

SOME APPLICATIONS OF RANK CLOCKS METHOD

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Abstract: A method first used to search for events leading to the changes of sizes of major US, UK, and world cities is applied to investigate the presence of events influencing incomes of commercial companies. Top 100 US companies from the period of 1955-2005 are analyzed. Distributions of incomes are found to be stable but the changes in rank positions of companies lead to discovery of some instabilities. Parameters describing changes in the rank positions are calculated, discussed, and compared to the results of previous studies.

Key words: companies' incomes, rank clocks, rank shifts

INTRODUCTION

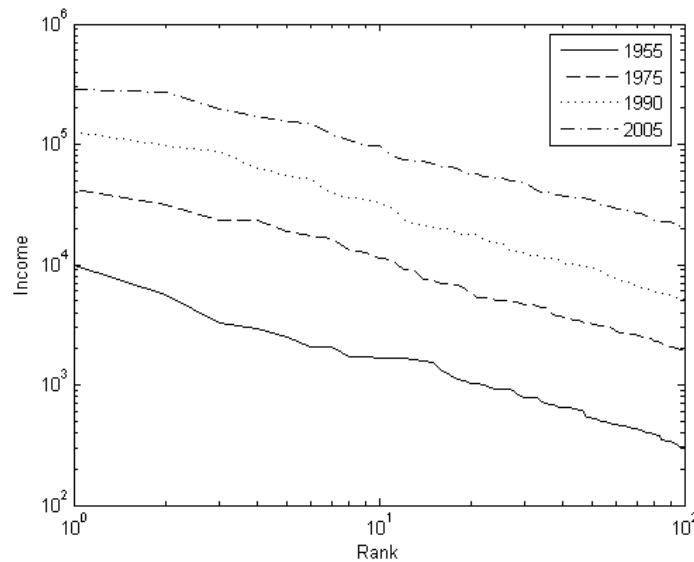
Many objects could be characterized by one parameter. Most works are focused on studying such objects in single instant of time. Sizes of cities, turnovers of companies, heights of cloud scrapers, network traffic etc. scale with time in the upper tail of their distributions [Blanc *et al.* 2000]. On the other hand, while such objects are growing sometimes violent changes of other nature could appear. Such evolutions could be present as changes of rank position of studied objects and were observed for largest cities in US, UK and whole world. Such micro dynamics could be manifest of the global changes influencing most of the studying objects. It has been shown that an investigation of micro dynamics for largest cities could exhibit such events like the fall of the Constantinople or migration of whites to the west of United States. The latter made some large eastern cities being partly abandoned and some very big ones appeared on the west [Turchin 2003]. However,

distributions of population at single instant of time are stable and scale with time, especially in their upper tail. It has been shown that such events could cause rapid changes in the cities' rank positions, while their aggregate distributions appear stable. In this work we performed studies of such micro dynamics and adopted graphical representation of rank position. for the top 100 US companies. Income of companies and changes in their rank positions could be influenced by an invention of new technology or an introduction of new products and services in a global range. Similarly, changes in the rank structure of cities could be determined by other, but also global, kind of events sometimes related to new technologies, level of life, wars, destruction, or migration of people.

DATA SELECTION AND ANALYSIS

We analyze income of 100 top US companies according to the Fortune magazine. Companies have been selected based on their annual income in 1955 to 2005 only, to avoid effects related to the recent global financial crisis. We investigated changes in rank position for companies noted in top 100 for two successive years, disregarding companies which fell below or just appeared on the list. We followed the procedure described in [Batty 2006]. As could be predicted [Stanley *et al.* 1996], the companies grow according to constantly increasing annual income (Figure 1) showing exponentially decreasing upper tail.

Figure 1. Distributions of income for 100 top US companies for years (from bottom to top): 1955, 1975, 1990, 2005



Source: own preparation

First we searched for micro dynamics by looking for changes in rank of one company at a time. Of course, one company is influenced by specific financial phenomena and sector specific economy. Thus results could be different according to the field the company is active in. In order to search for global effects we calculated average change in rank position over all companies selected for each year. That procedure would made our results more comparable to other works as well. Another step in the analysis was looking at the growth rates. Following [Batty 2006], we defined total growth rate as weighted average of growth rates of individual companies, as described below.

- growth rate (i – th company):

$$\lambda_i(t) = \frac{P_i(t)}{P_i(t-1)} \quad (1)$$

- share:

$$p_i(t) = \frac{P_i(t)}{P(t)}, \text{ where } P(t) = \sum_i P_i(t) \quad (2)$$

- total growth rate (all companies):

$$\lambda(t) = \sum_i p_i(t) \lambda_i(t) = \left(\frac{P(t)}{P(t-1)} \right) \left(\sum_i p_i(t) \frac{P_i(t)}{P_i(t-1)} \right), \quad (3)$$

where $i = 1$ to N (N – number of companies), $P_i(t)$ – income of i -th company in year t .

As could be seen from the above equations, total growth rate is expressed as the product of two terms. The first one depends only on the increase of total income of all companies and thus could be related to the global economy or progress of US market itself. The other term depends on the shares of separate companies in total income. Thus being related to the changes of individual companies as compared to all. The latter term could be influenced by changes in individual sectors of market or new technology invented what would “push” some of the companies up in the rank position. Both terms are given below:

$$\Gamma(t) = \frac{P(t)}{P(t-1)} \quad (4)$$

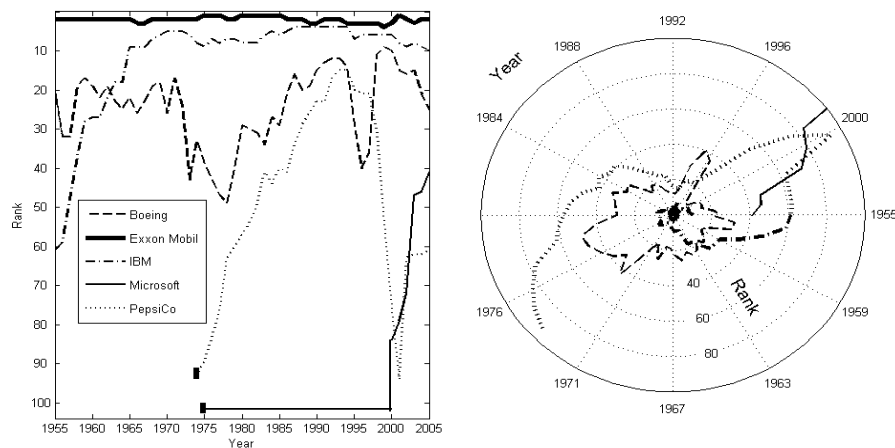
$$\Theta(t) = \sum_i p_i(t) \frac{P_i(t)}{P_i(t-1)} \quad (5)$$

After averaging both parameters over years we compared them to the results from the paper [Batty 2006].

RESULTS

Figure 2 contains changes in rank position for selected 5 companies: Boeing, Exxon Mobil, IBM, Microsoft, PepsiCo.

Figure 2. Rank position of separate 5 sample companies. Both plots present the same data in different ways



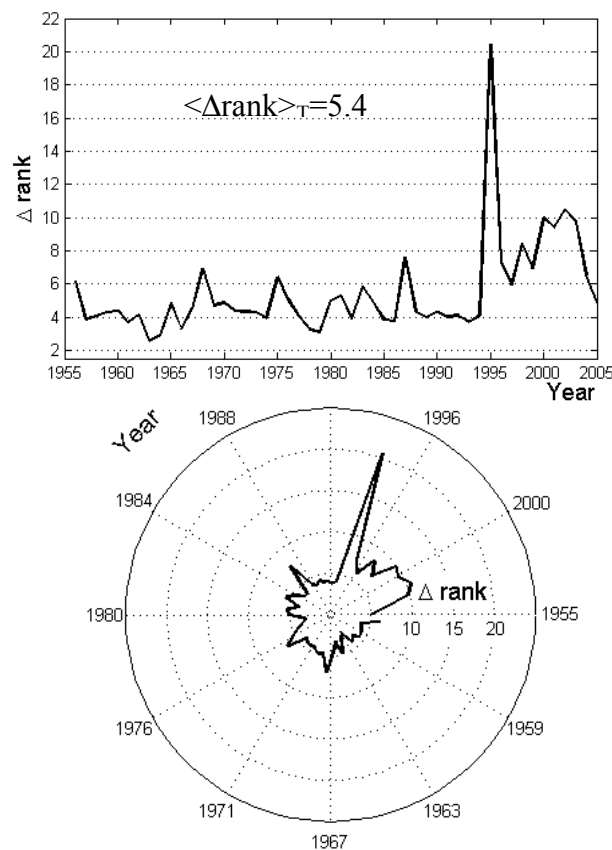
Source: own preparation

As follows from an inspection of Figure 2 the most stable position in the rank have IBM and Exxon Mobile. The IBM has been in the top 10 since 1965, what could be related to the rapid growth of the computer technology. IBM is known worldwide for its inventions in that field. The growing importance of IT in the US as well as economy ensured IBM a stable position in the ranking. Even more stable is Exxon Mobile which for the whole period is in the top 5. That is for sure related to the constant demand for traditional petroleum-based fuels. However, that situation could be changed in the future, due to the increasing funds on the invention of technologies related to natural sources of energy. Big changes in the rank position are observed in the case of Boeing – the one of the largest aircraft manufacturers. The reason of that behavior is harder to explain. Such a big changes in the rank position could be related to the construction of new aircraft models by Boeing or its competitors. The other two companies were founded between 1995 and 2005, what was indicated by small rectangles on the figure. PepsiCo was formed in the 1965 with the merger of the Pepsi-Cola Company and Frito-Lay. Since then PepsiCo expanded from its namesake product Pepsi to a broad range of food and beverage brands, by acquiring another companies. In 2001 PepsiCo merged with company Quaker Oats. Maybe that decision was the reason its position was so low then. Another company, which originated during analyzed

period of years was Microsoft. However, the company has not been noted on the top 100 list till the year 2000, what was indicated in the figure by horizontal line. After the 2000 the rapid improvement in its rank position could be observed. Microsoft is well known of its strong marketing politics and its expansion into new sectors of technology as well as forcing their solutions towards industry standard. The change in rank position could be due to the launch of new version of MS Windows, which always is a big marketing event.

We analyzed the average rank position change for every year. Figure 3 contains results, where one can observe strong stability from the beginning of data till the year 1995. The average range from 3 to 7 regardless of year.

Figure 3. Average change in the rank position for all companies and years analyzed



Source: own preparation

One shall keep in mind we are talking about the 40-year-period, where a lot of companies emerged while the others disappeared. New technologies were developed and new products were invented. After this 40 years there is a high peak

at 1995, meaning that the average change in the rank position has raised from 4 to 20. This could hardly be related to the invention of new technologies, because implementation of new products and services usually takes at least few years. A possible explanation of the observed effect could be some kind of actions which opened new markets or made possible to sell new products with no or drastically smaller limits. It is important to note that after the 1995 the studied parameter is consistently larger than before 1995.

At the last step we average studied parameter over all years and compare it to the results for top cities [Batty 2006]. Table 1 contains results of our work and the results of the same analysis for US, UK and World cities. For completeness, we also compared average $\lambda(t)$, $\Gamma(t)$ and $\Theta(t)$.

Table 1. Parameters averaged over all analyzed years

<Param>	US Cities	UK Cities	World's cities	US Companies
Δrank	4.67	4.22	14.28	5.45
$\lambda(t)$	1.38	1.00	1.13	1.06
$\Gamma(t)$	1.31	0.99	0.99	1.09
$\Theta(t)$	1.05	1.05	1.06	0.98

Source: own calculations

The average change in rank position is larger than for the US and UK cities but is smaller when compared to world's cities. On the other hand average growth rate is rather small being only slightly bigger than for UK cities. The growth rate is more related to the overall progress than to increase of separate companies ($\Gamma(t) > \Theta(t)$). The same behavior has been observed previously for US cities.

CONCLUSIONS

Utilizing the rank clocks methodology we studied micro dynamics behind the ranking of biggest US companies for the period of fifty years starting from 1955 till the end of 2005. Income of companies constantly grew up because of change in value of money and development of companies. The distribution of companies' income scaled with time showing well known exponential upper tail. On the other hand we studied micro dynamics which could show influences of other factors on the income of companies. Such factors could force changes in rank position what could not be observed by studying typical aggregated income distributions.

The average change in rank position was very stable for 40 years being about 5, what was of the same order of magnitude like for the US and UK cities studied previously. On the other hand that value was almost three times smaller than for world's cities. We observed very strong rise in the average rank position change (Δrank) in year 1995 as well as increased Δrank value thereafter. That may

indicate that some important events or changes took place in US economy in 1995. Moreover effects of those changes are visible in subsequent years. Total growth rate being slightly more influenced by overall increase of income than by progress of separate companies. For future studies we plan to analyze a nature of changes in more details by looking at the separate sectors of economy and comparing values of $\lambda(t)$, $\Gamma(t)$, $\Theta(t)$ on the year by year basis.

LITERATURE

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