by region.

Table 3. Rank-Size model for container port systems

| | 2000 | 2005 | 2010 | 2015 |
|---|---|---|---|---|
| All ports | | | | |
| Constant | 12.519*** | 12.498*** | 12.207*** | 11.925*** |
| | (0.230) | (0.233) | (0.226) | (0.228) |
| Ln(S) | -0.638*** | -0.615*** | -0.585*** | -0.558*** |
| | (0.018) | (0.018) | (0.017) | (0.017) |
| Observations | 222 | 222 | 222 | 222 |
| R-squared | 0.852 | 0.847 | 0.846 | 0.834 |

| | | | | |
|---|---|---|---|---|
| Europe/Africa | | | | |
| Constant | 12.103*** | 12.532*** | 12.268*** | 11.733*** |
| | (0.436) | (0.457) | (0.439) | (0.472) |
| Ln(S) | -0.702*** | -0.714*** | -0.687*** | -0.640*** |
| | (0.034) | (0.035) | (0.033) | (0.035) |
| Observations | 67 | 67 | 67 | 67 |
| R-squared | 0.866 | 0.866 | 0.869 | 0.835 |
| Asia/Australasia/Mid East | | | | |
| Constant | 10.747*** | 10.466*** | 10.377*** | 10.397*** |
| | (0.509) | (0.537) | (0.526) | (0.539) |
| Ln(S) | -0.566*** | -0.523*** | -0.506*** | -0.500*** |
| | (0.038) | (0.038) | (0.037) | (0.037) |
| Observations | 65 | 65 | 65 | 65 |
| R-squared | 0.780 | 0.747 | 0.750 | 0.743 |
| America | | | | |
| Constant | 12.199*** | 12.291*** | 11.813*** | 11.530*** |
| | (0.357) | (0.404) | (0.455) | (0.422) |
| Ln(S) | -0.708*** | -0.693*** | -0.649*** | -0.622*** |
| | (0.029) | (0.032) | (0.035) | (0.033) |
| Observations | 90 | 90 | 90 | 90 |
| R-squared | 0.872 | 0.845 | 0.793 | 0.806 |

Standard errors in parentheses and *** p<0.01, ** p<0.05, * p<0.1

To complement former results on port hierarchy, the quadratic model from Rosen and Resnick (1980) is applied so that:

## **Bibliographie / Bibliography**

ln⁡(R)=α+β ln⁡S+δln⁡S^2

When δ>0, the Rank-Size distribution is convex meaning that average size ports is less predominant while when δ<0, the distribution is concave meaning the existence of a large proportion of average size ports counterbalances the weight of small and large ports.

Results (Table 4) show that the coefficient of hierarchy δ is negative (concave curve) and is increasing over the year. This implies that medium-size ports are more and more important in the worldwide port system. At the regional level, it is however important to stress that the general growth of medium-size port is however not always true, and in particular in 2005 and 2010 for ports located in Asia/Australasia/Mid East and America. When comparing results for 2015 with those reported in 2010, the situation is almost equivalent for these two regions.

Table 4. Rank-Size model for container port systems (Quadratic model)

| | 2000 | 2005 | 2010 | 2015 |
|---|---|---|---|---|
| All ports | | | | |
| Constant | -10.478*** | -10.845*** | -9.831*** | -9.292*** |
| | (0.381) | (0.400) | (0.412) | (0.457) |
| Ln(S) | 2.966*** | 2.922*** | 2.712*** | 2.595*** |
| | (0.060) | (0.060) | (0.061) | (0.068) |
| Ln(S)2 | -0.139*** | -0.132*** | -0.122*** | -0.115*** |

| | | | | |
|---|---|---|---|---|
| | (0.002) | (0.002) | (0.002) | (0.002) |
| Observations | 222 | 222 | 222 | 222 |
| R-squared | 0.992 | 0.992 | 0.990 | 0.986 |
| Europe/Africa | | | | |
| Constant | -11.965*** | -12.449*** | -12.219*** | -13.983*** |
| | (0.940) | (0.891) | (1.357) | (1.306) |
| Ln(S) | 3.053*** | 3.064*** | 2.971*** | 3.206*** |
| | (0.147) | (0.135) | (0.204) | (0.196) |
| Ln(S)2 | -0.145*** | -0.141*** | -0.135*** | -0.142*** |
| | (0.006) | (0.005) | (0.008) | (0.007) |
| Observations | 67 | 67 | 67 | 67 |
| R-squared | 0.990 | 0.992 | 0.983 | 0.981 |
| Asia/Australasia/Mid East | | | | |
| Constant | -11.553*** | -15.500*** | -16.665*** | -15.700*** |
| | (0.949) | (1.158) | (1.337) | (1.627) |
| Ln(S) | 2.826*** | 3.294*** | 3.378*** | 3.197*** |
| | (0.144) | (0.170) | (0.192) | (0.230) |
| Ln(S)2 | -0.127*** | -0.138*** | -0.137*** | -0.129*** |
| | (0.005) | (0.006) | (0.007) | (0.008) |
| Observations | 65 | 65 | 65 | 65 |
| R-squared | 0.980 | 0.975 | 0.971 | 0.956 |
| America | | | | |
| Constant | -11.813*** | -13.968*** | -19.389*** | -15.165*** |
| | (0.641) | (1.024) | (1.187) | (0.995) |
| Ln(S) | 3.152*** | 3.426*** | 4.267*** | 3.542*** |
| | (0.103) | (0.161) | (0.187) | (0.155) |
| Ln(S)2 | -0.153*** | -0.160*** | -0.191*** | -0.160*** |
| | (0.004) | (0.006) | (0.007) | (0.006) |
| Observations | 90 | 90 | 90 | 90 |
| R-squared | 0.994 | 0.984 | 0.980 | 0.982 |

Standard errors in parentheses and *** p<0.01, ** p<0.05, * p<0.1